Chemical Process Utilities
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Lecture - 28
Economizer, Super heaters, and Safety devices

Welcome to the next part of esteem and accessories. Before we go into the other aspect of accessories, if you recall, we have discussed the various other aspects of the boiler house, including the boiler, some of the parts of the steam distribution network, steam traps etc. In this particular chapter, we will be going to discuss the concept of an economizer in detail concept of a superheater in detail.

We will also discuss the various safety devices attached to the boiler house as you know that boiler is a pressure vessel. So, it requires so many safety devices for smooth functioning and to prevent pressure-based hazards. So, first, we will discuss the economizer.

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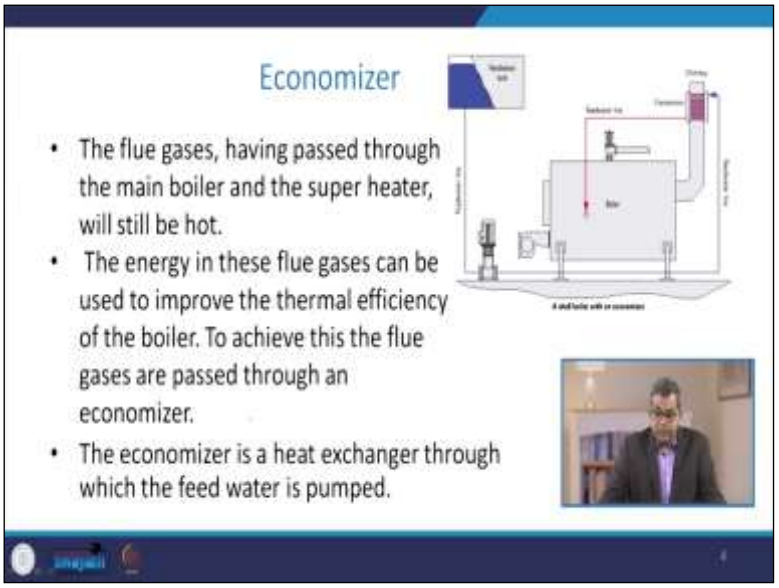

Although briefly, we; had discussed this concept in different segments, including the boiler and steam distribution network. The concept of an economizer is to maximize the energy efficiency and to extract the excess amount of heat being liberated or attached to the flue gases. The flue gases pass through the main boiler, and superheated have a significant amount of heat.

If we discharge all this heat into the atmosphere, there would be a significant loss with respect to energy. So, the energy in these flue gases can be used to improvise the boiler's thermal efficiency. It may be utilized to preheat the different segments. To achieve this, the flue gases are usually passed through the economizer. An economizer is nothing special only thing is a heat exchanger through which the feedwater is pumped. Here you see that this is the boiler house.

You see that this is the feed water tank, and this feed water line comes from this way to the pump and the boiler. Here you see that this is the chimney through which we are passing through the flue gases, and this is the economizer through which we are preheating the feed water so that the thermal shock to the boiler can be avoided.

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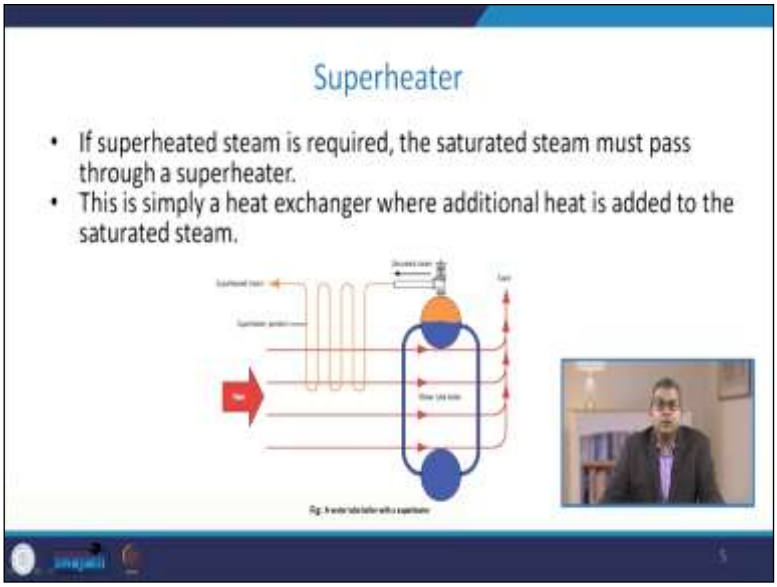

Let us take the superheater. We have already discussed these superheater segments in past lectures. So, if you require the superheated steam, you must have saturated steam with us, and this must pass through a superheater. Here you see that this superheater is situated it is none it is not any special device only thing is a simple heat exchanger where eddy you may add the additional heat to the saturated steam to get the superheated steam. So, this saturated steam is passed to the heat source to get this superheated steam.

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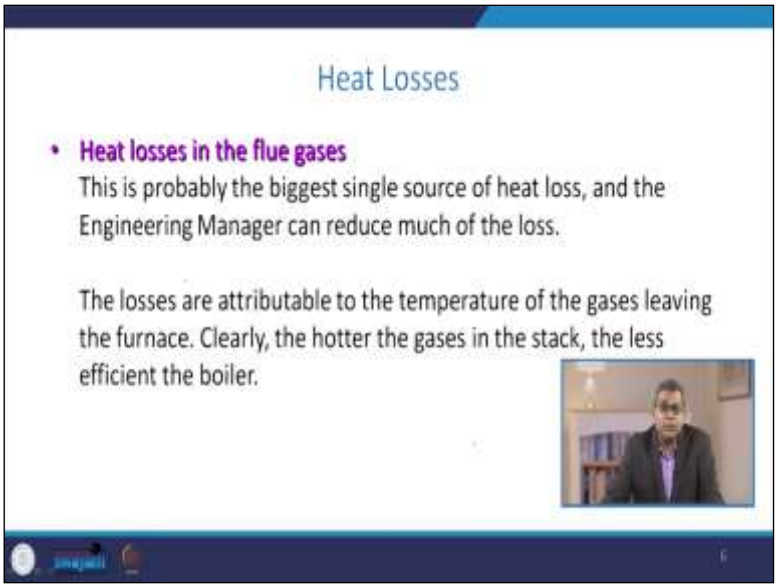

Let us have a look at the heat losses. There are various heat losses attributed to the flue gas, and you can say the flue gases are the biggest single source of heat loss, and the engineering manager, chemical engineers,, or any other engineers can reduce much of these heat losses by simply adopting the various design phenomena. These losses are attributed to the temperature of the gases leaving the furnace.

Clearly, the hotter the gas in the state, the less efficient the boiler, but you have to maintain a certain temperature of this hot gas to maintain the draught of those flue gases. There may be a couple of things that these gases may be too hot for one or two reasons, and the question in the engineering question is why these gases are too hot. So, that means the burner is producing more heat than is required for a specific load of the boiler, which means you are pumping more and more fuel and performing more combustion action in the burner.

The burners and the damper mechanism require maintenance and recalibration based on the engineering calculation.

