Chemical Process Utilities

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Lecture – 29
Boiler Water, Safety Valves and Condensate Recovery

Welcome to the next segment of steam and accessories. If you recall that we previously discussed the concept of economizer, we discussed superheaters. Apart from this, we discussed the various other essential accessories and mountings attributed to the boiler, including the pressure cage, TDS sensors, temperature gaze, glass viewing system, etcetera.

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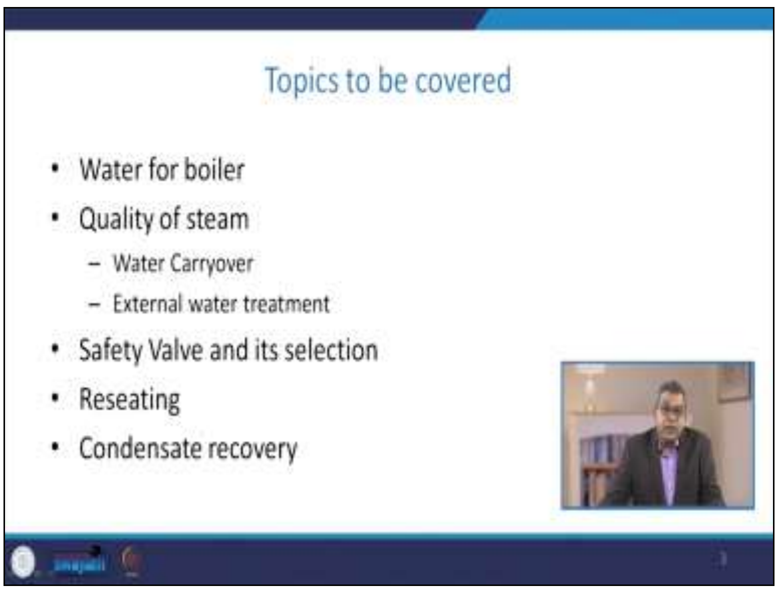

In this lecture, we will discuss the essentials for attributed to the water quality of a steam concept of water carryover, external water treatment. We will discuss in detail the safety valve and how we can select the appropriate safety valve for the boiler in question. We will discuss the other safety devices, including the seating and other shear pinning systems. We will discuss condensate recovery and the importance of condensate in the previous lectures.

We will discuss how we can recover and what is essential for the condensate to recovery system? So, let us start with the water for the boiler.

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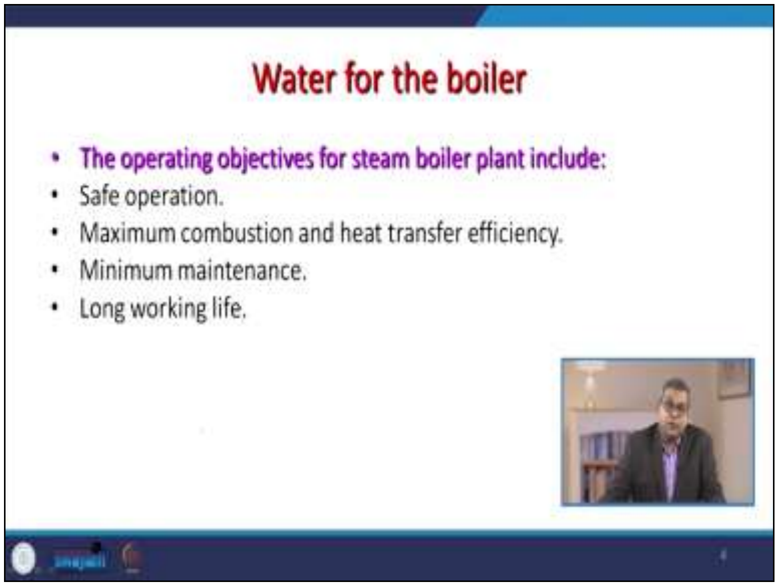

The operating objective for the steam boiler plant includes having a safe operation must have a maximum combustion output and heat transfer efficiency. It also should offer a minimum maintenance and a long working life. These are some of the other essential aspects of a boiler. See, we discussed that the quality of the water used to produce the steam in the boiler has a profound effect on meeting the objective of the boiler. There is a need for the boiler to operate under various criteria.

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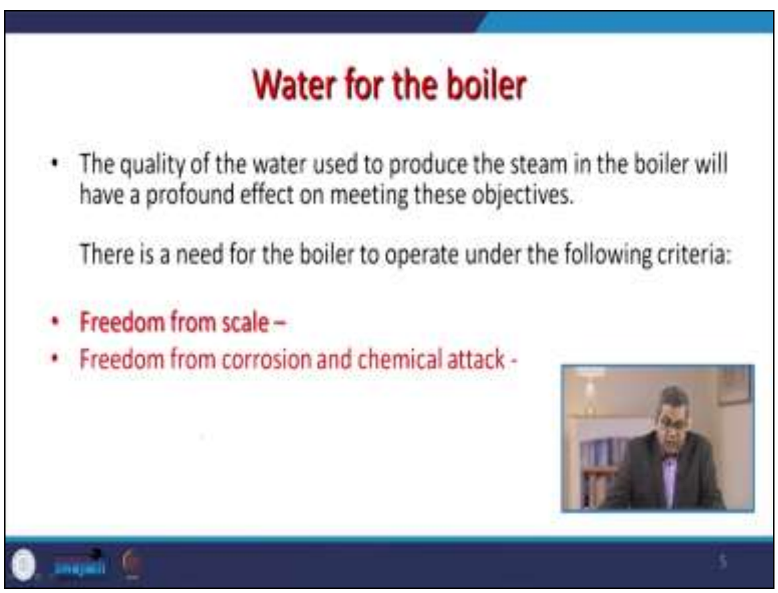

These criteria include that it must have freedom from scale and freedom from corrosion, and chemical attack. In the previous lectures, we discussed the concept of scale, how these scales are generated, how dangerous these scales are, and how they are nonefficient. Similarly, apart from this scale, the corrosion and chemical attack is also very important because some of the debris carried may carry the metal part.

And if you are using this steam directly for any chemical reaction, it may create a catalytic effect. So, all these things are extremely you can say, important.

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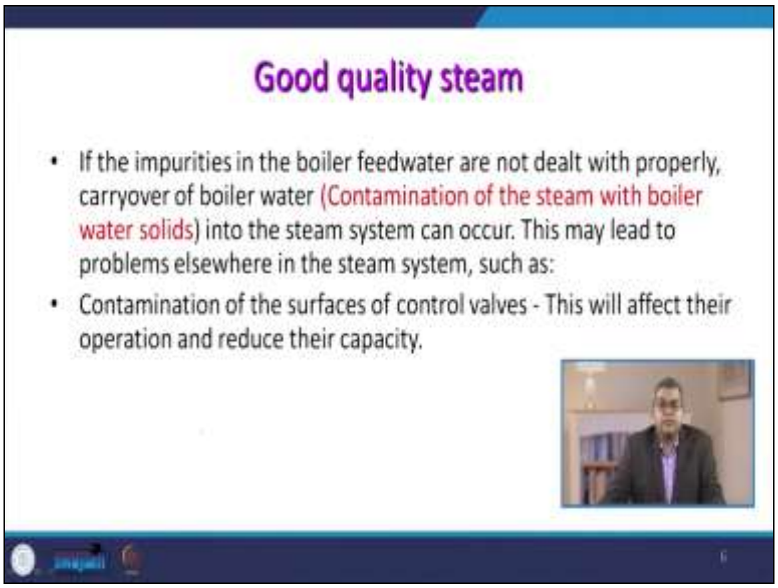

So, for good quality of steam, the impurities in the boiler feed water are not appropriately dealt then the carryover of a boiler means the contamination of the steam with boiler water solids into the steam system can occur. And this may lead to a problem elsewhere in the steam system. As I discussed, if you are directly introducing steam, this steam into any chemical reaction even the small metal particles may participate in the reaction.

