Chemical Process Safety
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Lecture 34
Type of Reliefs

Now welcome to the new module of this Relief, in this particular module we will discuss the various types of reliefs. Let us have a look that what we had studied previously. We have gone through the relief concepts, what is the relief etc.

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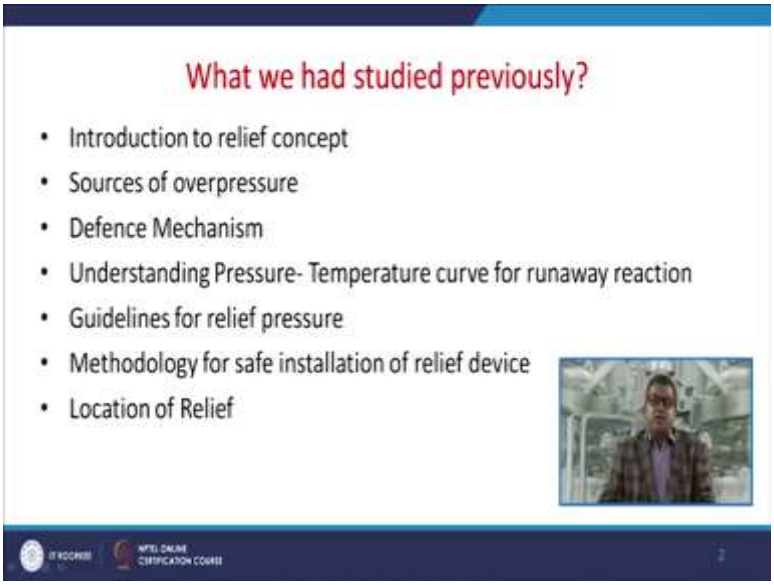

We discussed about the various sources of overpressure. We had a discussion about the defense mechanism, we analyzed the pressure temperature curve for various runaway reactions. We have discussed about the guidelines for the relief pressure along with the methodology of for the safe installation of various relief devices. We had a brief discussion about the installation and a location of various reliefs.

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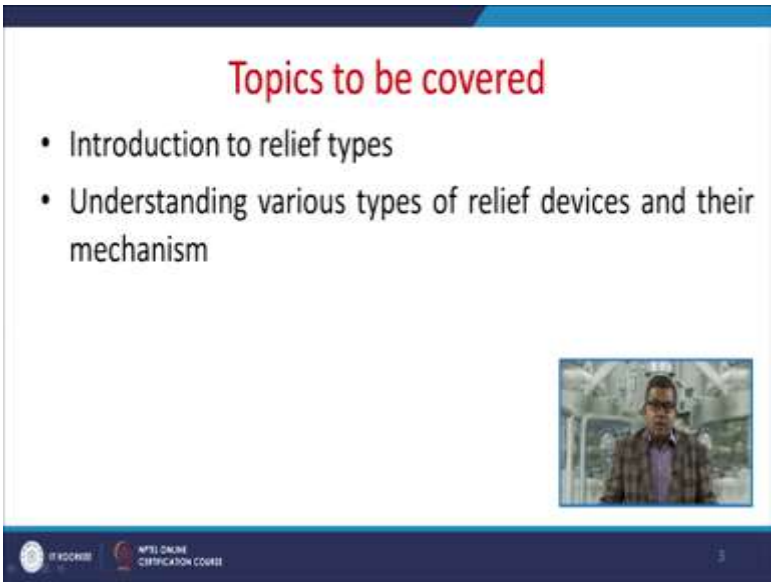

Now in this particular chapter, in this particular module, we will discuss the relief types and we have will understand that various type of relief devices and various mechanisms.

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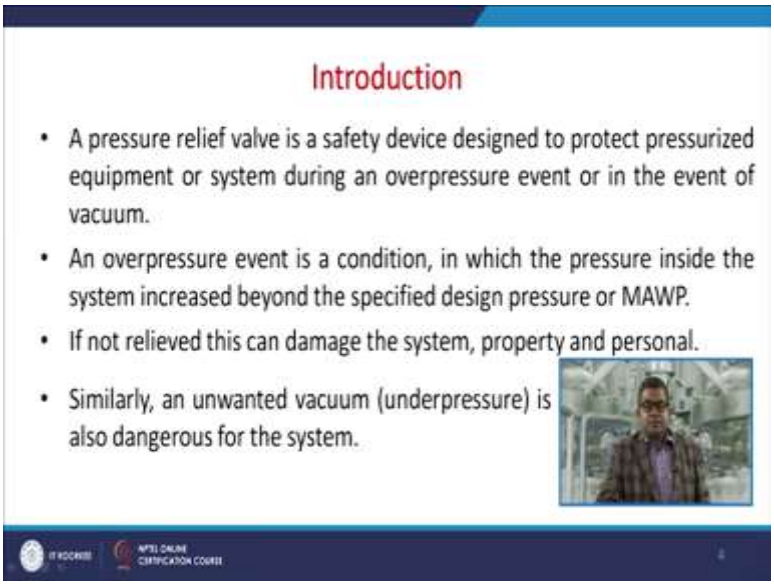

Now a pressure relief valve is safely designed to protect the pressurized equipment or system during an overpressure event or in the event of vacuum. Now an overpressure event is a condition in which the pressure inside the system increased beyond the specified design pressure or MAWP, Maximum Allowable Working Pressure. Now if not relieved this can damage the

system property and personal. So similarly an unwanted vacuum or under pressure is also dangerous for the system.

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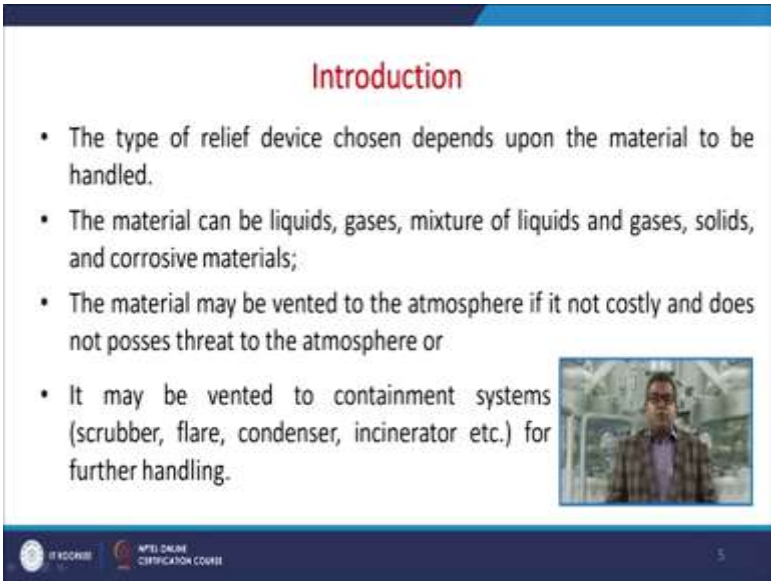

Now the type of relief devices chosen depends upon the material to be handled, this is very core issue. The material can be liquid, gas, mixture of liquid and gases, solids and corrosive materials. So you have to choose the appropriate relief device based on this particular material. The material may be vented to the atmosphere and if it is not costly and does not possess any threat to the atmosphere, it may be vented to containment system scrubber, flare, condenser, incinerator, etc for further handling. So this is again a very crucial issue.

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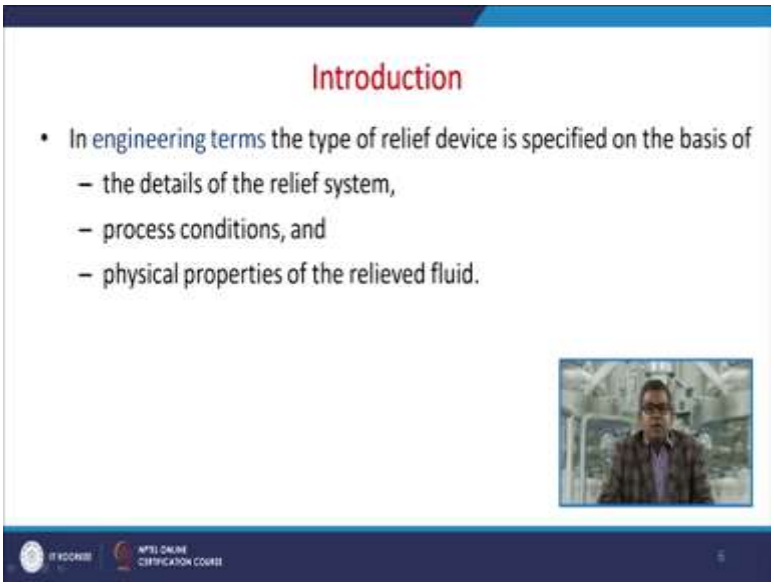

Now in engineering terms, the type of relief device is specified on the basis of the details of the relief system, what are the process conditions involved in that particular process? What are the physical properties of the relieved fluid? So these are the things which we need to be addressed (in) while designing the proper relief device. Now based on this particular aspect, different type of relief devices or a relief valves are designed. The reclosing type of pressure relief valve is one of them.

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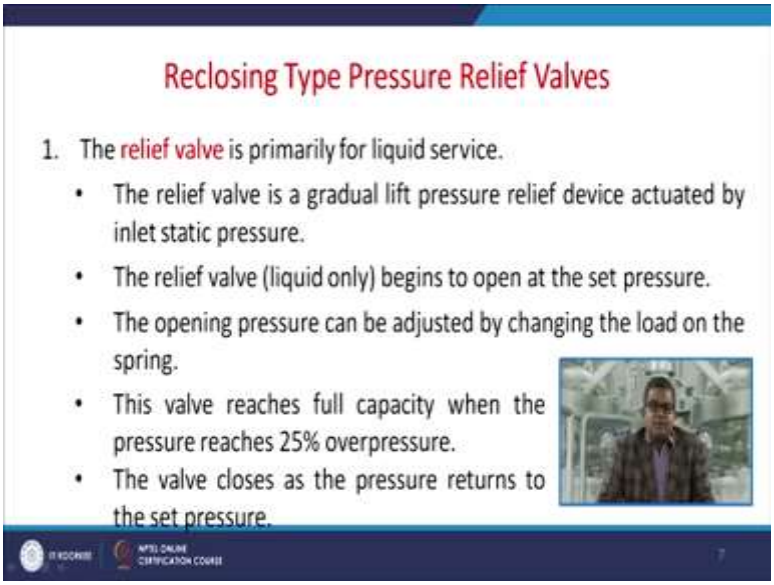

Now the relief valve is primarily for the liquid service. The relief valve is gradual lift pressure relief device actuated by inlet static pressure. Now the relief valve liquid only that is the specified now we are discussing the liquid only, the relief valve begins to operate at a set pressure, the definition of set pressure we have already discussed in previous module. The opening pressure can be adjusted by changing the load on the spring. This valve reaches the full capacity within the pressure reaches 25 percent over pressure if it is set at 25 percent. The valve closes at the pressure returns to the set pressure.