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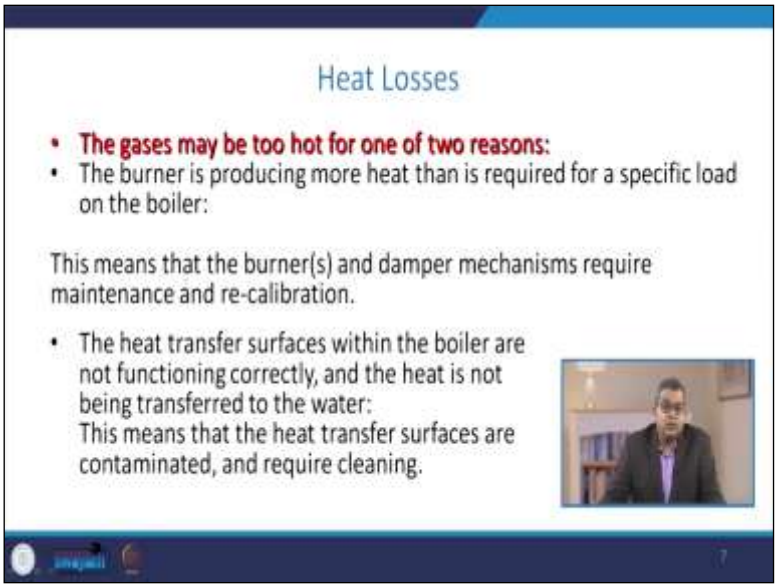

Another thing is that the heat transfer surfaces within the boiler are not functioning correctly, and the heat is not being transferred to the water. So, this means that the heat transfer surfaces are contaminated and require cleaning again; some care is needed. Too much cooling to the flue gas may result in the temperature falling below the dew points. We have already gone through this dew point concept, and the potential for corrosion is also increased. So, you have to be maintained, and it is the responsibility of the engineers to maintain the flue gas temperature at an appropriate level.

So, that either corrosion or excessive heat loss can be avoided. Apart from this, since we are maintaining a very high temperature to the boiler, there may be a significant chance of radiation heat losses. And this is I mean you can say it is very rare to avoid these losses. The next aspect is a burner and controls you know that in the boiler, we are using different types of burners, sometimes single burners sometimes multiple burners, to produce the combustible mixture and produce the desired temperature.

If we say what a burner is in a very synchronized manner. So, burners are devices responsible for the proper mixing of fuel and air in the correct proportion for efficient and complete combustion. So, it is one of the deliverables that any burner must have that is must go for proper mixing of the combustible mixture and perform the combustion reaction, and moreover the determining the

shape and the direction of the flame. So, sometimes you need to direct. So, the only targeted element should be heated so let us take a couple of examples of the burners.

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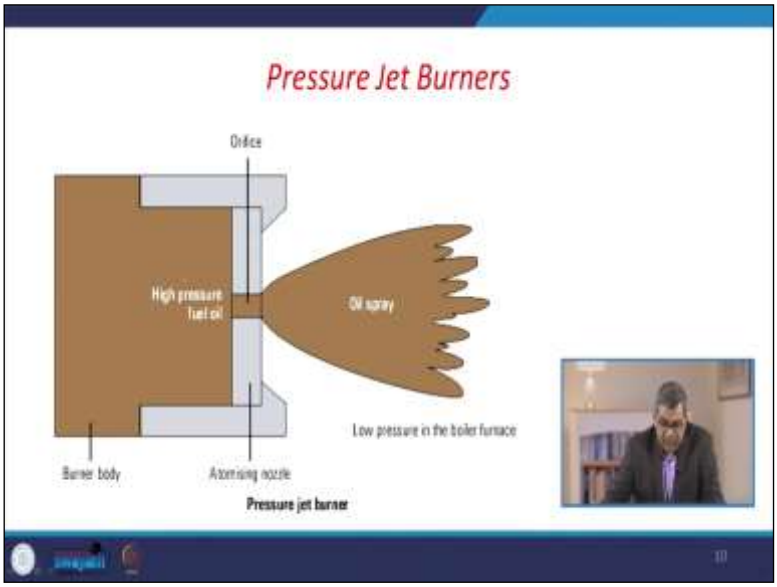

One example is the pressure jet burner. Here you see this is the burner body here. We have a high-pressure fuel oil may be from some external source the pressure is imparted, and through this orifice, the oil is being sprayed to the boiler furnace where this atomizing nozzle is supplying the desired quantity of air or excess air to make this particular mixture a combustible mixture for the firing within the boiler.

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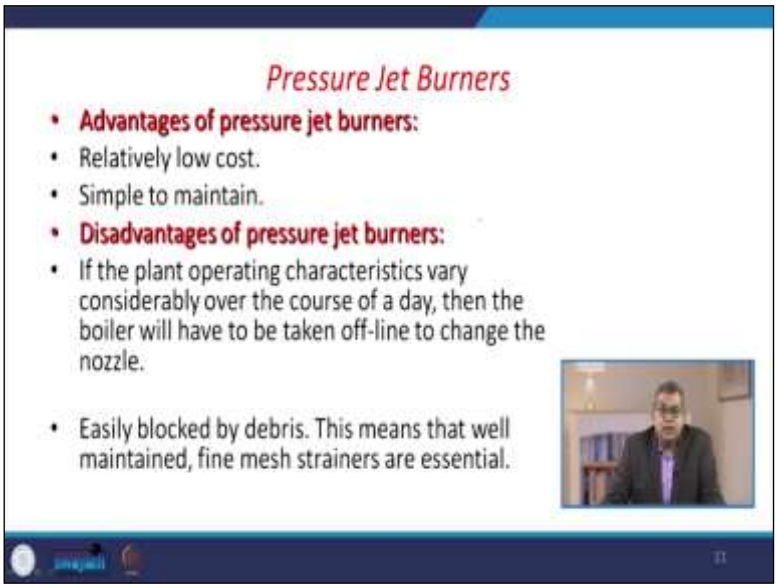

There are various advantages attached to the pressure jet burners: having a very low cost relatively low cost compared to the other burners andare very simple to maintain as evident in this figure. But simultaneously have certain disadvantages. One is that if plant operating characteristics vary considerably over the course of a day, then the boiler will have to be taken offline to change the nozzle.

Because here you have a roof is supported by the nozzle. So, you have to change to meet the load changeover since it is a very orifice-driven function. So, it can be easily blocked by debris or carbon, and this means that well maintained and fine meshing stainers are essential for this boiler's proper functioning.