So, the removal of all such kinds of things is quite essential. May contaminate the surface of the control valves maybe by the deposition or by the corrosion erosion etcetera. So, this will affect their operation and reduce their capacity. The contamination of the heat transfer surface of the process plant will increase the thermal resistance and reduce the effectiveness of heat transfer, which is essential for the maximization of the efficiency concept.

Sometimes it may restrict the steam trap orifice and again it may create a problem because if steam trap is not working properly then it will not sense the or it cannot distinguish between the steam and the water, and that will be extremely dangerous for the boiler operation or the steam is the distribution network.

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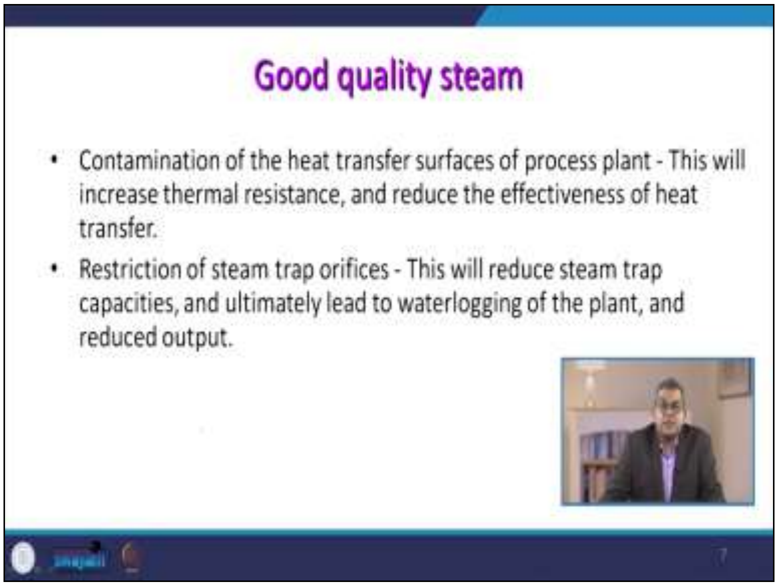

So, if there is a restriction in the steam trap orifice this will reduce the steam trap capacity and ultimately lead to the waterlogging of the plant and reduce the output.

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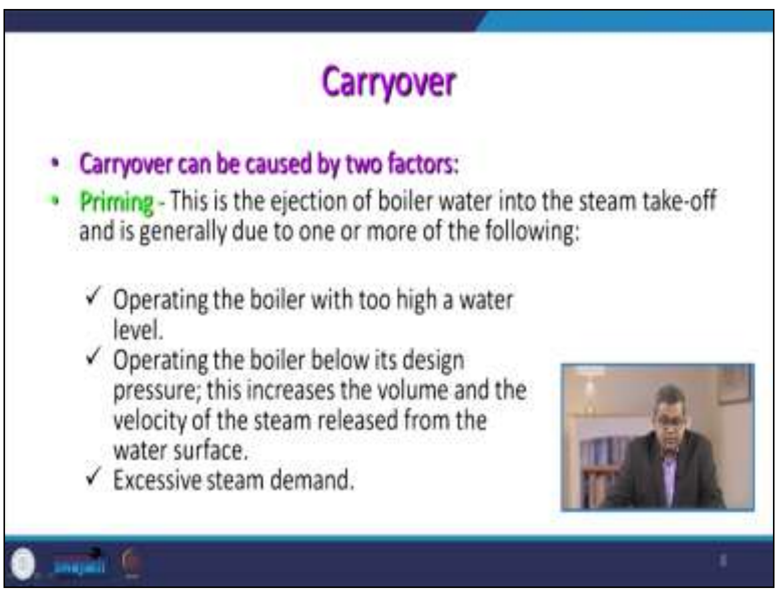

Let us talk about the carryover. Two factors can cause this carryover. One is the priming. This is the ejection of boiler water into the steam takeoff and is generally due to one may be one or more reasons attributed to this one operating the boiler with the too high water level. So, again it is very dangerous because you are imparting an excess amount of energy to produce the steam. Operating the boiler below the design pressure

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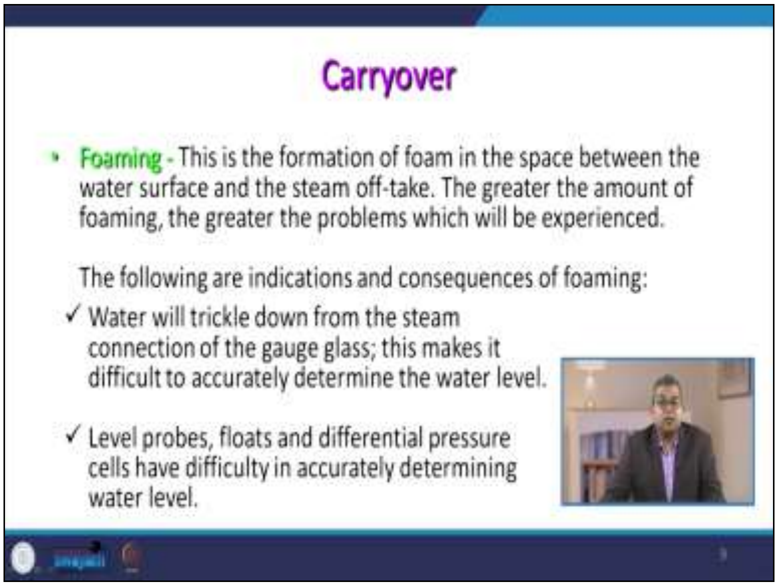

The second aspect is foaming. This is the formation of foam in the space between the water surface and the steam takeoff. The greater the amount of foaming, the greater the problems which can be experienced. There are certain indications and consequences of foaming. One is that water will trickle down from the gauge glass's steam connection, which makes it difficult to accurately determine the water level.

So, it is just like this that this is your gauge glass, and if the foam is deposited over here in that case, it will be quite difficult for a person who is visualizing the water level and or sensing the water level through the sensor. In that case, it will be quite difficult for them to sense the accurate water level. And in that case, the results may be extremely dangerous. Another thing is that the level probes float, and differential pressure cells have difficulty accurately determining the water level.

In case of any such problem, alarms may be sounded, and the burners may even lockout. This will require the manual resetting of the boiler control panel before the supply can be re-established. These problems may completely or partly due to the foaming in the boiler; however, foaming is endemic to the boiler water. Sometimes, if you are having excessive agitation within the system, it also increases the foaming because of the alteration in surface energy.

So, again it causes a problem. Another cause of foaming is the hardness; usually, hard water does not foam; however, boiler water is deliberately softened to prevent the scale formation, which gives it the propensity to foam. So, you have to be very careful, and if you are imparting any kind of a chemical dose or providing the dosing, you have to be very much aware of all the consequences.