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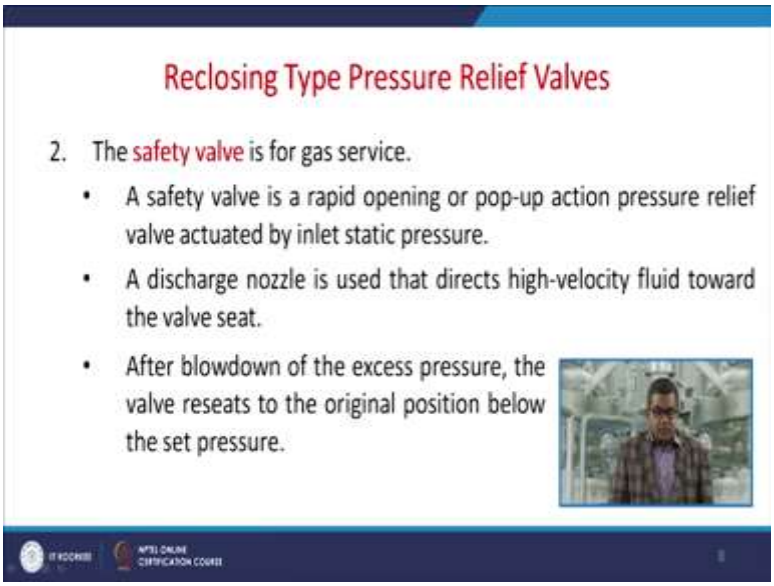

Now if we discuss about the safety valve for the gas service, a safety valve is a rapid opening or pop-up action pressure relief valve actuated by inlet static pressure. A discharge nozzle is sometimes used to direct the high-velocity fluid towards the valve seat. Now after the blowdown of the excess pressure the wall reseats to the original position below the set pressure.

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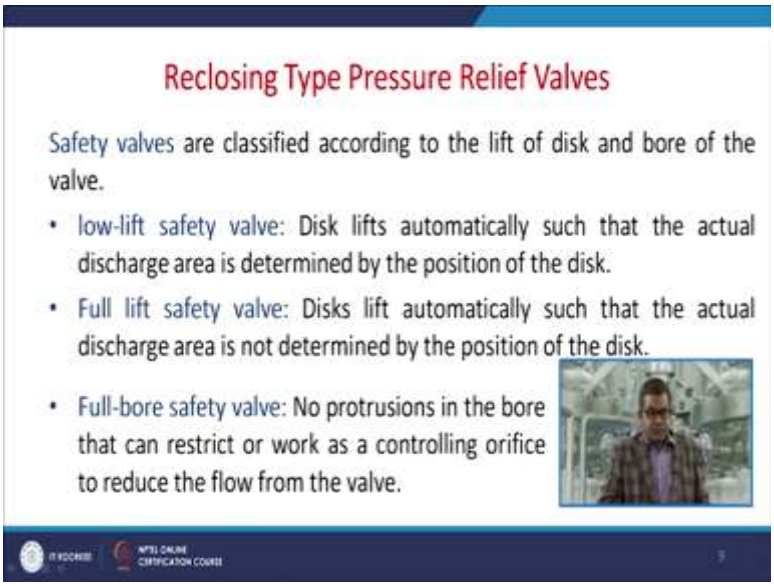

So safety valves are classified according to the lift of disc and bore of the wall. So based on this particular aspect, there are various type of safety valve, one is that low lift safety valve. Now in this particular low lift safety valve disc lifts automatically such that the actual discharge area is determined by the position of the disc. Second is the full lift safety valve, the disc lift automatically such that the actual discharge area is not determined by the position of the disc. Another one is the full bore safety valve, no protrusions in the bore that can restrict or work as a controlling orifice or to reduce the flow from the valve.

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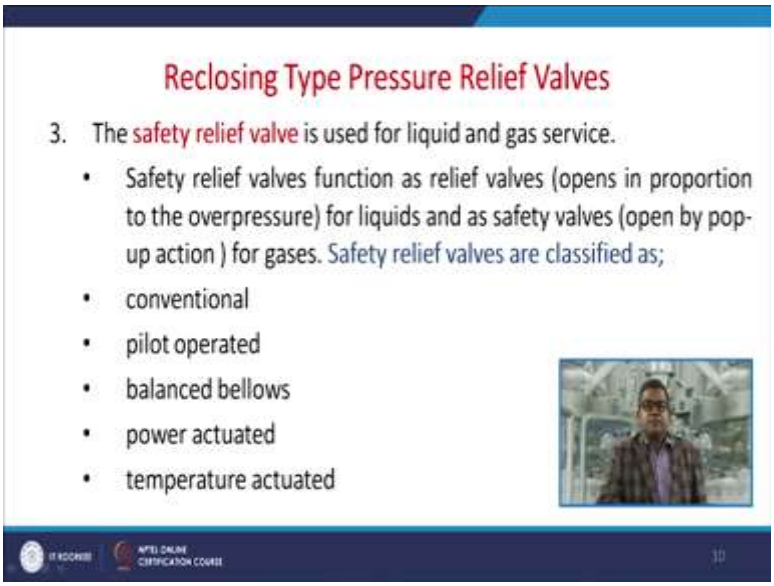

The safety relief valve is used for liquid and gas service, the safety relief valve function as a relief valve open in proportion to the overpressure for liquid and a safety valve that is open by pop-up action for the gases system and the (safety revolve) safety relief valves they are classified as the conventional one, the pilot operated, the balanced bellow, the power actuated, the temperature actuated. So based on these two aspects like that liquid and a gas service we can classify as for the following 5 different types.

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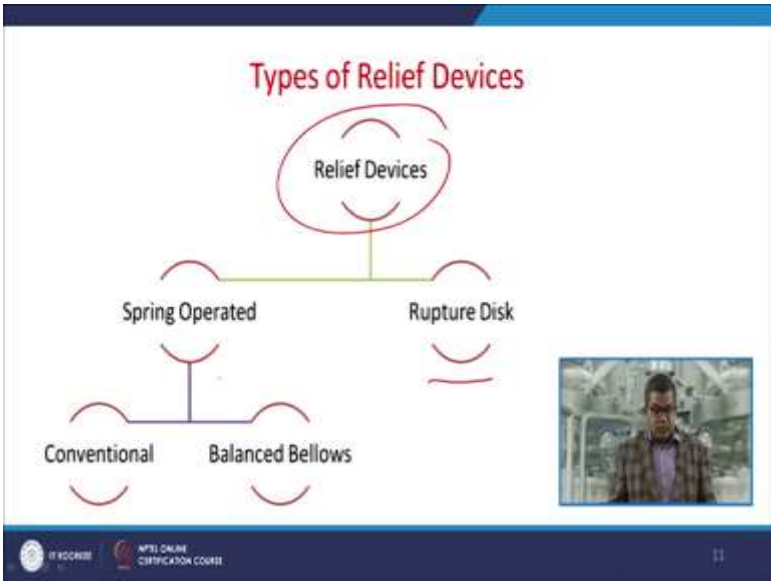

Now here, you can have a look of about the classification stream, these are the relief devices they are further divided into the spring operated one and the rupture disc one. Now spring operated one again they are further classified in two aspect, the conventional and the balanced bellow.

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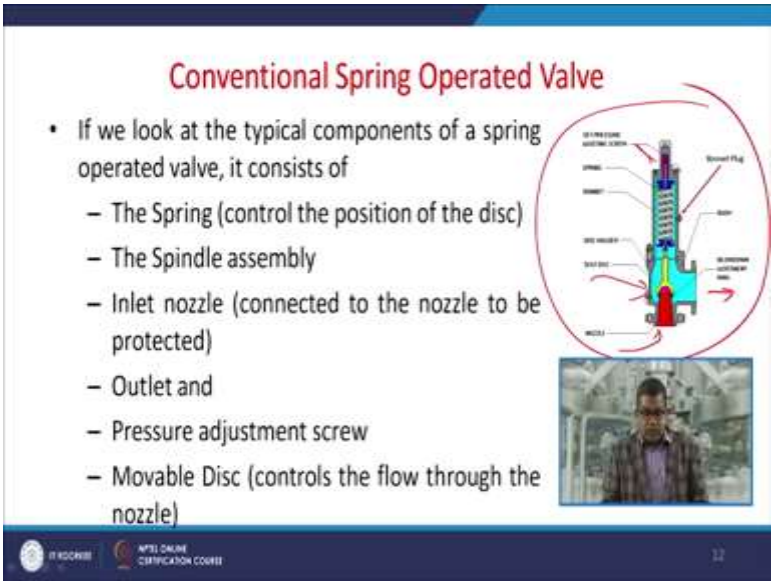

So let us have a look of one by one, the conventional spring-operated valves. So if you look the typical component of spring-operated valve. Now this is the best example is the spring operated valve. Sometimes they are used in the boilers. Now the spring this control the position of the disc. Now this is the spring, the inlet nozzle connected to the (node) connected to the nozzle to be protected this one, the outlet one, the pressure adjustment screw that is the set pressure adjusting screw which from which you can change the pressure or tension on the spring. The movable disc, this is the movable or C-disc here, this controls the flow through the nozzle.