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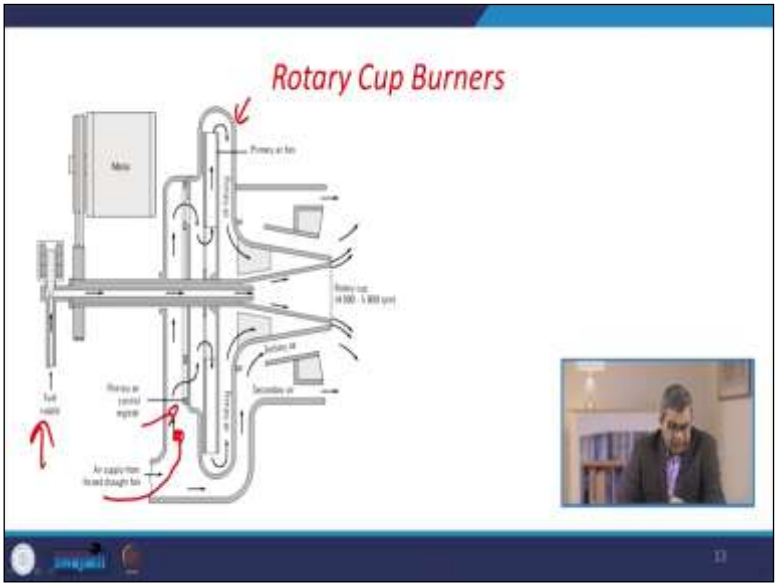

Another type of burner is the rotary cup burner. Here you see that this is the rotating disc, and you are supplying the fuel, and here there are three different sources of air based on the requirement here, you have the primary air here you are supplying the air from the force dot fan. The primary air is again bifurcated over here to provide the secondary and tertiary air. And this is the rotary cup that rotates may be in between 4000 to 5800 rpm and maximize the heat efficiency of the burner so that the energy and the combustible mixture are imparted to the main furnace zone.

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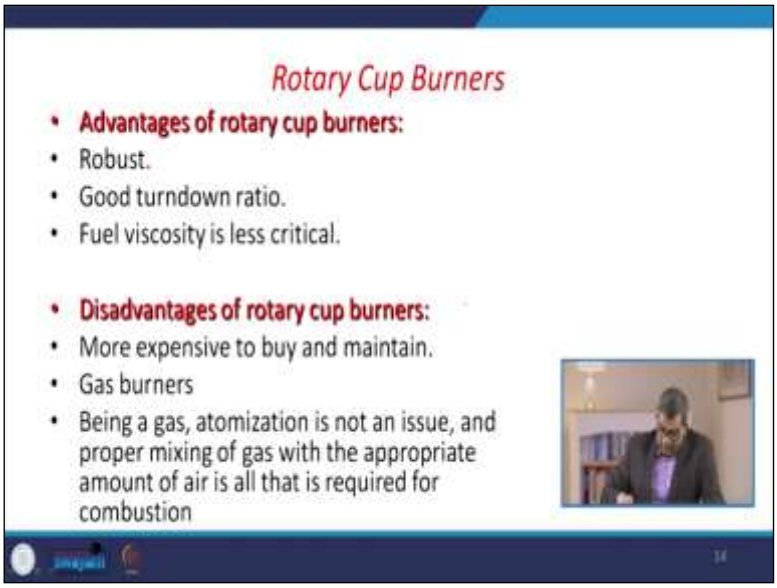

Again, the advantage of these rotary cup burners is that they are robust in design, have a good turndown ratio, and the fuel viscosity is less critical. Due to the atmospheric condition, supply, and quality of the fuel the viscosity of the fuel is again sometimes very high or sometimes very low. So, that is not the question with respect to the rotary cup burner.

There are certain disadvantages of rotary crop burners are more expensive to buy and maintain; basically, you can say the gas burners. Being gas atomization is not an issue, and the proper mixing of gas with the appropriate amount of air is required for the combustion. So, sometimes you may need to replace all these oil-fired burners with the gas-fired burner to minimize certain disadvantages of these rotary cup burners.

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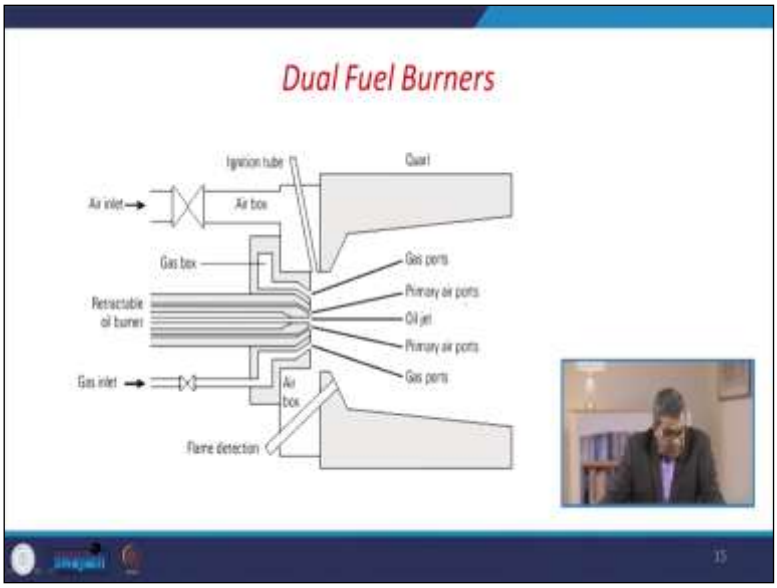

Another is the dual-fuel burner sometimes, maybe because of the various reasons you may go for oil and the gas type of fuel source. These dual fuel burners offer a very good candidacy for this particular approach. Here you see that you have oil, and you have gas. So, those two fuel sources are altogether different with the supply of a calculated amount of air inlet.

Here you see that this is the most critical zone where the gas ports, oil jets, and primary airports are mixed together to form a combustible mixture to supply in the furnace zone of the boiler.

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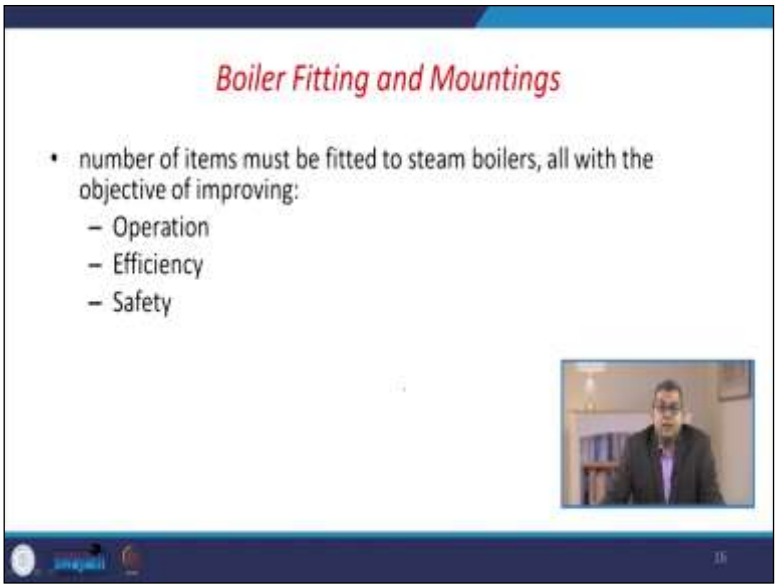

Let us talk about certain boiler fittings and mountings that are also integral to the boiler. The reason is that without those fittings and mountings, you cannot assure the smooth functioning of the boiler. So, you may have a number of items that must be fitted to the steam boilers with an objective of improvisation in operation, maximization of efficiency, and, above all, safety aspects.