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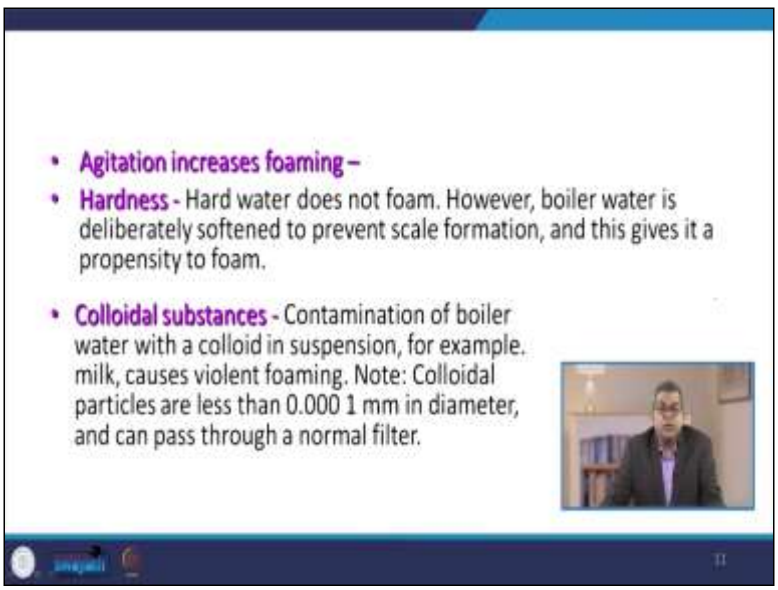

Sometimes colloidal substances are also very important. The contamination of boiler water with the collides in suspension. For example, milk causes violent foaming. Collider particles are those that are less than 0.0001 millimeters in diameter and can pass through a normal filter. So, all these need to be addressed. We have already discussed this TDS concept.

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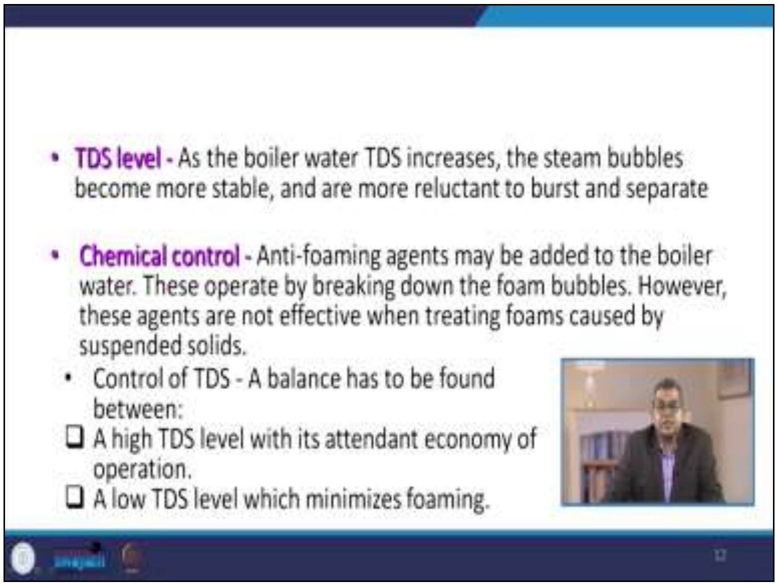

The TDS level as the boiler water TDS increases, the steam bubbles become more stable and more reluctant to burst and separate. There are certain chemical controls like adding certain anti-foaming agents or chemicals that may be added to the boiler water. This operates by breaking down the foam bubbles, which means are the surface active agents. However, these agents are not effective when treating form caused by the suspended solids.

So, to control the fatigues, a balance has to be found between the high TDS level with its attendant economy of operation and a low TDS level that minimizes foaming.

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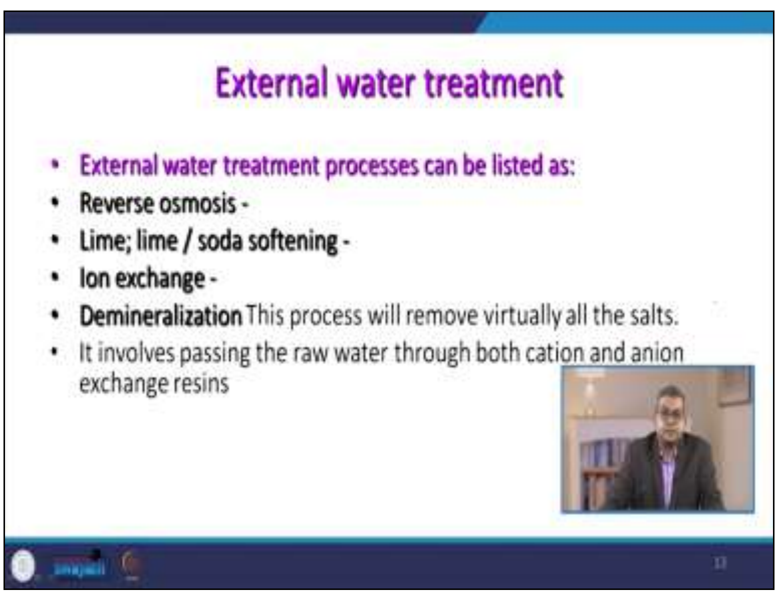

We need to have some external water treatment protocols because there are various sources of water may be the natural water may be surface water may be groundwater may be the, subsurface water, maybe you are taking water from the river or a canal or maybe municipal water. So, you cannot feed this water directly to the boiler because there are certain inherent impurities.

Inherent impurities may be attributed to the hardness, or the certain debris may be attributed to the certain dissolved solids et. So, you need to go for the water treatment process, which is termed the external water treatment. So, the external water treatment processes can be listed as reverse osmosis, lime soda softening, and ion exchangers demineralization. These processes or this process remove virtually all the salts.

And it involves passing the raw material through the cation and ion exchange raisins or other chemical dosings as the case may be or as the case may be required, and this all depends on the impurities inherent impurities in question. So, we are not going to discuss these water treatment protocols because we will address this thing in a separate section. Let us talk about the safety valves in detail.

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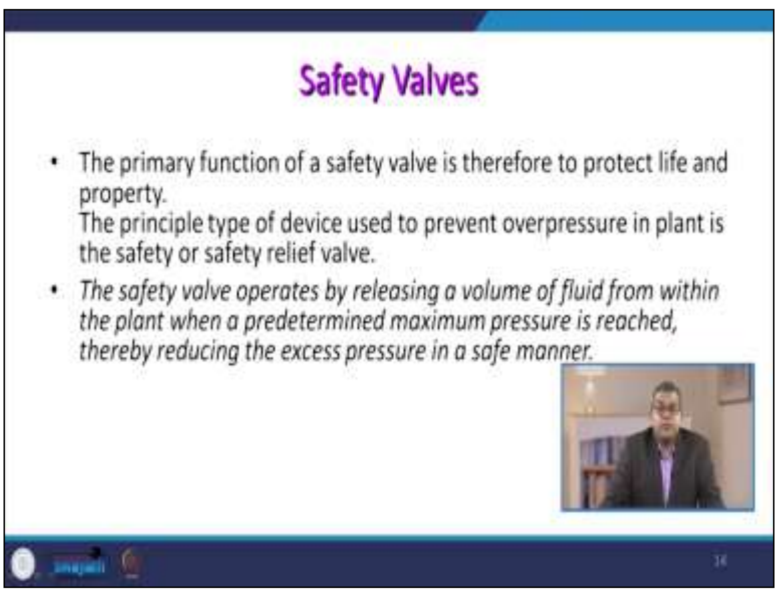

The primary function of a safety valve is to protect life and property. As discussed in the previous example, a domestic pressure cooker is equipped with two different types of safety devices. The principal type of device used to prevent overpressure in the plant is the safety or safety relief valve. The safety valve operates by releasing a volume of fluid from within the plant when a predetermined maximum pressure is reached, thereby reducing the excess pressure safely.

When we were discussing the boiler and the boiler rating, there are three different types of pressure working pressure, bursting pressure, and hydraulic pressure. So, if it crosses the working pressure limit, the safety device is always actuated, and the excess pressure can be released safely. Pressure excess can be generated in a number of different situations. This may be like an imbalance of a fluid flow rate caused by an inadvertently closed or opened isolation valve on a process vessel.