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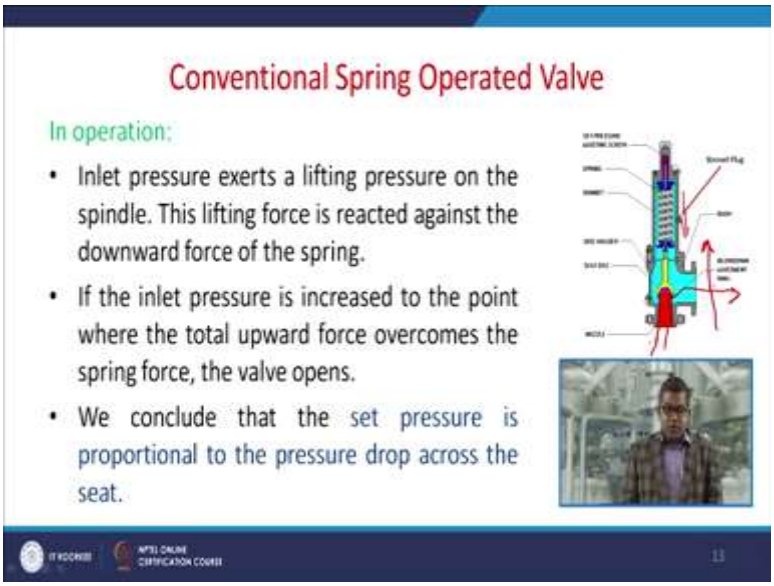

Now while considering the operation, the inlet pressure exerts a lifting pressure on the spindle, this one, the lifting force is reacted against the downward force of the spring because of based on the spring constant, spring exerts this downward force. Now if the inlet pressure is increased to the point where the total upward pressure overcomes the spring force like this, then the valve opens and when the valve opens then the pressure or the fluid may come out from this zone to this one. So we conclude that the set pressure is proportional to the pressure drop across the seat.

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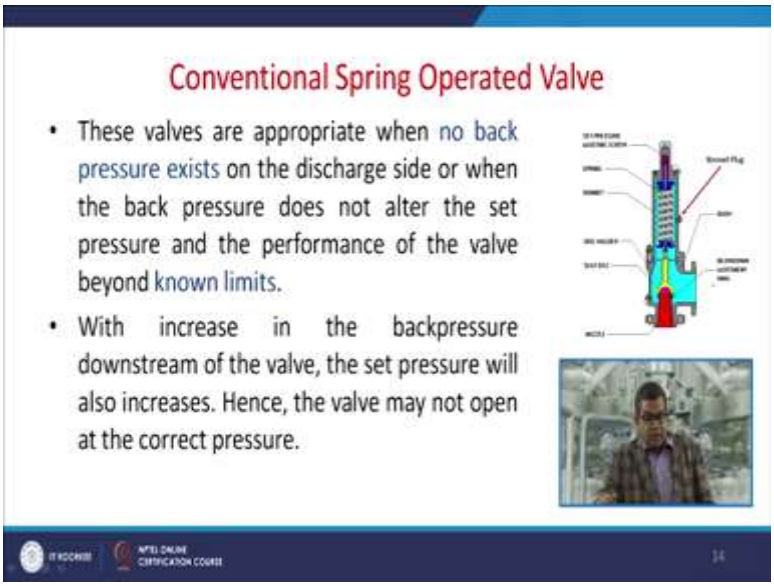

So these valves are appropriate when no back pressure exist on the discharge side or when the back pressure does not alter the set pressure and the performance of the valve known as beyond limit. Now with increase in the back pressure downstream of the valve, the set pressure will also increase hence the valve may not open at a correct pressure.

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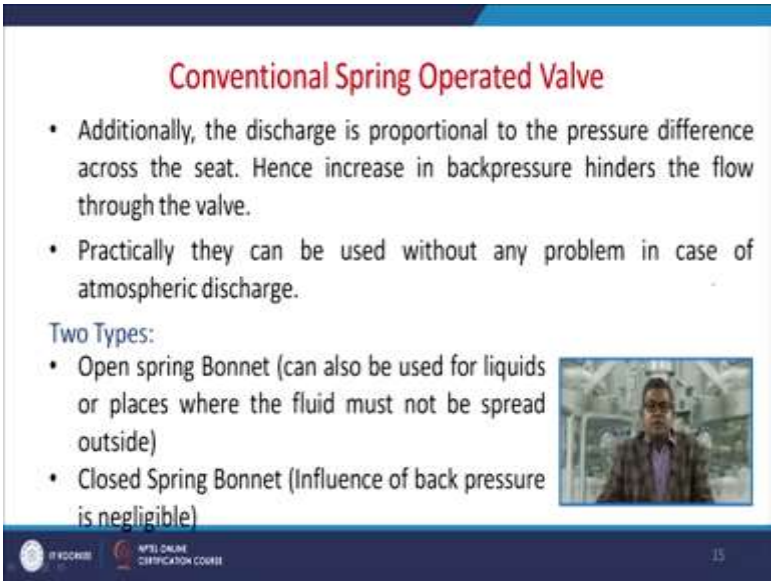

Now additionally, the while discussing the conventional spring-operated valve additionally the discharge is proportional to the pressure difference across the seat. So hence the increase in the

back pressure hinders the flow through the valve. Now practically they can be used without any problem in case of atmospheric discharge. Now there are two type of conventional spring operated valve, Open Spring Bonnet also, we used for the liquid or places where the fluid must not be spread outside, the Closed Spring Bonnet the influence of back pressure is negligible.

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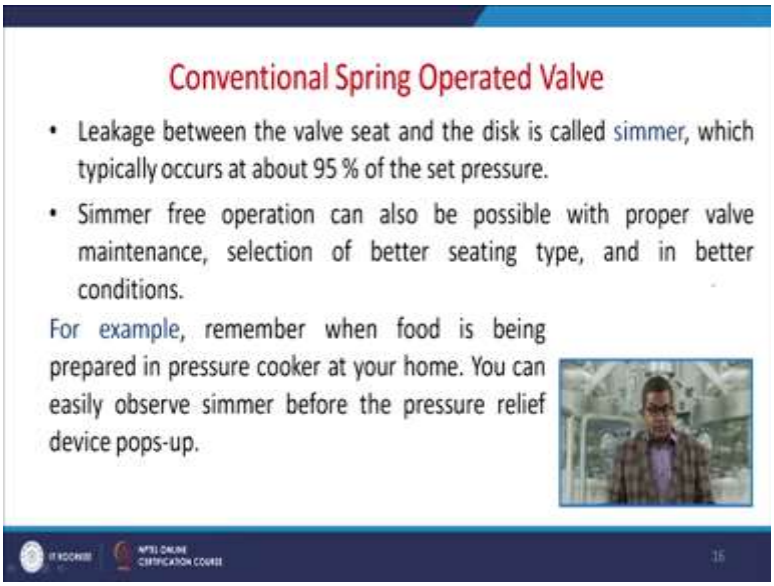

Now leakage between the valve, seat and disc is called the simmer which typically occurs about at about 95 percent of the set pressure. Now simmer free operation can also be possible with the proper valve maintenance, selection of a better seating type and in better conditions. Now for example, the remember when food is being prepared in pressure cooker at your home, you can easily observe the simmer before the pressure relief device pops up, so you may experience that there is leakage of steam around the gasket or around the vessel.

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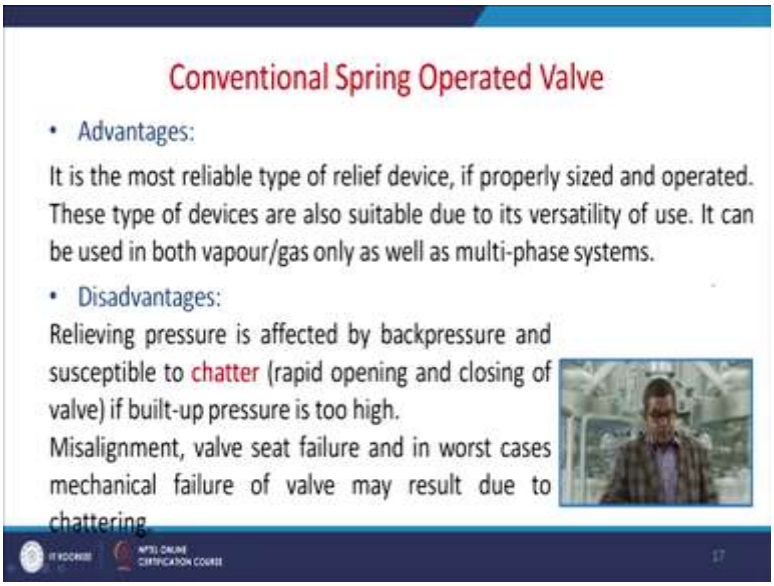

Now there are certain things related to the advantages of these conventional spring operated valve. So it is most reliable type of relief device if properly sized and operated. Now these type of devices are also suitable due to its versatility of use, it can be used in both vapor gas only as well as multi-phase systems. When we are having the advantage, there are certain disadvantages also associated with these conventional spring-operated valves.

The relieving pressure is affected by back pressure and susceptible to chatter, that is the rapid opening and closing of valve. Now if built-up pressure is too high, now sometimes misalignment of valve seat failure in worst-case mechanical failure of valve may result due to chattering. So this is the disadvantage associated with the conventional spring operated valve.

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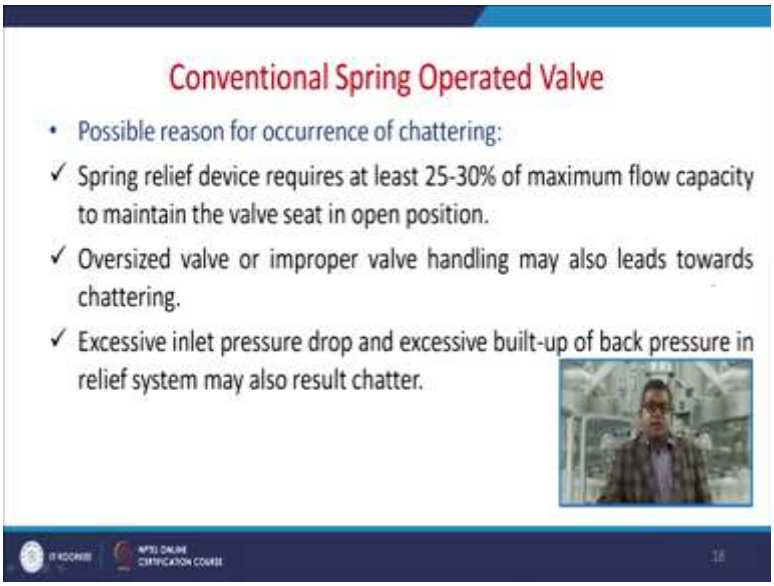

Now there are various reasons because we have discussed about the chattering. So there are possible reasons for the occurrence of chattering. So we you can have a look of those reasons. The spring relief device requires at least 25 to 30 percent of maximum flow capacity to maintain the valve seat in open position. Oversized valve or improper valve handling may also lead towards the chattering. Sometimes excessive inlet pressure drop and excessive buildup of back pressure in relief system may also result chattering.