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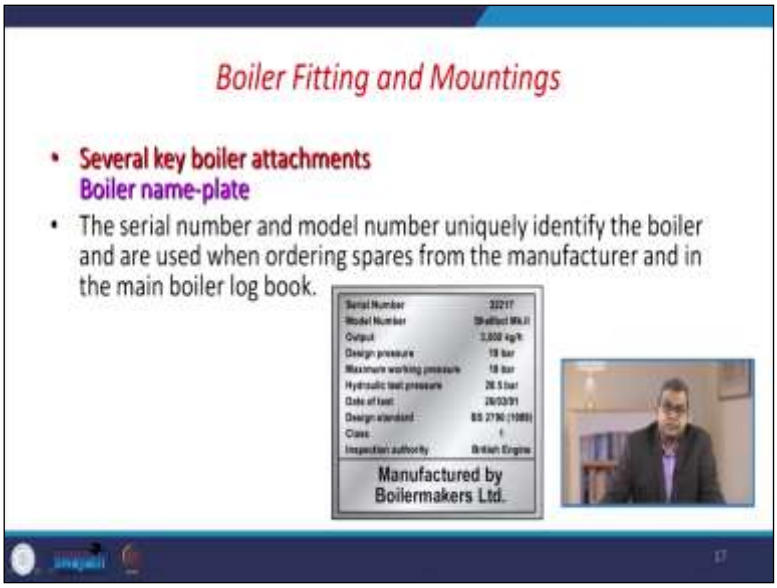

So, one of the key factors in the boiler fitting and mounting is the boiling implant. See, this is not only the nameplate, but it also provides you variable information that up to what pressure you can handle this boiler, who is the manufacturer, and who is the certifying authority. So, if you are moving that particular boiler from one country to another country, you need to take some additional certification under the aegis of the targeted countries' regulations, etc.

So, all these kinds of information are enlisted in the boiler nameplate. So, apart from this, the serial number is then the model number because usually, the companies or manufacturers do vary their models in due course of time, and some of the old models may get phased out. These two pieces of information are quite essential when you are looking for some spare parts for those boilers, and spare parts are already very sensitive because you cannot run the boiler efficiently without the essential parts.

Apart from this, you are having the output that what is the maximum designed output design pressure maximum working pressure and hydraulic test pressure or all these things are essential

for the safety aspect because if you go beyond this hydraulic test pressure or if you have achieved these maximum working pressure that gives a ceiling beyond which you cannot go otherwise there may be certain safety issues pertaining to it.

Then regular testing of this boiler for assessment of this pressure vessel code is essential. So, you need to put that on which date perform the test of that particular boiler. Then again, one more important thing is that what is the design standards in which under which design code these boilers are designed. Above all, these things should be addressed with the help of boiler manufacturers name etc. So, you can say the nameplate is a key part of the boiler.

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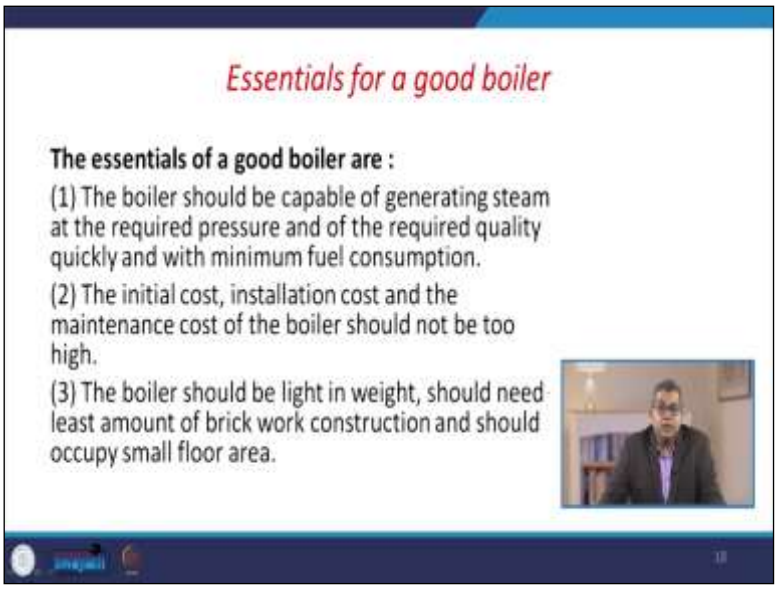

Sometimes people ask what the various essential aspects of a good boiler are. So, essential of good boilers like the boiler should be capable of generating steam at the required pressure and of the required quality quickly with the minimum fuel consumption. This is the foremost requirement. The boiler's initial installation and other maintenance costs should not be too high; otherwise, your economics will be at stake.

The boiler should be light in weight, need at least amount of brickwork construction, and occupy a very small floor area, which is a very important thing for the boiler. It should maintain the fluctuating demand of a steam supply without being overheated, and that is because precisely the

steam steady demand of his team nobody can predict and therefore, it must cater to the need of this fluctuating demand.

The different parts of the boiler should be easily approachable for the repairs because sometimes the scale formation sometimes the other safety issues demand the replacement of the part, maintenance of the part etc. all these things are essential. So, it should be easily approachable. Since boilers again boiler is the heart of any industry. The boiler should have only minimum joints, and those two should be away from direct flames otherwise, expansion may create a severe problem with respect to safety.

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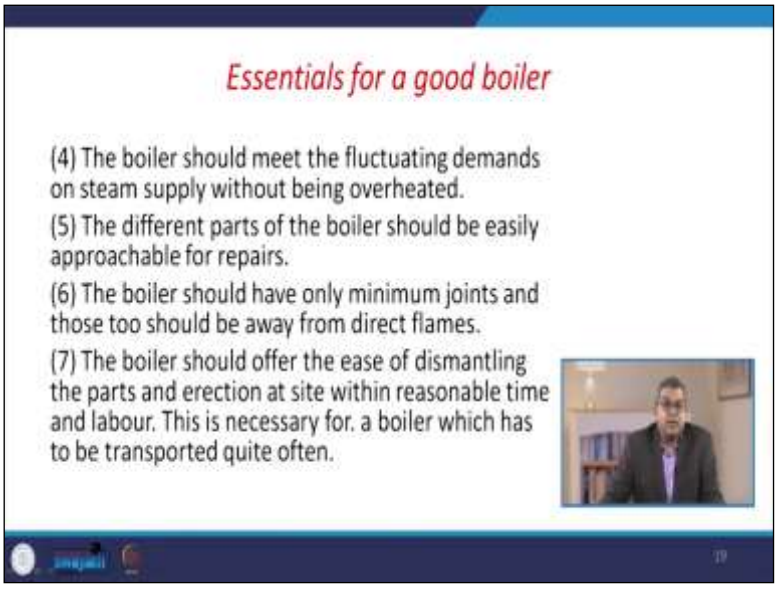

The boiler should offer the ease of dismantling the part erection at the site within a reasonable time and labor. This is necessary for the boiler, which has to be transported quite often. For efficient heat transmission rate, the water and the flue gases should have maximum velocity without an occurring heavy frictional loss. To minimize the impact of scale formation within the tubes, there should be no deposition of mud and other debris or foreign particles on the heated surface.

Otherwise, the heat transfer aspect may be badly affected. The boiler should confirm the safety regulations as laid down by the boiler act, and as I told you, these boiler acts are different for different countries and states. So, this must be conferred by the applicable boiler act. Another

important accessory is mounting in the boiler is the safety valve because, see we I told you that this is a pressure vessel.