Failure of cooling system; which allows vapour or fluid to expand compressed air or electrical power failure to control the instrumentation.

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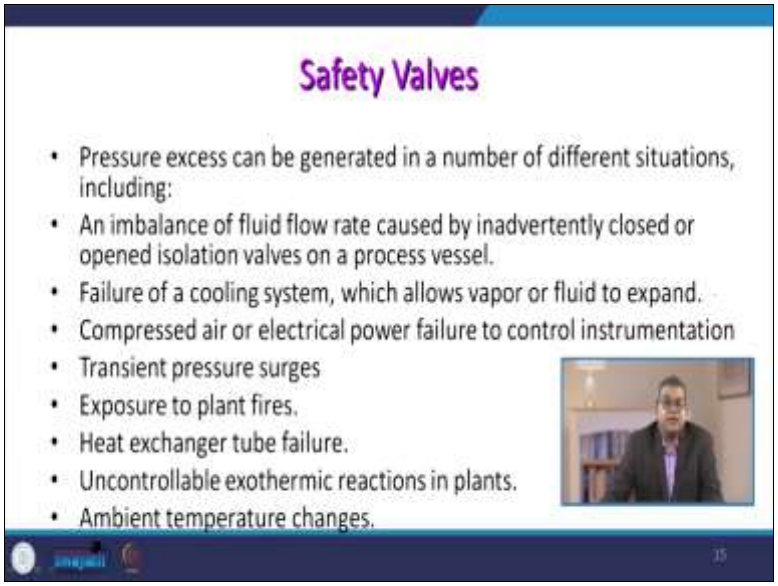

There may be certain transient pressure surges there may be certain exposure to the plant fire heat exchanger tube failure, uncontrollable exothermic reaction or thermal runaway reaction in the plant, and ambient temperature changes.

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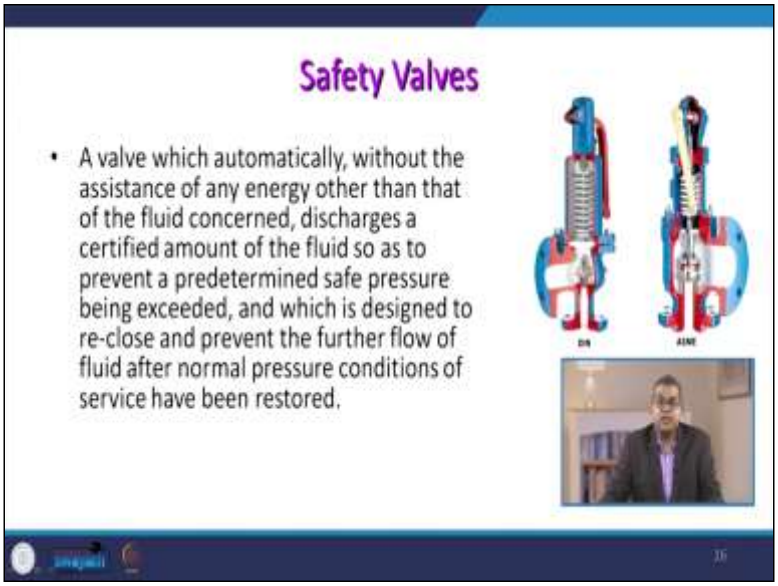

Usually when we; talk about safety devices, a valve automatically, without the assistance of any energy other than that, the fluid in question discharges a certified amount of fluid. So, as to prevent a predetermined safe pressure from being exceeded and which is designed to reclose and prevent the further flow of fluid after normal pressure conditions of the service have been restored. These are the two essentials of safety valves.

So, the safety valve is actuated when the pressure is beyond the working pressure. So this can be achieved by a variety of methods, but if the original, desirable pressure is restored, then automatically safety valve should be closed. So, the precious fluid or pressure as steam cannot go beyond the periphery of the boiler or the process in question.

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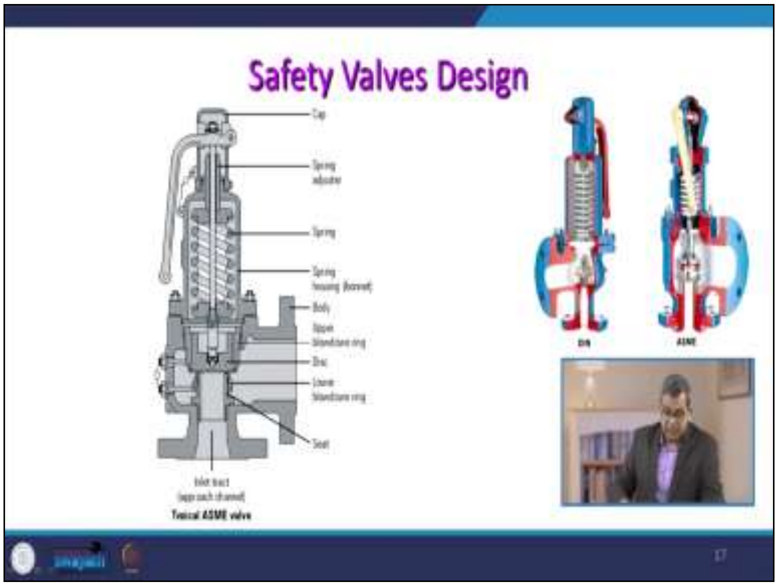

This is the anatomy of the safety valve. You see that this is the cap and this is the spring adjuster to meet any kind of a fluctuation within the system. This is the spring, and based on the spring constant this usually works; and this is spring housed in a system that is called the bonnet, through which a protective shell can be designed. This is the main body, and this here you see this is the blowdown ring and this is the main thing that is the disc, and this is the seat.

So, usually, the disc is seated over the seat. So, when the pressure is mounted, or pressure is above, this is based on the spring constant. The spring is usually compressed, and the excessive steam can go out. And when the desired pressure is achieved, this disc can be reseated to the seat and the flow of the fluid can be seized off. Here you see two different types of safety valves here you see that this is the spring, and here this is the seat and a disc, and you can adjust the things with the spring adjuster.

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Let us talk about some basic operations of a safety valve, and the foremost operation is called lifting. When the inlet static pressure rises above the safety's set pressure, the disc will begin to lift off the seat. as soon as the spring starts to compress as you we discussed in this particular figure the spring force will increase, and this means that pressure would have to continue to rise before any further lift can occur and for there to be any significant flow through the valve.

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The additional pressure riser here you see that is a more closer look this is the disc, and this is the seat. the additional pressure rise required before the safety valve will discharge at the rate its rated capacity is called overpressure.

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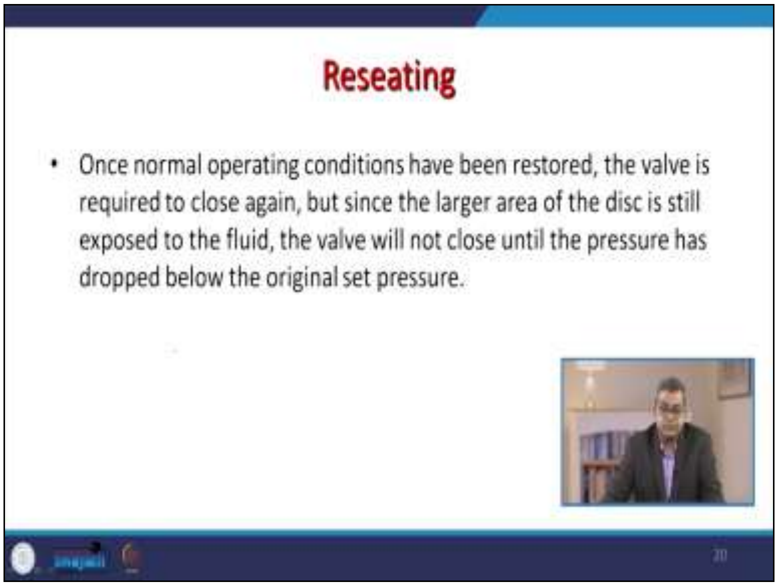

Next is the reseating because once you restore the normal operation condition, the valve is required to be close again. Since the large area of the disc is still exposed to the fluid, the valve will not close until the pressure has dropped below the original set pressure. So, you have to look at this particular equilibrium between the disk and the boiler pressure.