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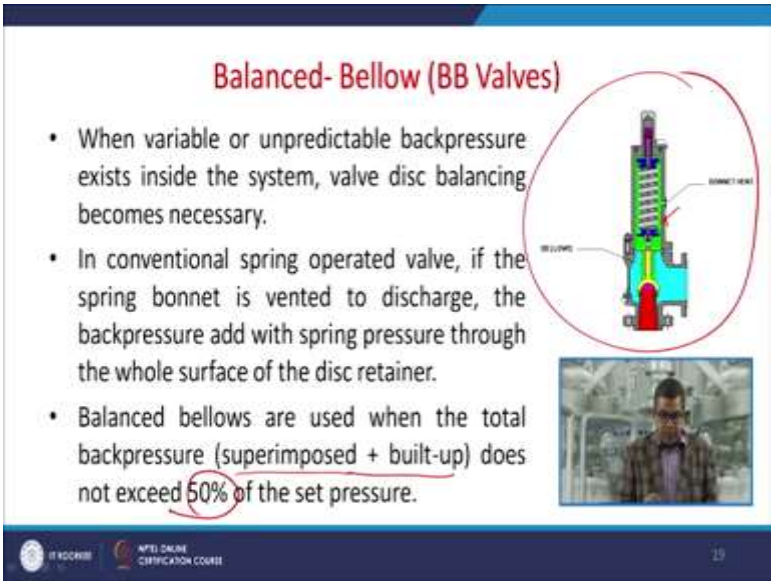

Now second is, the Balanced-Bellow or BB valves. Now this is you can have a picture of this balanced bellow valves bit similar to the spring operated or spring actuated valve. So when variable or unpredictable back pressure exist inside the system, valve disc balancing become necessary. So in conventional spring-operated valve if the spring bonnet is, this one is the bonnet, now if spring bonnet is vented to discharge the back pressure add with the spring pressure through the whole surface of the disc retainer. Now balanced bellows are used when the total back pressure that is the superimposed plus built up. So the total back pressure does not exceed the 50 percent of the set pressure.

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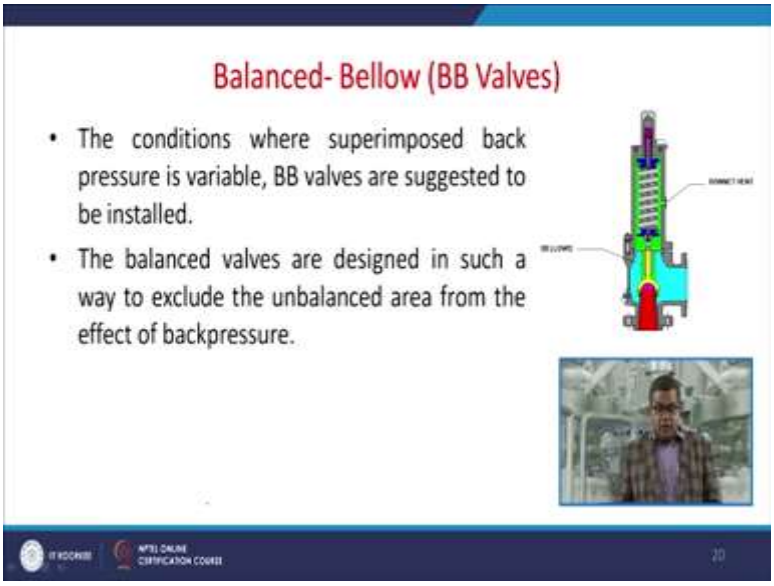

Now the conditions where the superimposed back pressure is variable these balanced bellow valves are suggested to be installed. So the balanced valves are designed in such a way to exclude the unbalanced area from the effect of back pressure.

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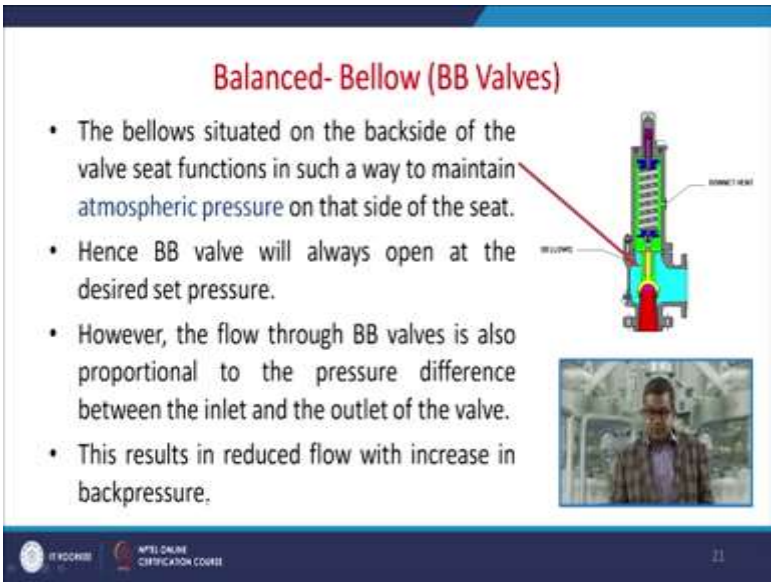

Now the bellows, these are the bellows you can see these are the bellows. Bellows situated on the back side of the valve seat function in such a way to maintain the atmospheric pressure on the side of the seat. So hence, balance bellow valve will always open at the desired set pressure. This is the plus point of this balanced bellow valve. However, the flow through balance bellow valve is also proportional to the pressure difference between the inlet and outlet of the wall. So this result in the reduced flow of with increase in back pressure.

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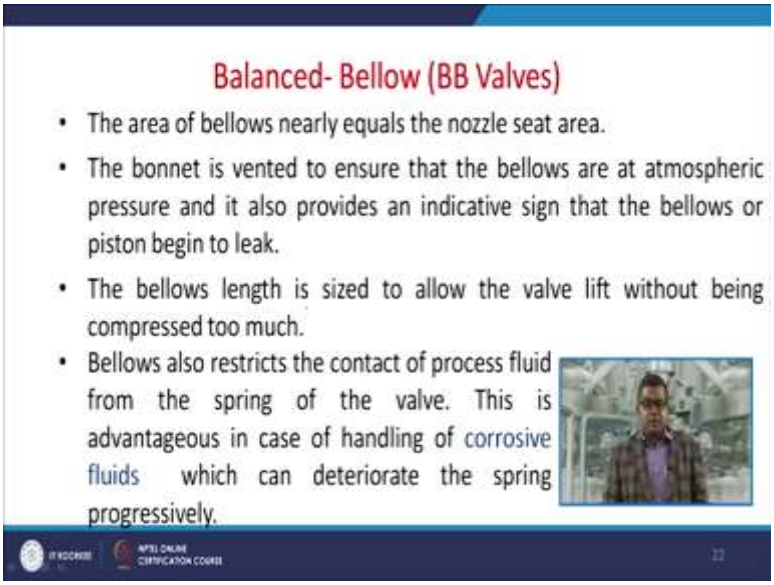

The area of bellows nearly equals the nozzle seat area, this one, the bonnet is vented to ensure that the bellows are at the atmospheric pressure and it also provides an indicative sign that the bellows or piston begin to leak. The bellows length is sized to allow the valve lift without being compressed too much. The bellows also restricts the contact of process fluid from spring of the valve. Now this is advantageous in case of handling the corrosive fluid which can be, which can deteriorate the spring progressively.

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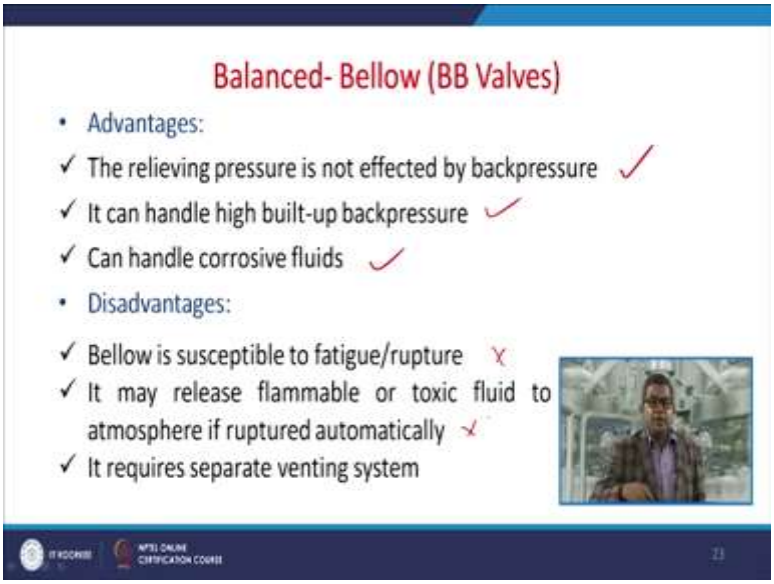

So there are several advantages and disadvantages associated with this balanced bellow valve. The advantage, let us have a look of advantages that relieve pressure is not affected by the back pressure. Now it can handle high built-up back pressure and also can handle the corrosive fluids. Now there are several disadvantages. Now this bellow is susceptible to fatigue or rupture, it may cause a problem. It may release the flammable or toxic fluid to atmosphere if not, if ruptured automatically. Now it requires a separate venting system, so these are the several disadvantages; although these advantages may be corrected if it is being used in due course of time.