And it is just like your domestic pressure cooker where there are two types of safety devices: the safety valve and the steam vent. These two are safety devices; otherwise, a boiler is an excessively pressurized vessel like your domestic pressure cooker. So, in case of any eventuality or any built-up excessive pressure boiler should be capable of releasing that particular excessive pressure with the help of safety devices. So, when we talk about safety devices, safety valves come into the picture.

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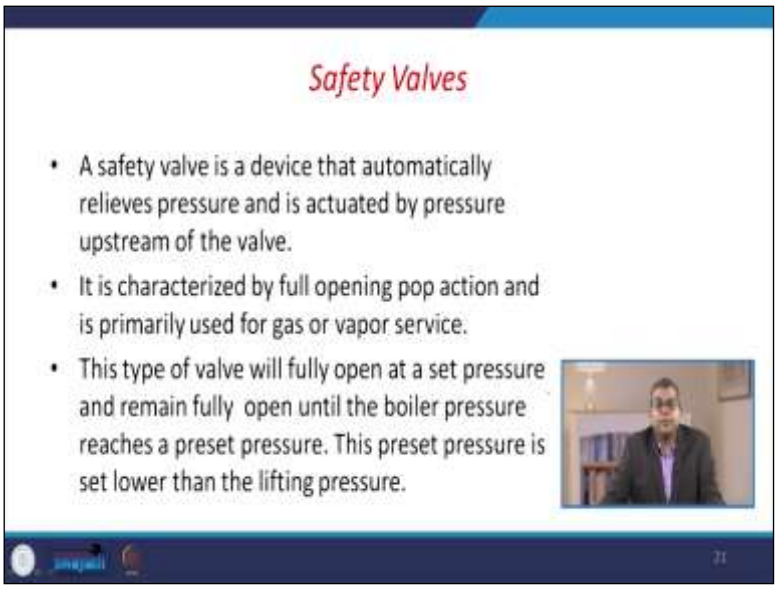

A safety valve is a device that automatically relieves excessive pressure and is actuated by the pressure of the stream of the valve. It is usually characterized by either full opening pop action and is primarily used for gas or vapor service. This type of valve fully opens at a set pressure and remains fully open until the boiler pressure or workable pressure reaches the preset temperature. The preset temperature is set lower than the lifting pressure.

So, obviously, this is essential for the smooth functioning of the boiler. Different types of safety valves are fitted to a steam boiler plant but must meet different criteria.

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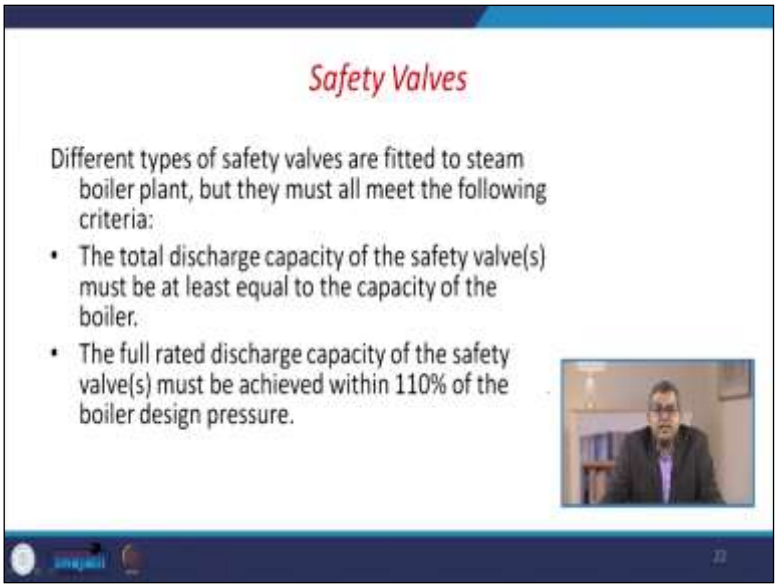

One criterion is that the total discharge capacity of the safety valve must be at least equal to the capacity of the boiler so that you can have a safe operation. Similarly, the full rated discharge capacity of the safety wall must be achieved within 110% of the boiler design pressure.

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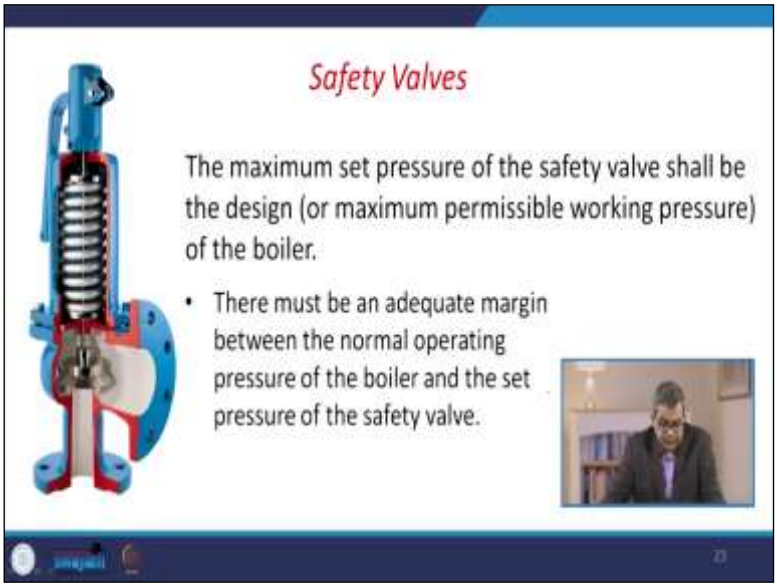

This is the maximum set pressure of the safety valve. This shall be designed for the maximum permissible working pressure of the boiler. If you recall the rating plate of the boiler there, it was clear cut mentioned what should be the maximum working pressure. So, this gives an idea. There must be an adequate margin between the normal operating pressure of the boiler and the set pressure of the safety wall.

This is the internal anatomy of the safety wall this is the spring-loaded safety valve here this is the spring and this is the seat and disc. We will discuss all these things in due course of time later on.

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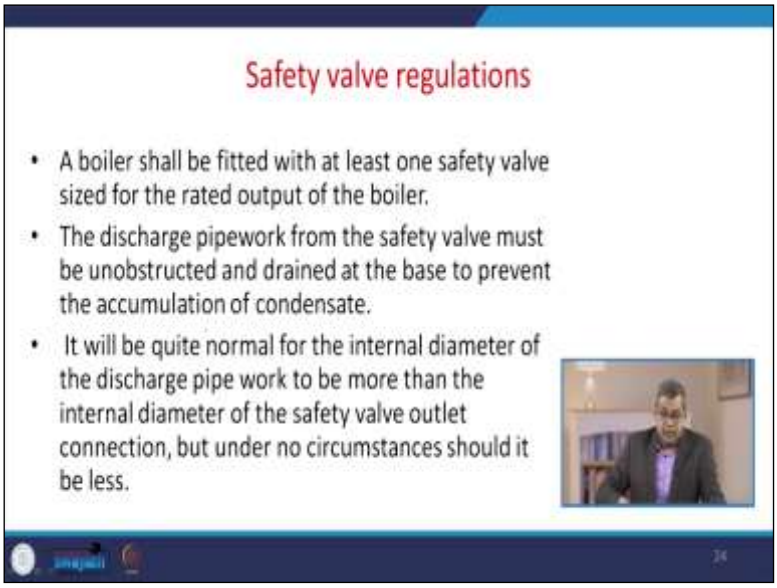

Once we are using this safety wall, we must comply with certain safety valve regulations and depend on the boiler to boiler, Boiler Acts, Indian Boiler Regulation. So, all these things are the governing factors or regulators towards the safety wall regulation as well as the boiler operation. So, the regulation says that a boiler shall be fitted with at least one safety wall sized for the rated output of the boiler.