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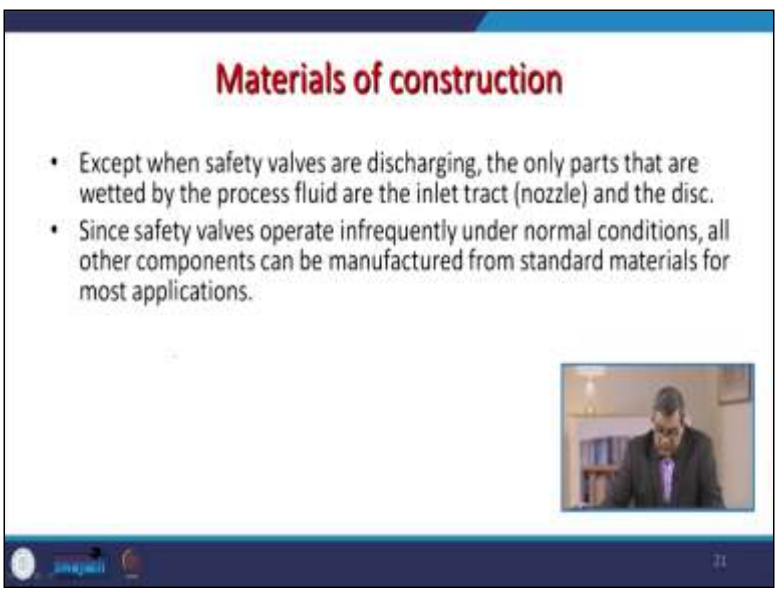

Sometimes people ask about the material of construction of these safety valves except when the safety valve is discharging. The only part that is wetted by the process fluid is the inlet tract or nozzle and the disc. And usually, the disc and seats are directly in touch with the working fluid.

Since these safety valves infrequently operate under normal conditions, all other components can be manufactured from standard materials for most applications.

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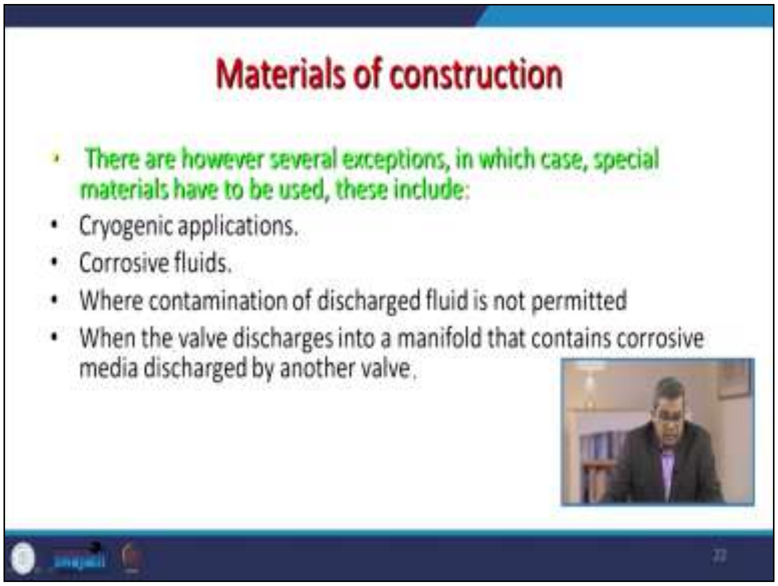

However, you can say the several exceptions in which spatial material has to be used, and this sometimes includes if you may require the cryogenic application, in that case, the expansion, and other things you need to look into. Then sometimes, you are handling corrosive fluids. So, you cannot make your disc or safety valve those that are very much reactive with those fluids.

Another aspect is that where the contamination of discharge fluid is not permitted, you have to keep some additional attachment to the safety devices. When the valve is discharged into the manifold that contains corrosive media discharged by another valve.

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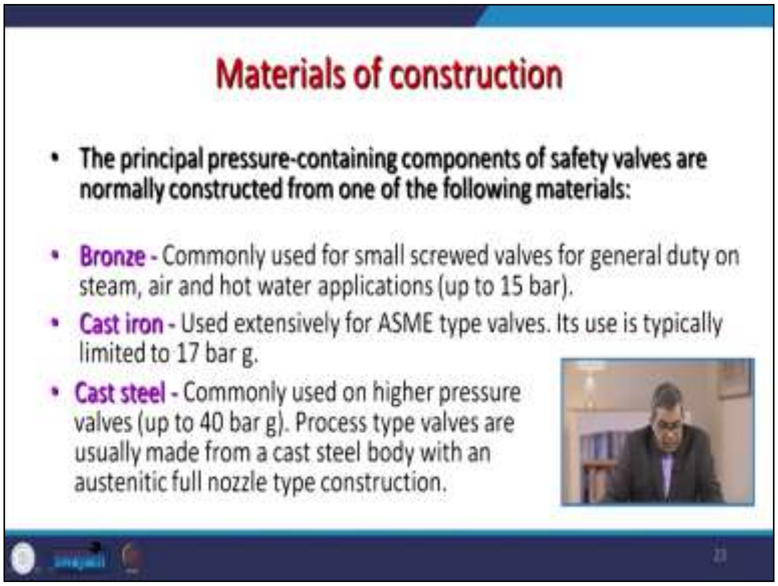

The principal pressure-containing components of safety valves are normally constructed from different metal materials like bronze is commonly used for a small screwed valve for general duty in steam air and hot water application that may be used up to 15 bar. Cast iron is usually used extensively for ASME (American Society For Mechanical Engineering) type of valve have designed their own codes.

And this the use is typically limited to 17 bar gram then the cast iron and or cast steel commonly used on high pressure valves up to 40 bar process type valves are usually made from a cast steel body with an austenitic full nozzle type construction.

Then the question arises: What should be the guiding parameter to have an appropriate safety valve selection. Several factors usually tutor the selection of a specific type of safety valve. One is the cost, and obviously, it is one of the key factor for consideration. So, when selecting a safety valve for noncritical operation, you can say most of the most obvious considerations.

When making a cost comparison, it is imperative to consider the valve's capacity and the nominal size.