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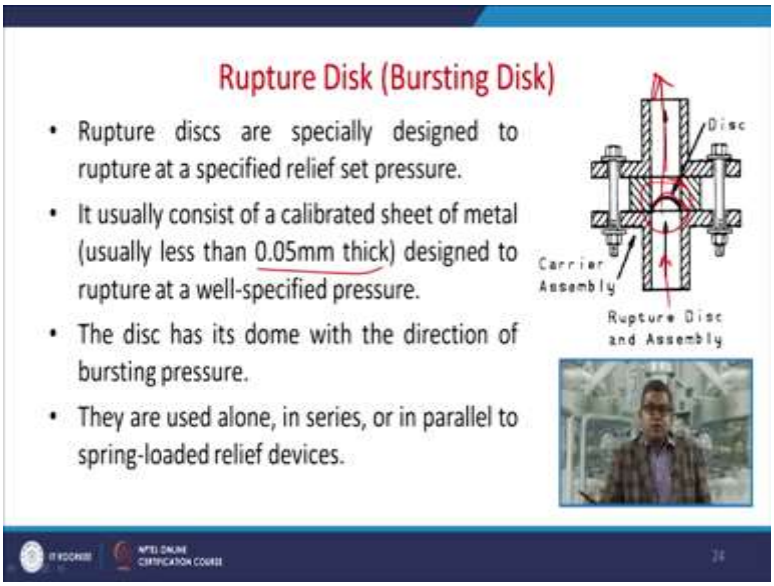

Now another relief device is called the rupture disc or bursting disc. Now these are the specially designed to rupture at specified relief set pressure and most common is your domestic pressure cooker safety valve. Now it is usually consists of calibrated sheet of metal usually less than 0.05 mm thickness. Now this is designed to rupture at a well specified pressure. Now here you can see that this one, now here if pressure rises and if it crosses the set pressure then it ruptures and it vent into the atmosphere. Now, usually this disc has its dome with the direction of bursting pressure, this one you can see, they are used alone in series or in parallel to spring loaded safety valve (())(16:07).

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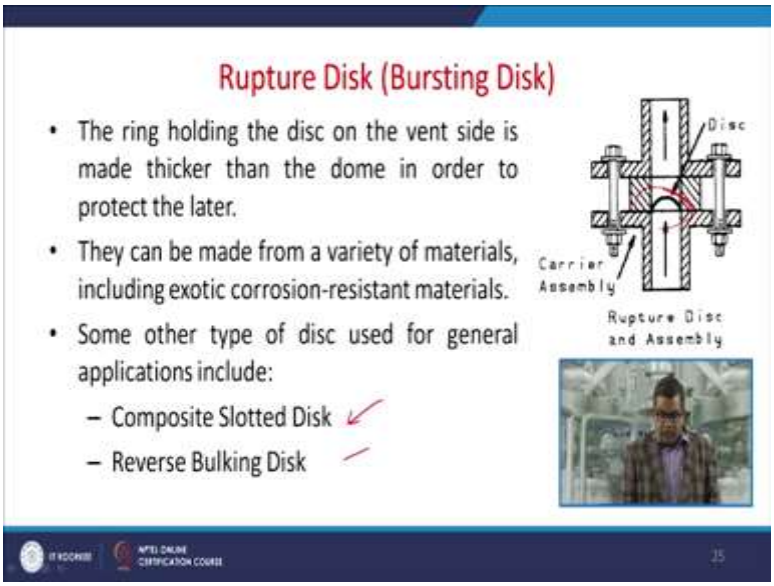

Now the ring holding the disc on the vent side is made thicker than the dome in order to protect it later. Now here, there is a ring. Now this can be made from a variety of the material including exotic corrosion-resistant material etc. Now some other type of disc used for the general application include composite slotted disc, reverse bulking disc.

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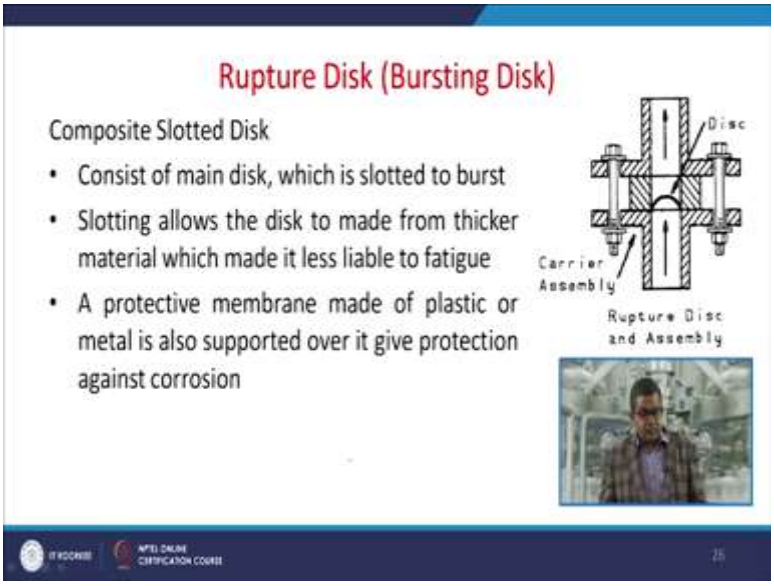

Now let us have a brief discussion about the composite slotted disc, this consists of a main disc (where) which is slotted to burst. Now slotting allows the disc to made from thicker material

which made it less liable to fatigue a protective membrane made of plastic or polymer or metal is also supported over it to give the protection against corrosion.

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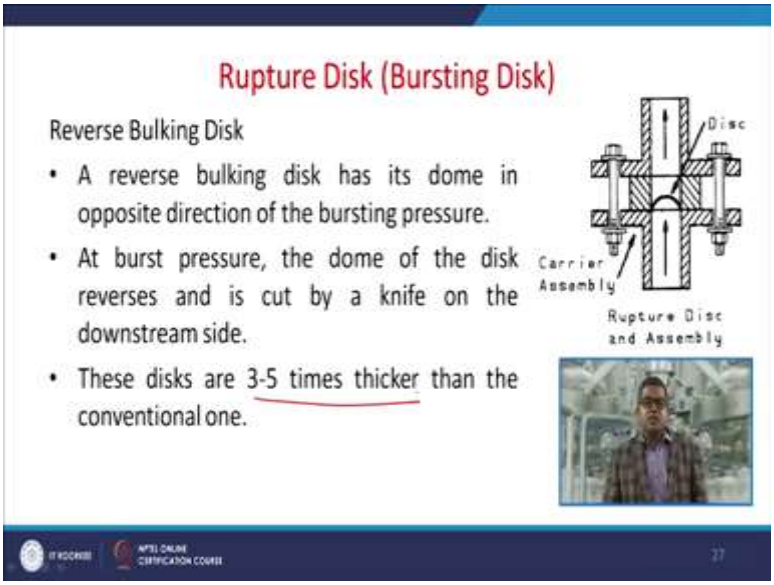

Now we have a reverse bulking disc. Now a reverse bulking disc has its dome in opposite direction of the bursting pressure. At burst pressure the dome of the disc reverses and it cut by a knife on the downstream side. Now these discs are 3-4 times thicker than the conventional one which we have discussed earlier.

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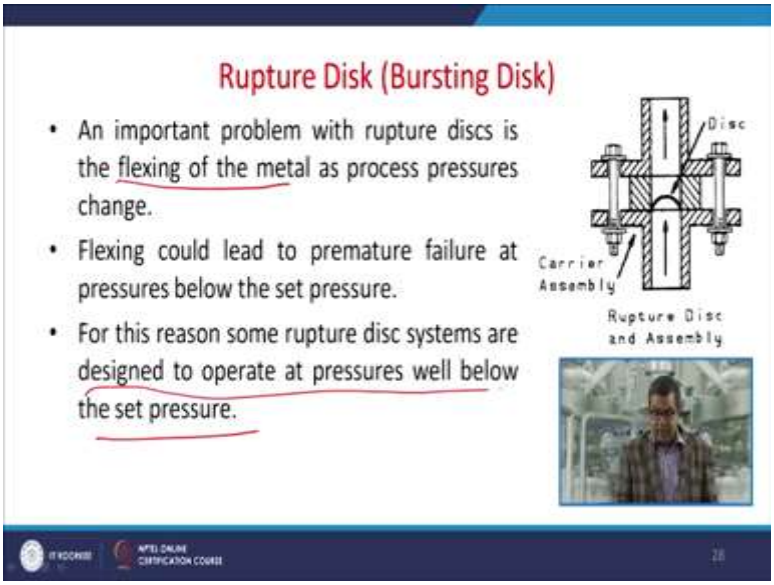

Now an important problem with the rupture disc is the flexing of metal as process pressure changes. So if the process pressure fluctuating then there may be a problem of flexing of the metal. So flexing could lead to the premature failure if the pressures below the set pressure. So this is you may term as the disadvantage. For this reason some rupture disc systems are designed to operate at pressure well below the set pressure. So this is the crucial aspect.

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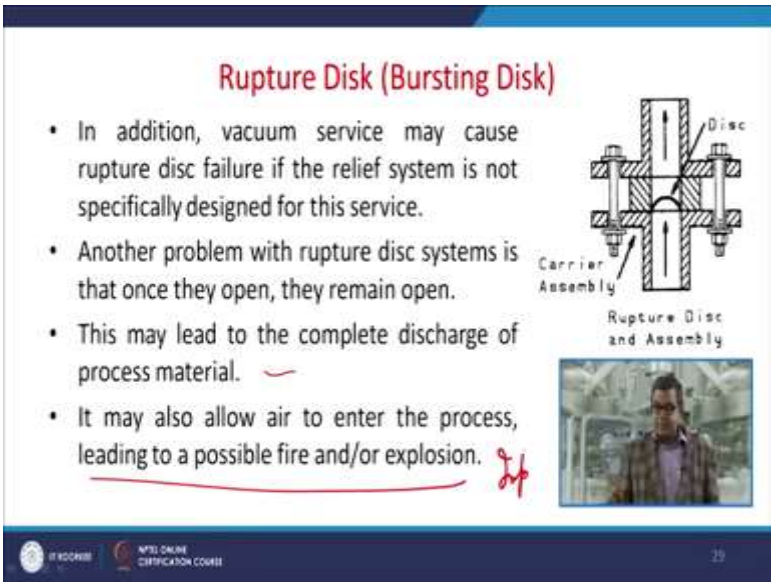

In addition, vacuum services may cause the rupture disc failure if the relief system is not specifically designed for the service. Now another problem with the rupture disc system is that once they open, they remain open. You need to replace those discs. So this may lead to the complete discharge of the process material. So this particular aspect need to be addressed while you are using or you are adopting this rupture discs. So sometimes because the all material or everything is exposed to the atmosphere or a the volume in question, so it may also allow to enter the process air or it may allow the air to enter the process leading to the possible fire and explosion. So this is again a very important thing.