We have already given the mathematical correlation or statement which decides what should be the capacity of the safety valve. The discharge pipework from the safety wall must be unobstructed and drained at the base to prevent the accumulation of the condensate because as soon as the steam releases from through the safety wall, it should be condensed, and it is the condensate which is usually at the temperature of the steam must be recovered as quickly as possible.

It will be quite normal for the discharge pipework to be more than the internal diameter of the safety valve outlet connection. But under no circumstances should it be less.

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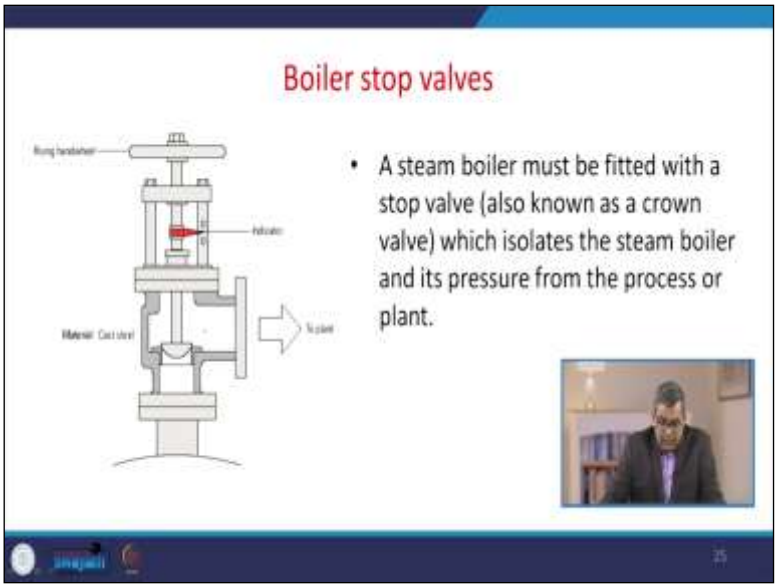

Apart from this another accessory is the boiler stop valve. So, the steam boiler must be fitted with a stop valve, sometimes known as the crown valve, which isolates the steam boiler and its pressure from the process or plant. So, this is the basic figure of the boiler stop valve. Here you are having this ring hand wheel rising handwheel and sometimes it is called the ring or sometimes it is known as the crown wheel and material for the construction of this is the cast iron.

as soon as you see that this particular at this particular juncture or joint is fitted with the shell of the boiler and if you open or close the steam can go like this. it is in a closed position. So, this valve is completely seated with the passage. So, you can maintain the steam passage through this wall.

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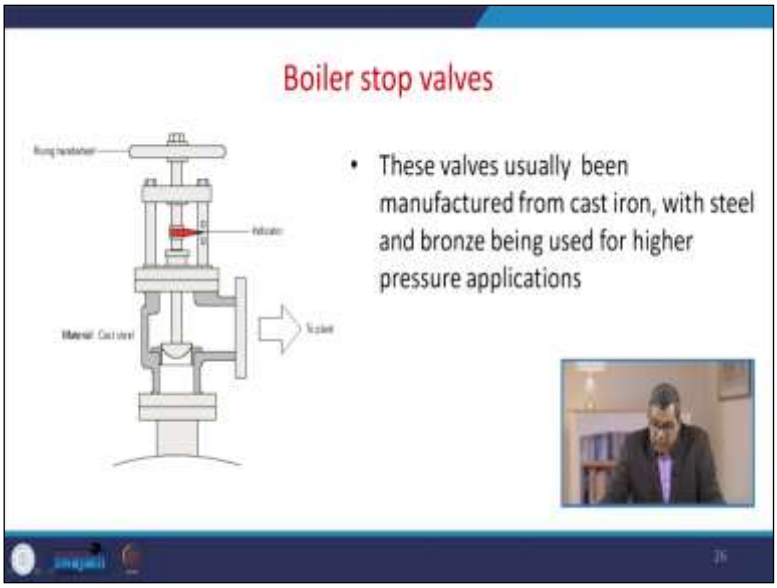

These valves usually been manufactured from cast iron, with steel and bronze being used for the higher pressure application.

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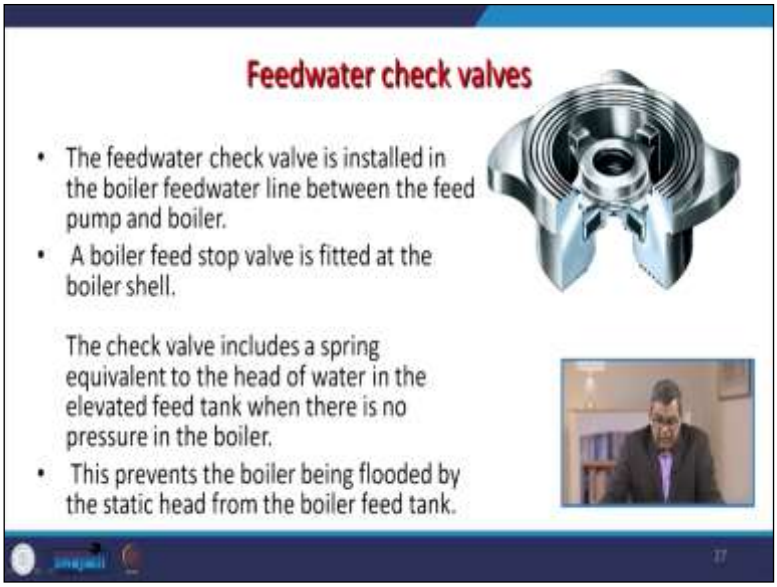

Another thing is important in the boiler necessary is come mounting that is the feed water check valve. This is the basic cut section of feedwater check valve. The feedwater check valve is installed in the boiler feedwater line between the feed pump and boiler. The boiler feed stop wall usually is fitted at the boiler shell. The check valve includes a spring equivalent to the head of water in the elevated feed tank when there is no pressure in the boiler. So this prevents the boiler from being flooded by the static head from the boiler feed tank.