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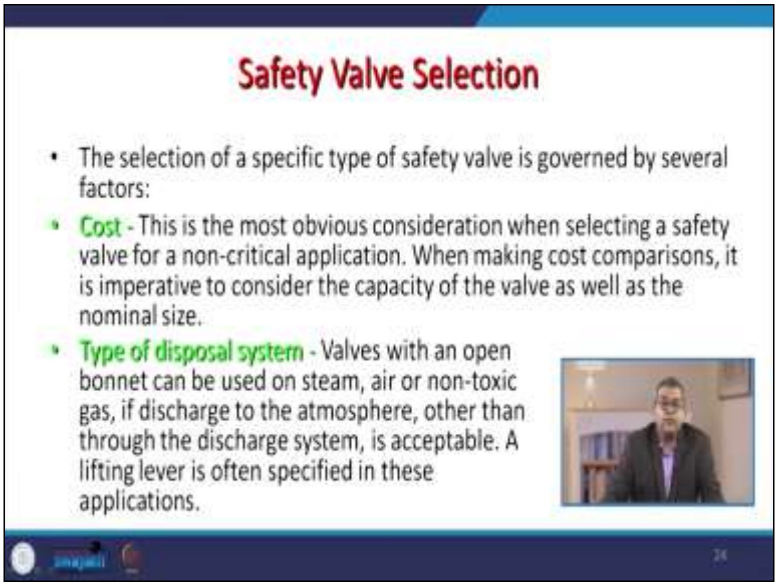

Another thing is that the type of disposal system valve with an open bonnet can be used on steam air or nontoxic gas but is acceptable if discharged to the atmosphere other than through the discharge system. A lifting lever is often specified in these applications, as you see in the figure.

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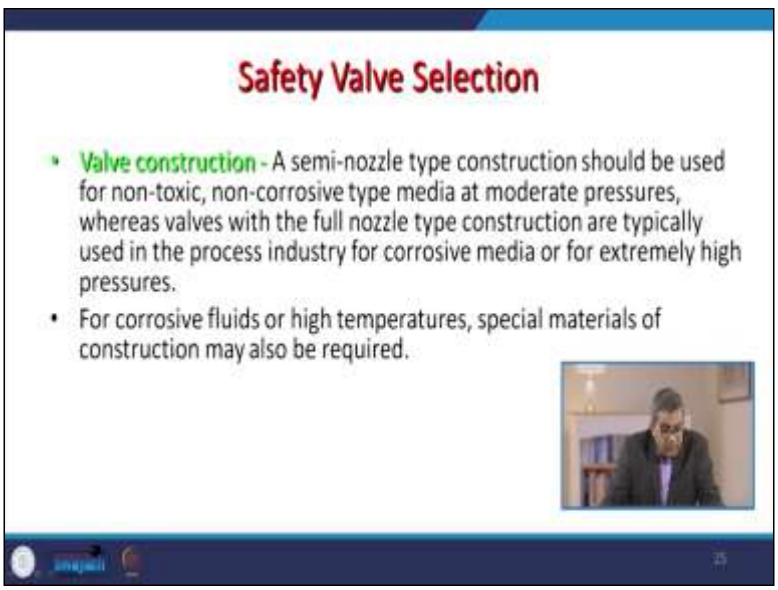

Then the valve construction is a semi-nozzle type construction. This should be used for nontoxic, non-corrosive type media at moderate pressures. At the same time, evolved with the full nozzle type construction is typically used in the process industry for corrosive media or for extremely high pressure. So, if we are using corrosive fluid or high-temperature special construction material, this may also be required.

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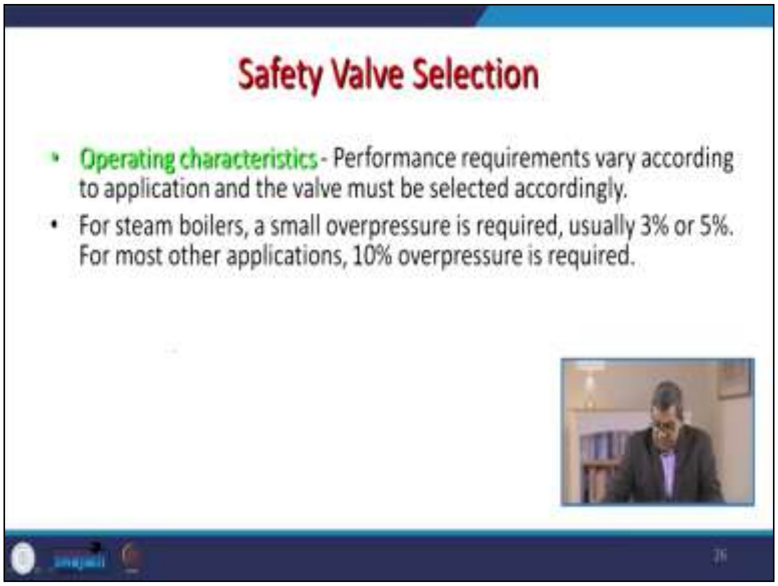

Another foremost criterion for the safety valve selection is the operating characteristics. Performance requirements may vary according to application, and the valve must be selected accordingly. For steam boilers, a small overpressure is usually required, say 3 to 5% for most of the replication 10% overpressure. A very important part of safety valve selection is the approval.

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So, for many valve applications, the end-user will state the required code or standard for the construction and performance of the valve. In boilers, we have different types of codes and standards-based from country to country, region to region. Similarly, we have similar codes and standards for the safety valve. This is usually accompanied by the requirement for approval by an independent authority to guarantee conformance with the required standard.

Apart from this, there are certain other alternative plant protection devices. If we compare the things with our domestic pressure cooker, where we have two different safety devices, one is the safety valve, another one is the safety vent, which is sometimes referred to as a whistle. Similarly, in all the boiler houses or steam power generation plants, other alternative plant protection devices are equipped with such types of different things.

So, the thing is that the safety valves are by far the most common devices used for plant protection in a steam system. There are several other devices available to protect the plant from overpressure conditions. Some of them you can use in place of a safety valve. Most of them have their own unique applications, and indeed some devices such as bursting disks. This may be used to complement the safety valve.

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Another thing is that weighted pallets, and previously various boilers are using the counterweight safety valves. The spring loaded safety valves largely supersede these. here, the concept is common you have weights, and this is the steam generation unit or boiler. If and this particular seating or reseating arrangement is usually complemented or supplemented by these counterweights.

So, in case there is any excess pressure, this lever may go downward, and by this way, the seat or disc can be open, and excess steam can be discharged to the atmosphere.

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We were talking about the bursting or a ruptured disc. This consists of an elastomeric membrane or thin metal disc that will burst at a set pressure-relieving any overpressure. Sometimes it also gives an edge towards the high-temperature system. If the melting point of these elastomeric membranes or disc operating temperature is more than the melting point of these elastomeric membranes may meltdown to release the excessive pressure as well as the temperature.

They can be used by themselves on many applications are used in conjunction with the safety valve. It is just like the domestic pressure cooker. A rupture disc can be installed either on the safety valve's inlet or outlet side.

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Here you see the fusible plug device or a safety device like your domestic pressure cooker. Here you see these consist of a plug with a lower melting point than the maximum operating temperature of the system that is protected. So, basically, it is meant as a temperature protection device. This is a simple example you can screw it. This is the plug body, and this is the fusible alloy sometimes elastomers are also being used.

So, if you may experience if you are experiencing excessive temperature, then this fusible alloy or elastomer may meltdown and excessive pressure can be released like this.