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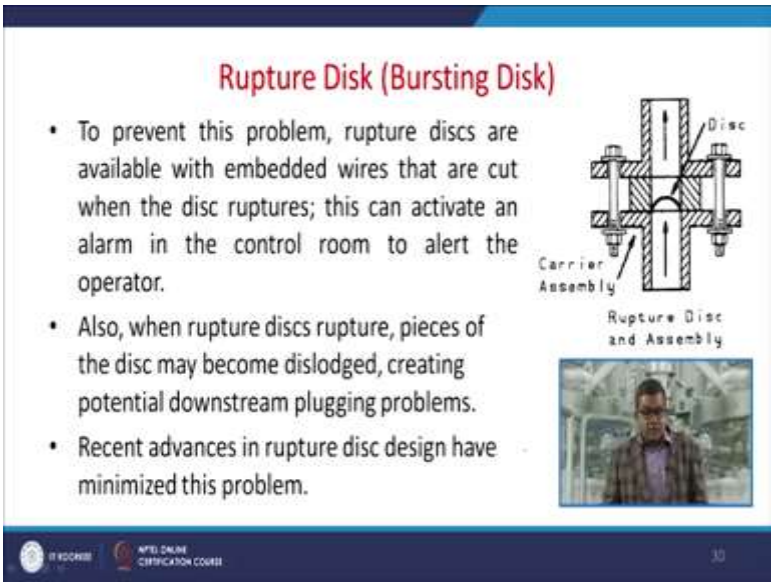

Now to sometimes to prevent this problem, rupture discs are available with embedded wires that are cut when the disc ruptures and this can activate an alarm in the control room to alert the operator, so that they may be aware about the emergency that or they may be aware that rupture disc burst. Also when the rupture disc rupture, the pieces of the disc may become dislodged, creating potential downstream plugging problem and sometimes if the metal is reactive it may lead to the runaway reaction or it may catalyze the reaction which is under the process. So, recent advances in the rupture disc design have minimized this particular problem.

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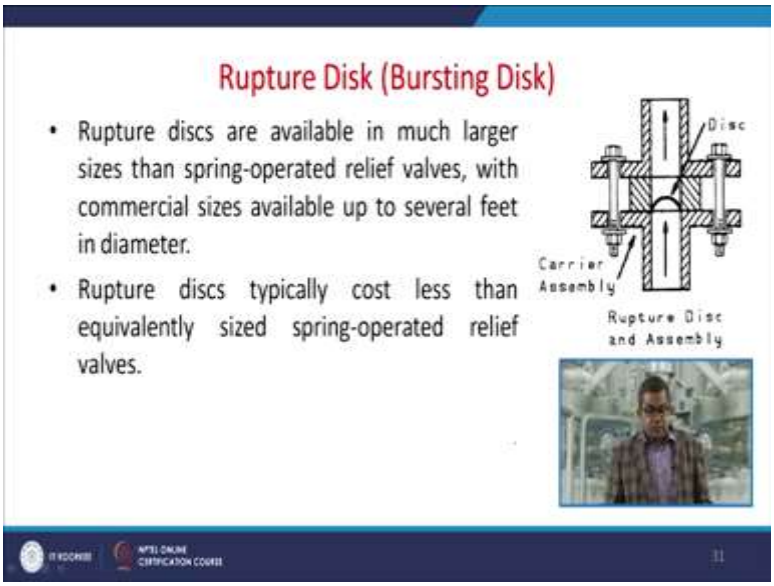

Now these rupture discs are available in much larger size than the spring operated relief valve with commercial sizes available up to several feet in diameter. These ruptured typically cost less than the equivalently sized spring-operated relief valve and moreover the maintenance and other things are on the lower side for these rupture discs compared to the spring operated relief valve where you need to perform the regular maintenance.

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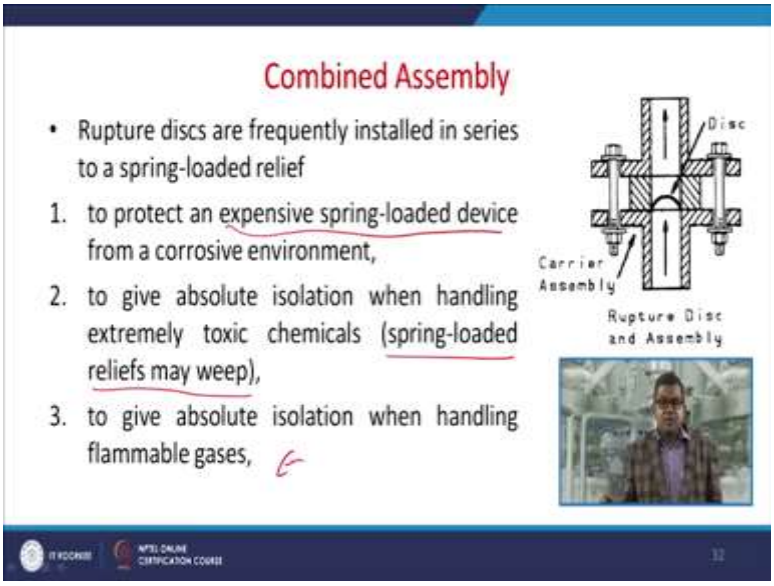

Now there are certain combined assemblies. (The) these the rupture discs are frequently installed in series in the spring loaded relief. Now to protect an expensive spring-loaded device from a corrosive environment because, these spring-loaded devices are very much expensive. Now to give the complete isolation, when handling extremely toxic chemicals and sometimes because the spring-loaded relief may weep at the time when you are using those toxic chemicals. Now to give the absolute isolation when handling the flammable gases. Again, this is very important.

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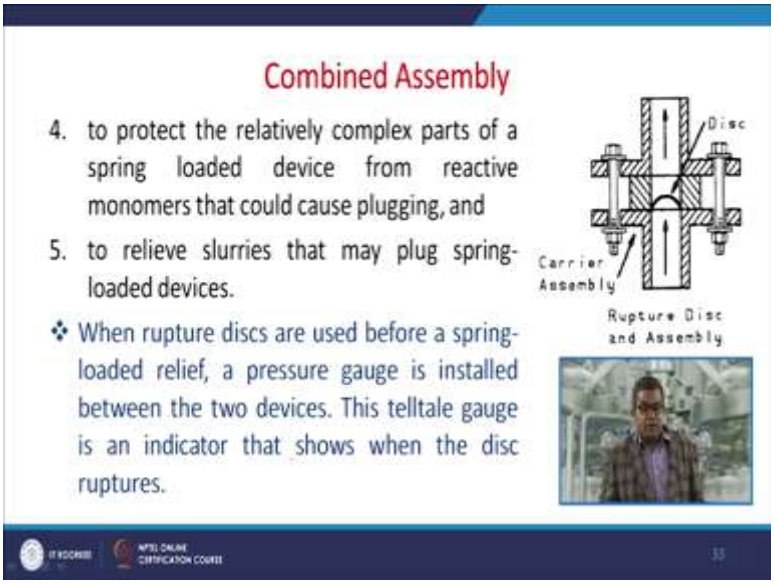

Sometimes they used to protect the combined assemblies to protect the relatively complex part of a spring-loaded device from reactive monomer that could cause plugging and sometimes the combined assemblies reused to relieve the slurries that may plug the spring-loaded devices. So they are having a variety of uses. So when rupture discs (disc) are used before a spring-loaded relief device, a pressure gauge is usually installed between these two devices. The telltale gauge is an indicator that shows when the disc ruptures. So they are having against (done by) proper arrangement for indicating that when this particular disc ruptures.

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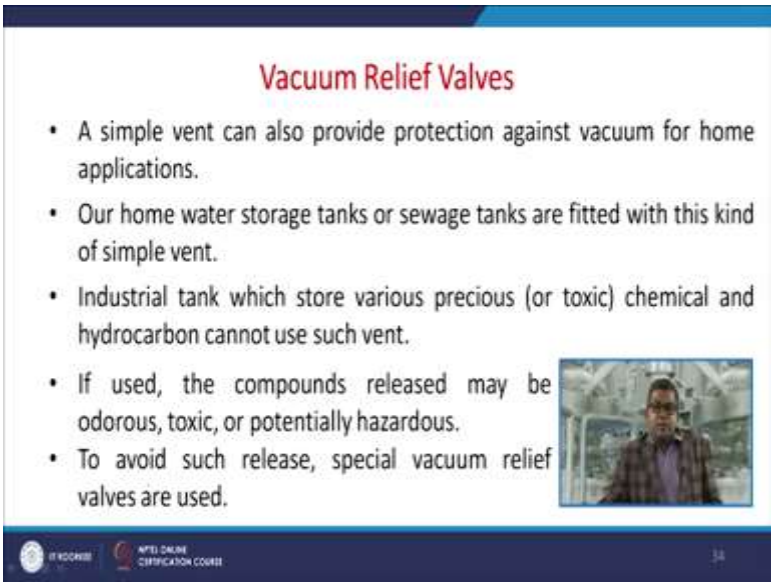

Now let us have a discussion about the vacuum relief valve. These are the simple vent can also provide protection against vacuum for home applications. So our home water storage tank sometimes or sewage tanks they are fitted with the kind of simple vent. Now industrial tanks which store various precious or toxic chemicals and hydrocarbons cannot use such vents. Now if used the component compound released maybe odorous, toxic or potential hazardous. Now to avoid such kind of a release, special vacuum valves are used.