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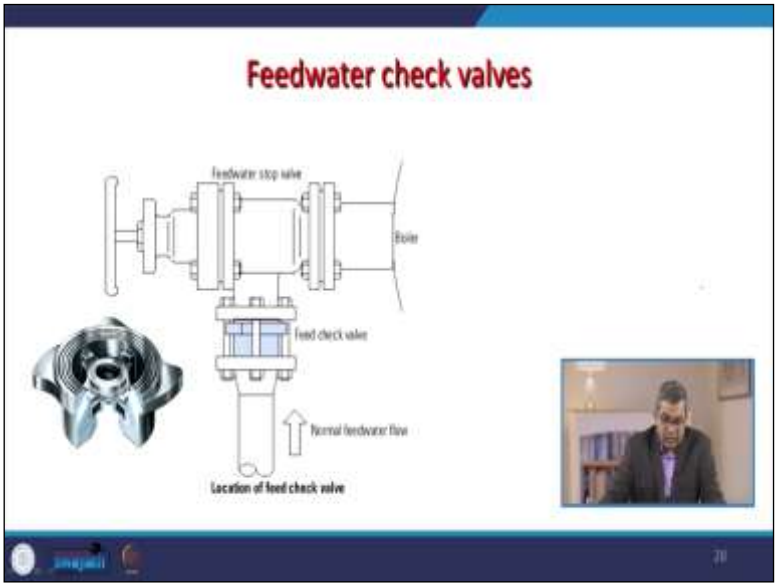

Here you see that where we fit this is the main boiler shell, and this is the feed water stop valve. So, the feedwater check valve is situated here, and this is a normal feedwater flow.

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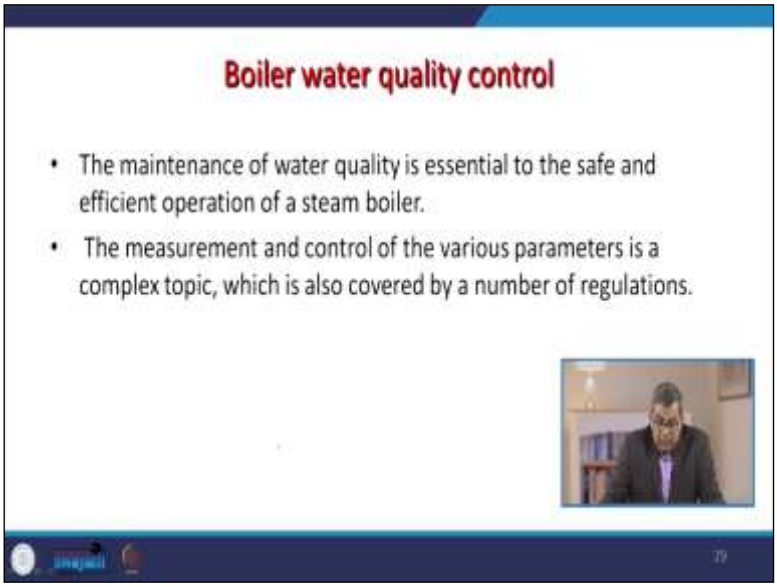

see boiler obviously for the production of a steam boiler uses the water and we discussed that the quality of water is extremely important because the natural water may contain certain dirt debris etc total dissolved solids etc apart from this some hardness. And sometimes, if you are reheating the boiler, maybe condensate recovery maybe through some other aspect it must be the quality of the wire the boiler water should be checked.

So, because it is again essential for the; smooth functioning and the proper efficiency of the boiler, the maintenance of water quality is essential for the safe and efficient operation of any steam boiler. The measurement and control of the various parameters is a very complex topic. The number of regulations also covers it because you cannot discharge the condensate as such because it carries the heat value and significant quantity. And you see that for proper, efficient operation, you need to demineralize or deionize water as well.

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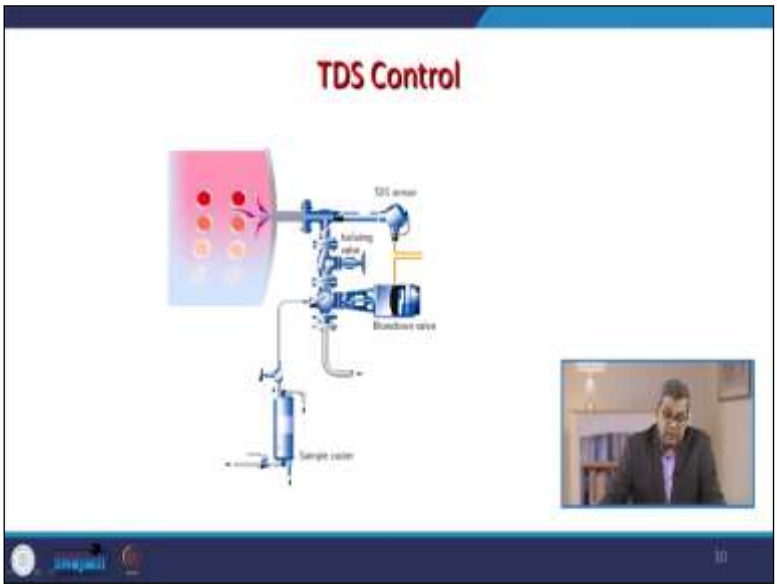

One of the major issues in the boiler operation is the total dissolved solids or the TDS. So, a boiler must control or must be operated within the permissible TDS; otherwise, the scales will be on the higher side, and the heat transfer rate etc., will have a negative impact. This is the TDS sensor, and this is the isolating valve and a blowdown valve and this is the sample cooler and your main boiler arena.

So, this TDS sensor usually sends the quantum of TDS, and if it is beyond the permissible limit, then isolating wall will be actuated to cut sort the supply of water, or some remedial measures or some chemical dosing may take place. So, this is again the most important.

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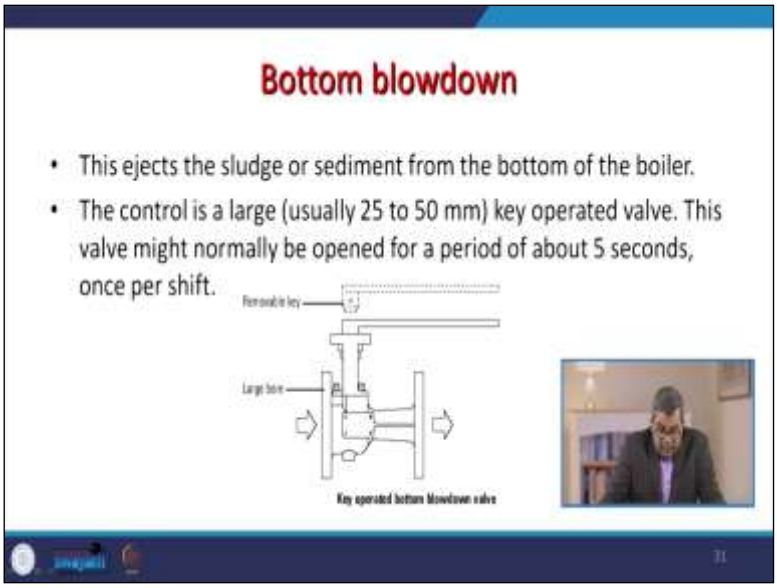

You see that the different types of scales may form over time, and the concentration may go up, and you are having a reheating of boiler water over time. So, some sludge may form over the period. This is the bottom blowdown which ejects the sludge or sediments from the bottom of the boiler. This control is a large key-only key operated wall, and this wall might normally be opened for about 5 to 6 seconds once per shift.

Here you see that this is a removable key that usually fits over here andusually operates in as per the directional requirement and by this way, a significant quantity of sludge or sediments may come out from the boiler. But due care must be taken because these sludge and sediments may have a temperature at equal to the boiler operating temperature.