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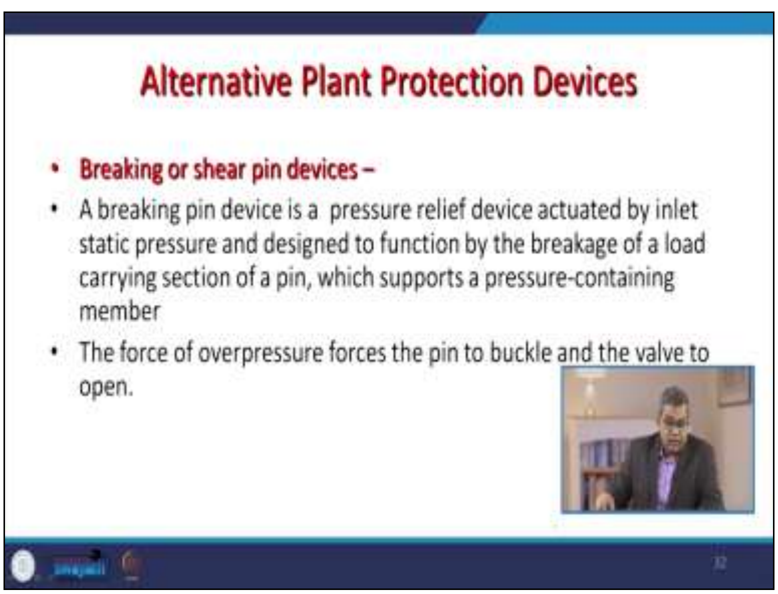

Sometimes the breaking or shear pin devices are also being used. Usually a breaking pin device is a pressure relief device actuated by inlet static pressure and designed to function by the breakage of a load carrying section of a pin that supports a pressure-containing member. The force of overpressure forces the pin to buckle out and the valve to open. The valve can then be reseated after pressure is removed and a new pin need to be installed over there.

These devices are usually installed on a low-pressure application and large gas distribution system, and that is why every time you need to install a new pin, it has limited applications. In last, we are talking about condensate recovery.

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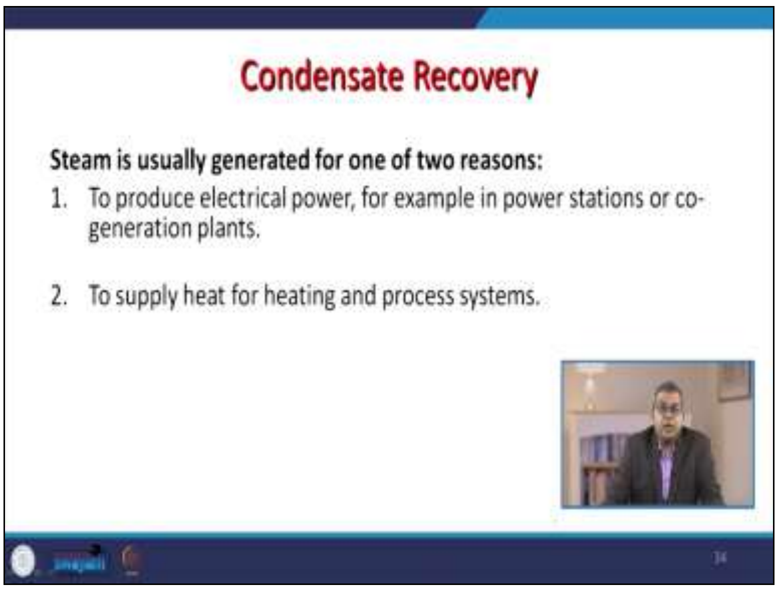

Usually, when we talk about condensate recovery or a condensate, just go to the basic concept that steam is usually generated for one or two reasons. One is to produce electrical power, for example, in a power generation plant or cogeneration plant, and supply heat to the heating and process system. We discussed a couple of things these things in previous lectures. The thing is how this condensate is recovered or how this condensate is formed.

So, usually, when you are extracting the mechanical energy or extracting the heat energy, the steam loss is latent heat and it converts into water. Since it has two valuable things in it, one is the heat because obviously, when you are condensing the steam, it will have the same temperature the condensate will have the same temperature as steam, and the second thing is the water value.

Because we discussed that whenever you are using the water in the boiler, you obviously need to perform some water treatment or water conditioning, it always causes the value. So, you cannot discharge that particular condensate as such to the atmosphere. So, every steam distribution network is usually equipped with condensate recovery lines. Based on this, how we can quantify this condensate recovery.

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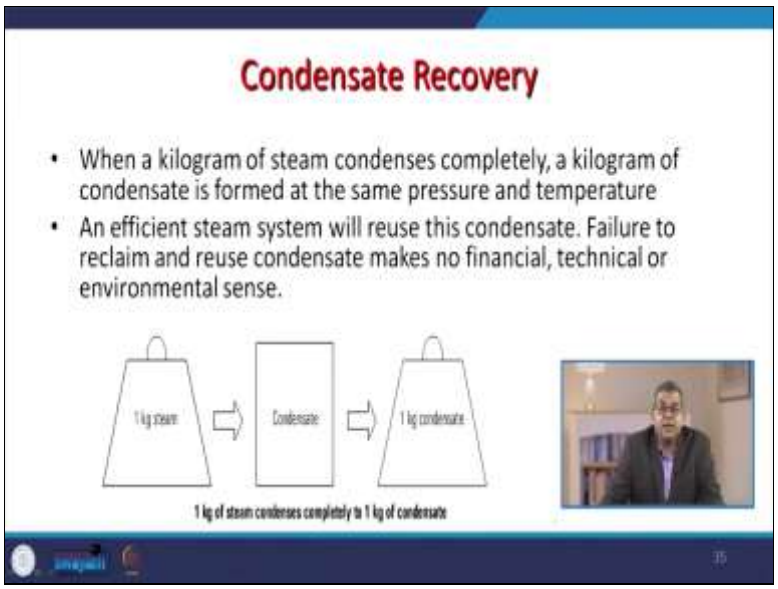

So, when a kilogram of the steam condenses completely, a kilogram of condensate is formed at the same temperature and pressure. Usually, an efficient steam system will reuse all these condensates. Failure to reclaim and reuse condensates makes no financial, technical, or environmental sense. You see one kilogram of steam condensate, and you must have one kilogram of condensate.

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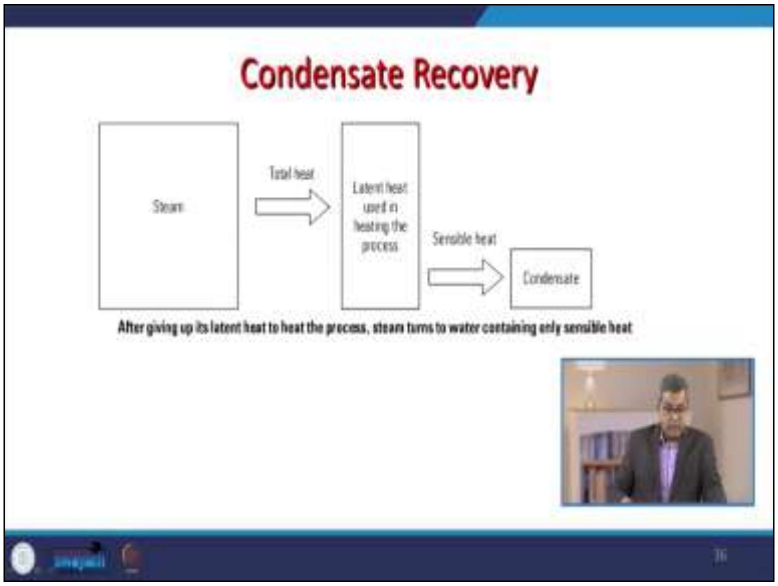

So, if you are giving up I mean after giving up its latent heat to the process, the steam turns into water and contains only sensible heat. This is the usual thermodynamic phenomenon.