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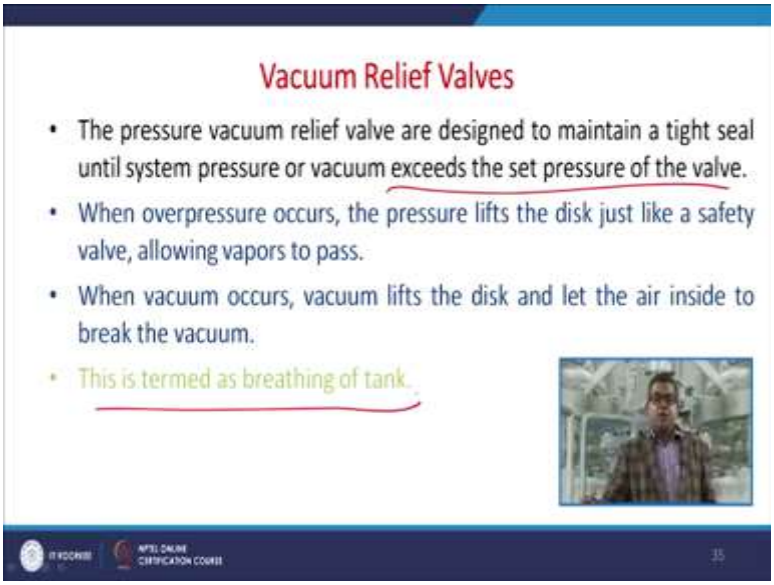

Now the pressure vacuum relief valve they are designed to maintain a tight seals until system pressure or vacuum exceeds the set pressure of the valve. So when the over pressure occurs the pressure lifts the disc just like safety valve allowing the vapors to pass and the when vacuum occurs the vacuum lifts the disc and let the air inside to break the vacuum. Now this is termed as (the) breathing of tank.

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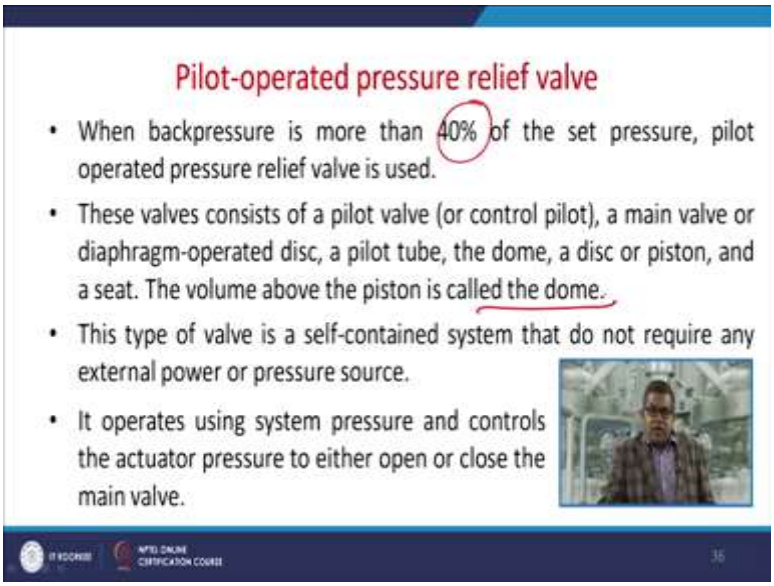

Now let us have a discussion about the pilot operated pressure relief valve. So when back pressure is more than 40 percent of the set pressure, the pilot-operated relief valve is used. This is a very common practice. Now these valve consists a pilot valve or a control pilot, a main valve or a diaphragm-operated disc, a pilot tube, the dome, a disc or piston and a seat. The volume above the piston is called the dome. Now this type of valve is a self-contained system and they do not require any external power or a pressure source. Now it operates using the system pressure and a control, the actuator pressure to either open or close the main valve.

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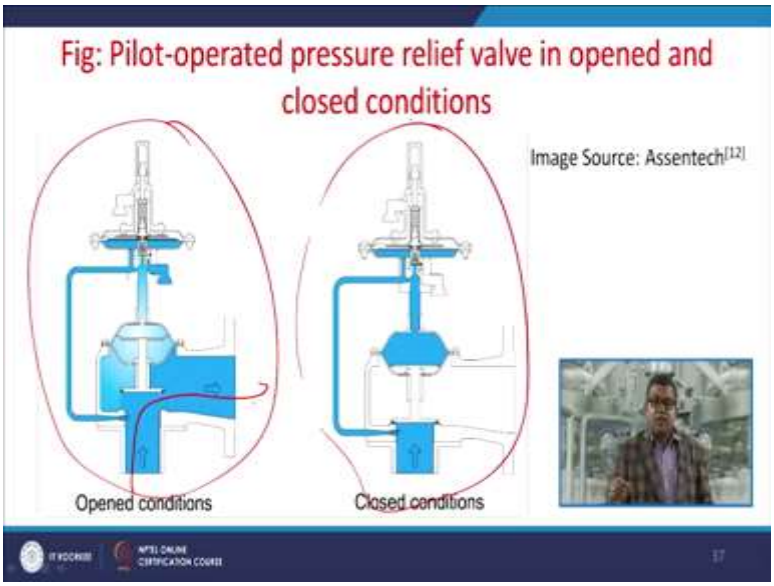

Now this is the typical figure of pilot-operated pressure relief valve in open and closed system. Now this is the open condition, so when fluid passes through this way and this one is the closed one. So you can see all the things which we have discussed in the previous slide, they are here.

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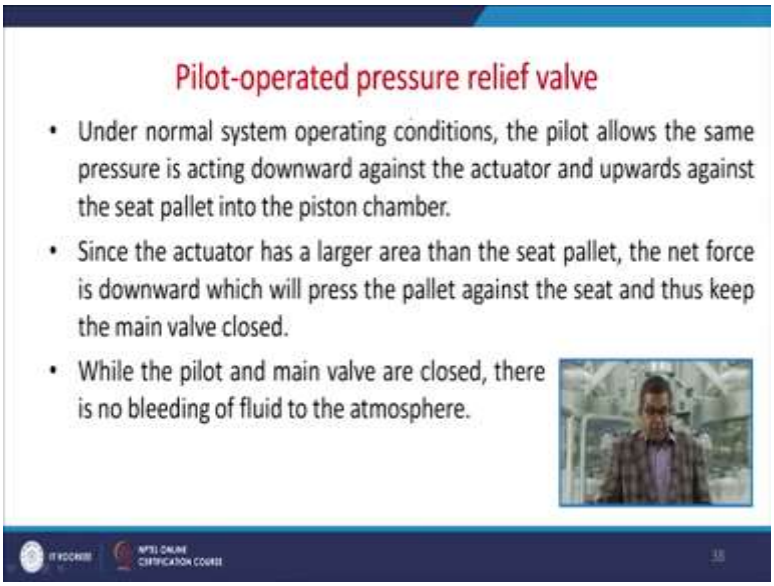

So under normal operating conditions, the pilot allows the same pressure which is acting downward against the actuator or upward against the seat pallet into the piston chamber. Now since the actuator has a large area then the seat pallet, the net force is downward which will press

the pallet against the seat and thus keep the main valve closed. So while the pilot and the main valve are closed there is no bleeding of fluid to the atmosphere.

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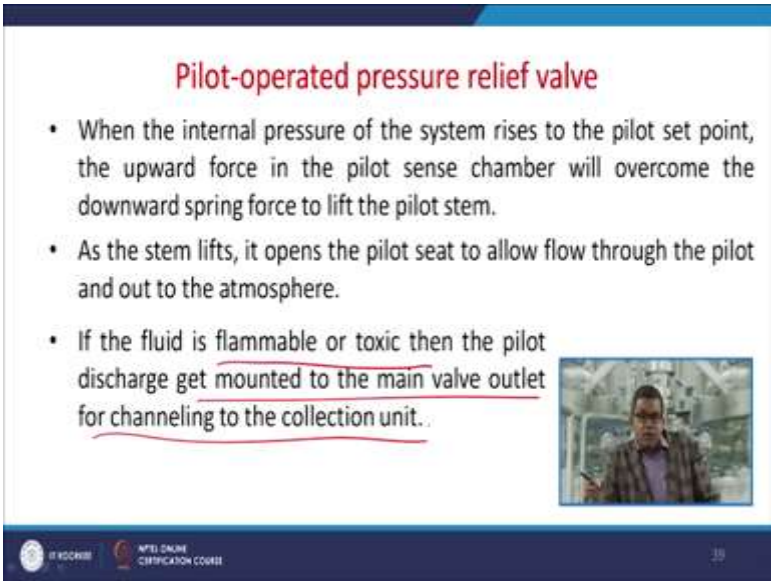

So when the internal pressure of the system rises the pilots set point, the upward force in the pilot sense the chamber will overcome and the downward spring force to lift the pilot is stem. So as the stem lifts, it opens the pilot seat to allow the flow through the pilot and (out) to the atmosphere. So if fluid is flammable or toxic then pilot discharge get mounted to the main valve outlet for channeling the collection unit, so that it cannot go into the atmosphere for the creation of further problem.

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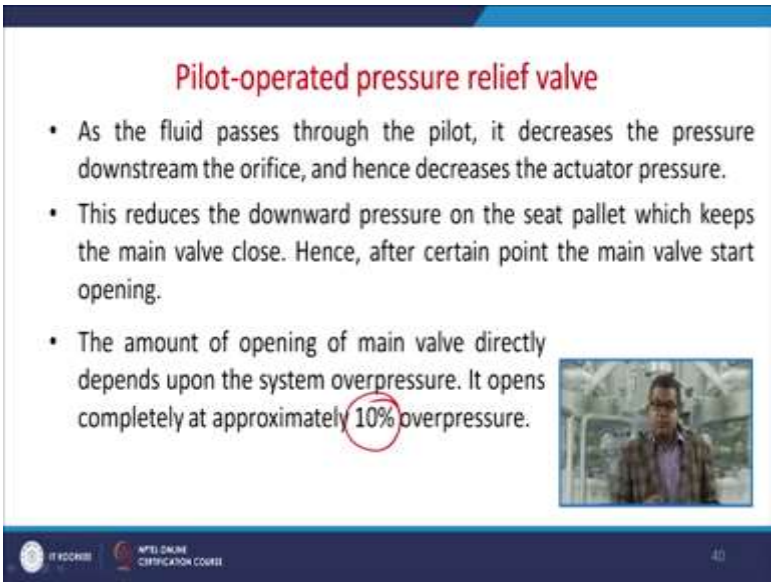

Now as the fluid passes through the pilot, it decreases the pressure downstream to the orifice hence decreases the actuator pressure. Now this reduces the downward pressure on the seat pallet which keeps the main valve closed. So hence after certain pilot, at certain point the main valve start opening. So the amount of opening of main valve directly depends on the system over pressure and it opens completely at the (approx) or you can say, the approximately 10 percent of over pressure.