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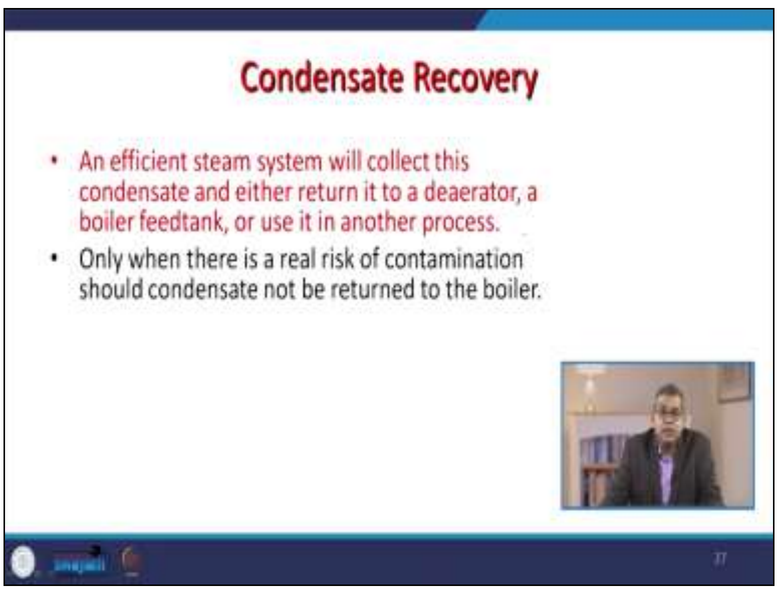

An efficient steam system will collect this condensate and either return it to a deaerator. Obviously, we discussed the concept of data to remove any entrapped air because air does not carry any heat value, and a boiler feed tank or used in another process. A feed tank means you can use this condensate at higher temperatures to maintain the water level and pre-heat the system.

Only when there is a real risk of contamination should condensate not to be returned to the boiler maybe some contamination through the corrosive chemicals or maybe some other contaminants in that case it needs to be sent for the efficient treatment plant.

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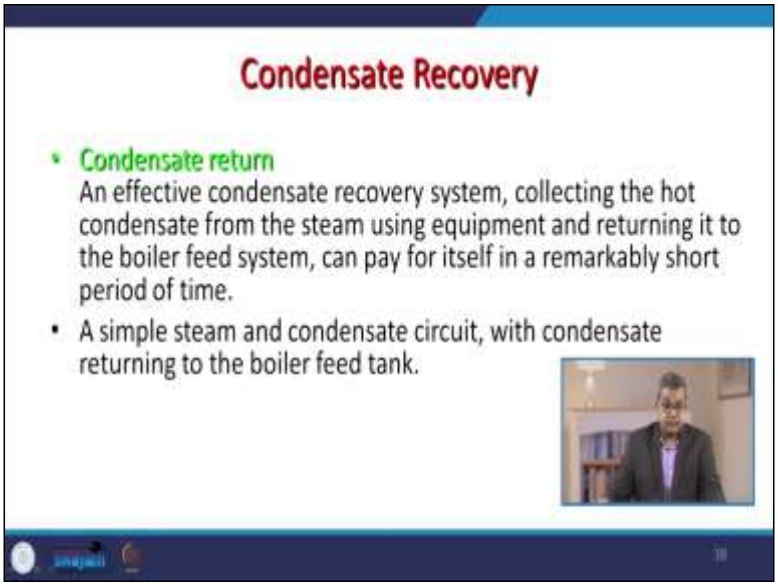

When we talk about the condensate return and an effective condensate recovery system usually collects the hot condensate from the steam using the equipment and returns it to the boiler feed system and can pay itself for a remarkably short period of time because the heat value as well as the water value always very you can say the attractive things in the condensate recovery. A simple steam and condensate circuit must be properly designed with the condensate returning to the boiler tank.

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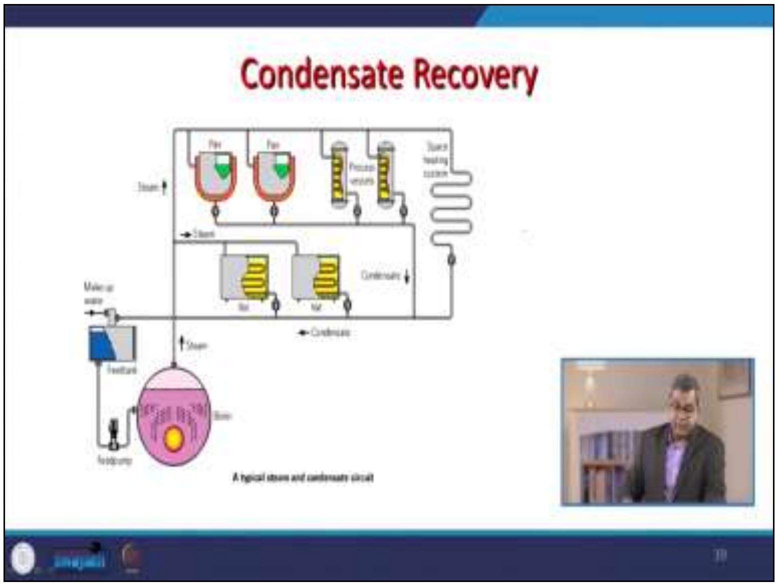

And you can see here it is a very simple diagram for steam and condensate recovery you see here, we are producing the steam, and this steam is being utilized in the various open pan or fan vessels for heating purposes and the processes team. Here you see that these are the condensate recovery lines, and these condensate recovery lines are connected to different types of a system and are usually returned to the feed tank. So, it is a simplified way for representing the condensate recovery line by this way.

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Question arises why return condensate and reuse it? I told you that this might be because of the financial reason because every drop usually costs because you are demineralizing deionizing the things. Then water charges because sometimes you are taking water either from the municipal corporation or a ground water or from river or canal or there are a number of sources of water where from where you can get it.

But ultimately, the pumping cost and other cost are also quite high. So, water charges are again there. So, you need to have a proper water balance to minimize these losses. Another aspect is the effluent restriction that is attributed to the temperature restriction, effluent because you see that we discussed that when condensate foam. So, usually, it is this at the same temperature which the steam has. So, it cannot discharge this effluent water to the atmosphere because of the high temperature.

Then obviously, when it carries the good quality of water applied to the boiler it carries the good quantum of heat because of the steam system. You can maximize the boiler output as well as the boiler feed water quality when you return these condensates to the system. So, by this way we are summing up this particular lecture, and here, we discussed the various aspects of a condensate. We discussed the safety valve anatomy of the safety valve.

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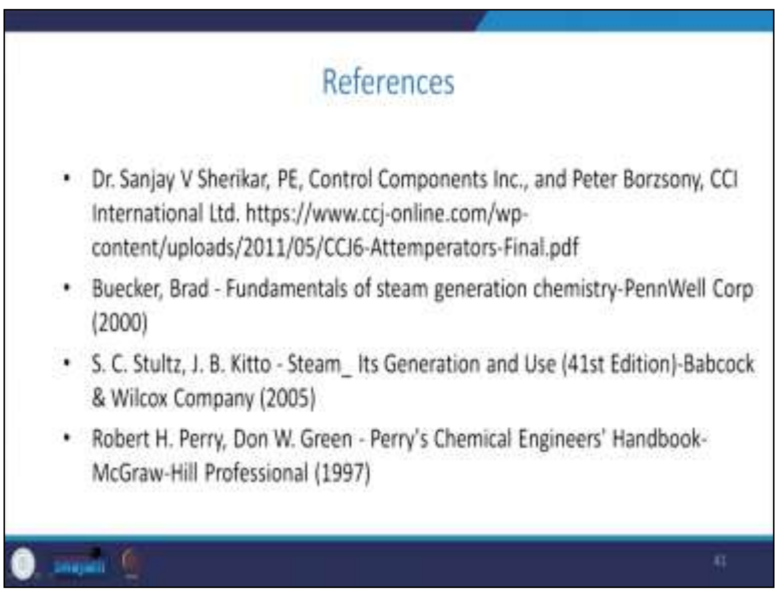

And if you wish to have further studies we have enlisted three four different references for your convenience you can go through all these references, thank you very much.