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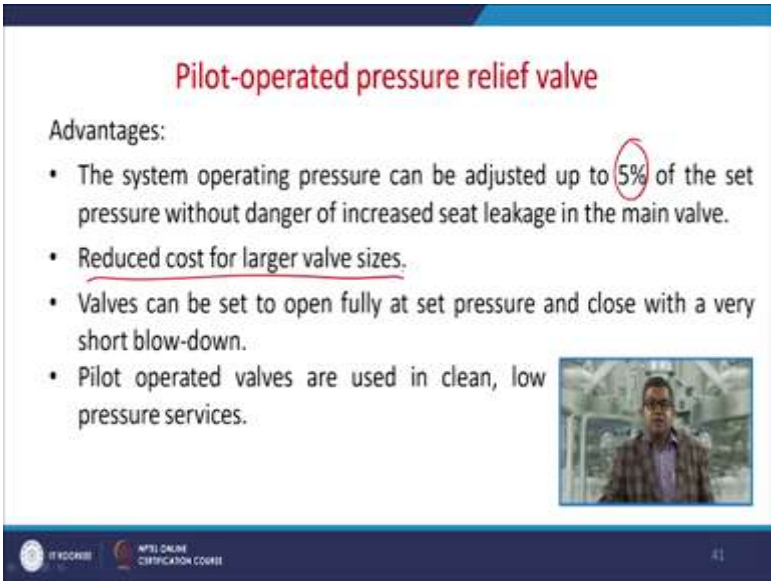

So, there are several advantages associated with this pilot operated pressure relief valve, the system operating pressure can be adjusted up to 5 percent of the set pressure without danger of increased seat leakage to the main valve. They reduced the cost for the larger valve size. Valves can be set to open fully at set pressure and closed with a very short blow down. The pilot operated valves they are used in clean, low pressure services.

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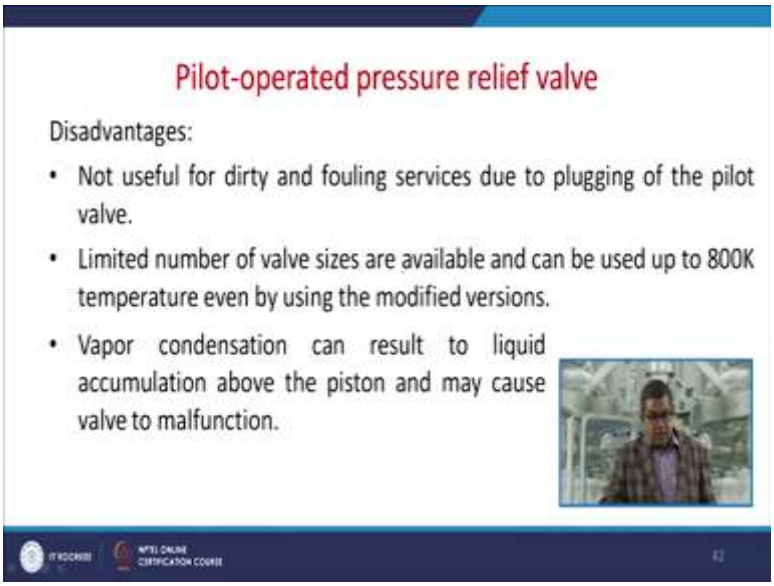

So while we have several advantages there are several disadvantages for this pilot operated pressure relief valves. They are not useful for dirty or a fouling services due to the plugging of the pilot valve. The limited number of valve sizes are available and can be used up to 800 Kelvin temperature even by using the modified versions. The vapor condensation can result to liquid accumulation above the piston and that may cause the valve to malfunction. So these are the several disadvantages of these valves.

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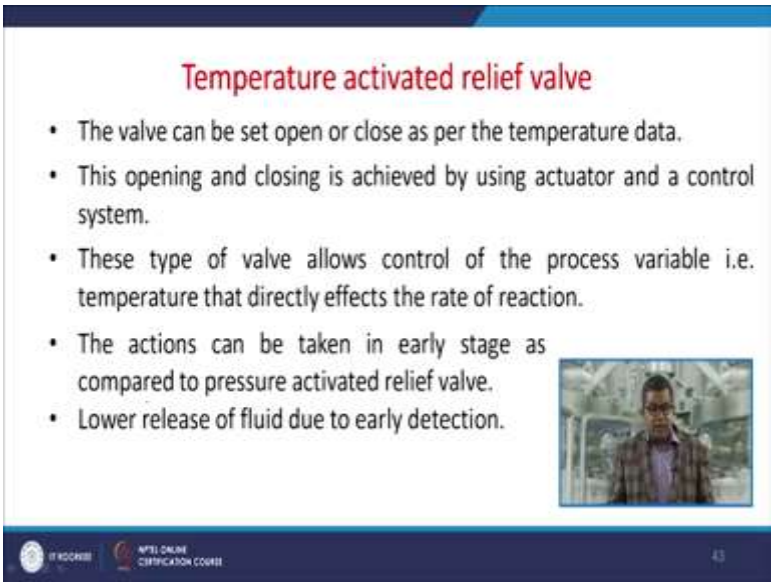

Now there are several temperature activated relief valves. So these valve can be set open or a closed as per the temperature data, which is readily available. The opening and closing is achieved by using actuator and a control system. So these type of valve always control the process variables that is temperature that directly effects the rate of reaction. The action can be taken in early stage as compared to the pressure activated relief valve. So the lower release of fluid is due to early detection.

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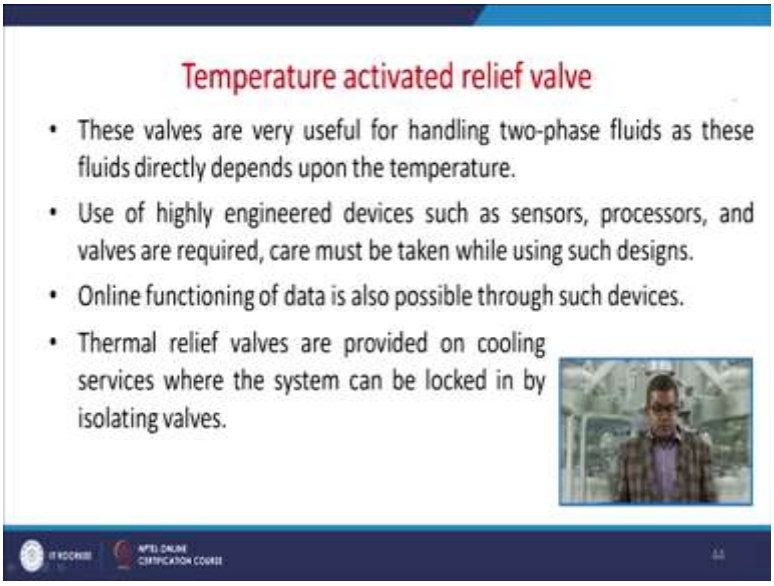

Now these walls are very useful for handling two-phase fluids as (there) these are, these fluids are directly depends upon the temperature. So use of highly engineered devices such as sensors, processors and valves are required and care must be taken while using such designs. Online functioning of data is also possible through such devices. The thermal relief valves are provided on cooling services where the system can be locked in by isolating valves. So in this particular module, we have discussed various classification of those relief devices.

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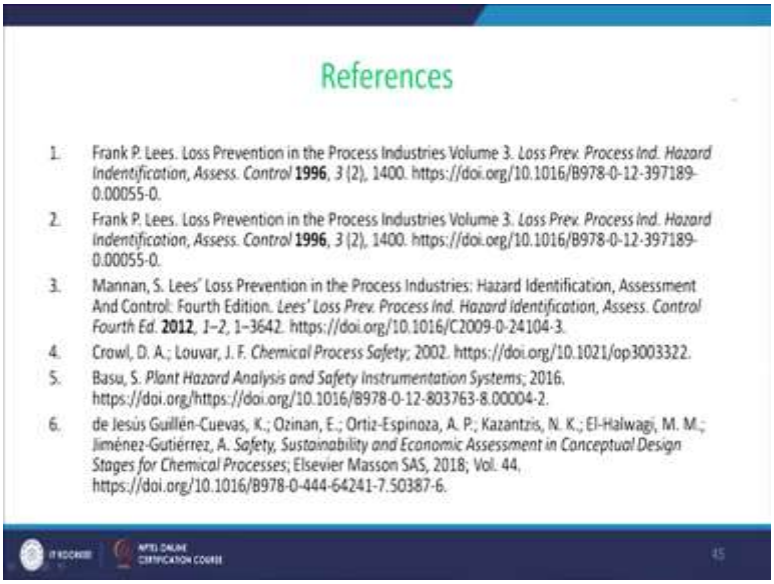

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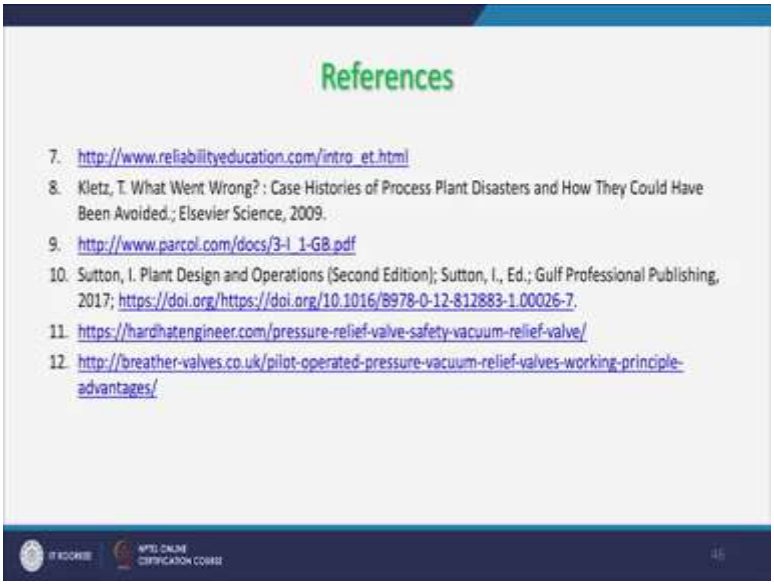

The advantages and disadvantages associated with these devices and for further study you can have a look of these references which we have already enlisted in this particular module. Thank you very much.