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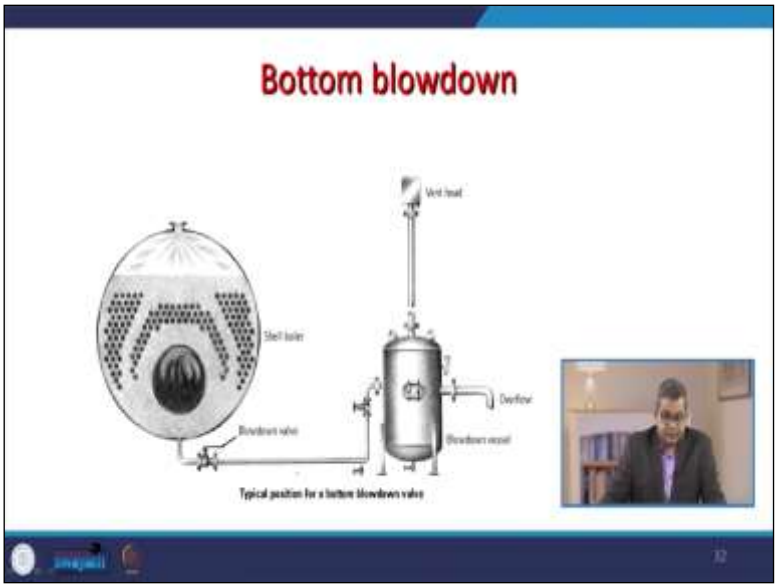

Here is a more pictorial thing: you have the blowdown valve that we have already shown here. This blowdown valve is connected to the blowdown vessel here because this blowdown usually comes out in the form of high temperature and excessive pressure. So, you need to perform the flashing operation to this blowdown vessel. And sludge, whatever concentrated sludge is, can be discarded over here. And vapors may go out from this way, and the condensate may come out from this way.

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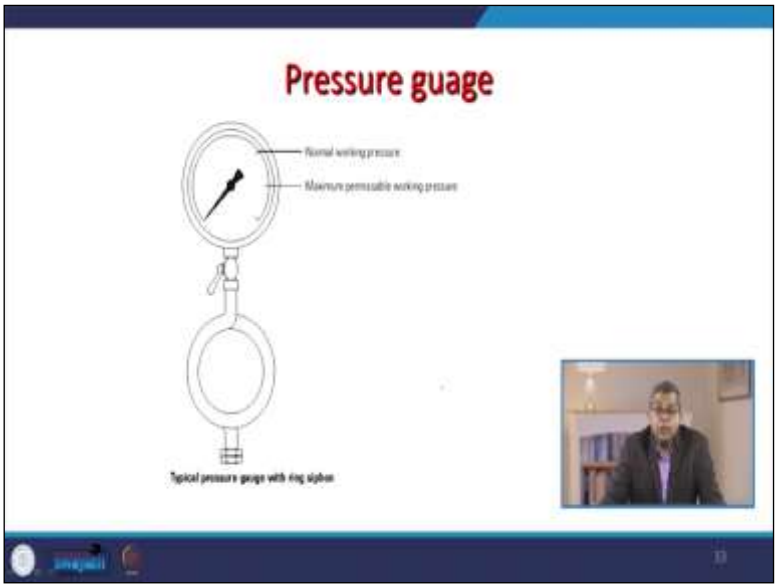

One of the key factors in the boiler is the pressure gauge, and obviously, without measuring the pressure, you cannot proceed further. So, the pressure gauge is again integral part, and some of the

boilers who are working at a very high temperature and pressure may have one or two pressure gauge. usually this indicates what is the normal working pressure and what is the maximum working pressure by either colour codes or some science system.

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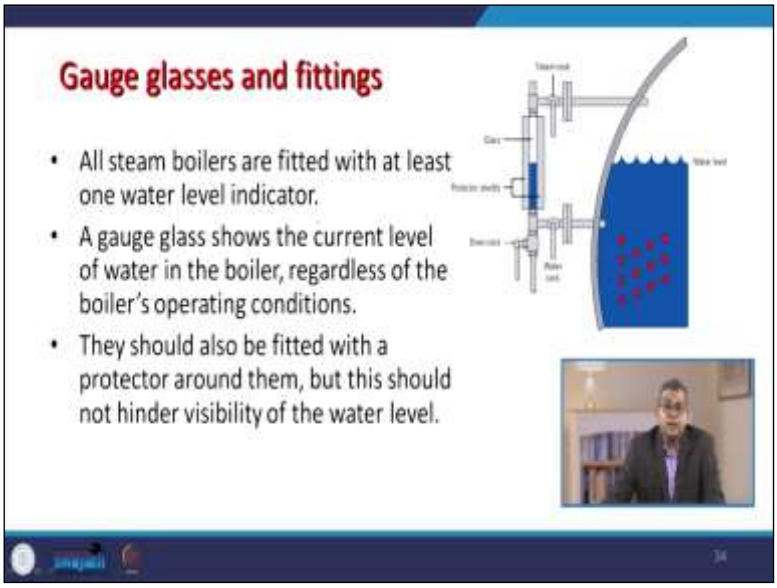

There are certain gauge glasses and fittings to see or visualize what is going on inside the boiler. And all the steam boilers are fitted with at least one water level indicator. So, the gauge glasses and the water level indicator is one of those things. A gauge glass shows the current level of water in the boiler we have already discussed that what is the; the impact of the water level in the boiler with respect to if it is too high or if it is too low.

So, they should be fitted with a protector around them but should not hinder any water level visibility. Here you see the glass and this is the protector shield you see and the steam caulk. So, you can clearly see what is the level of water inside the boiler.

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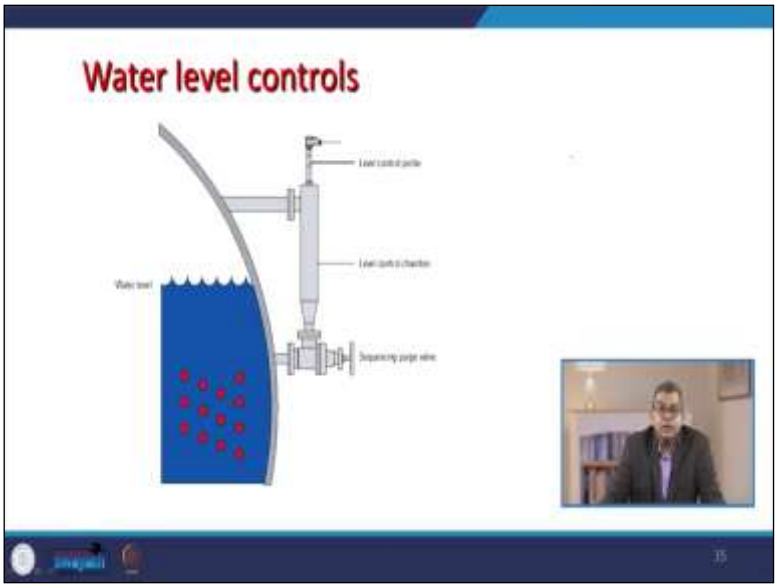

And by this way, you can control the water level because we have discussed that if the level is too high or a level is too low, the operation of the boiler would be extremely difficult.

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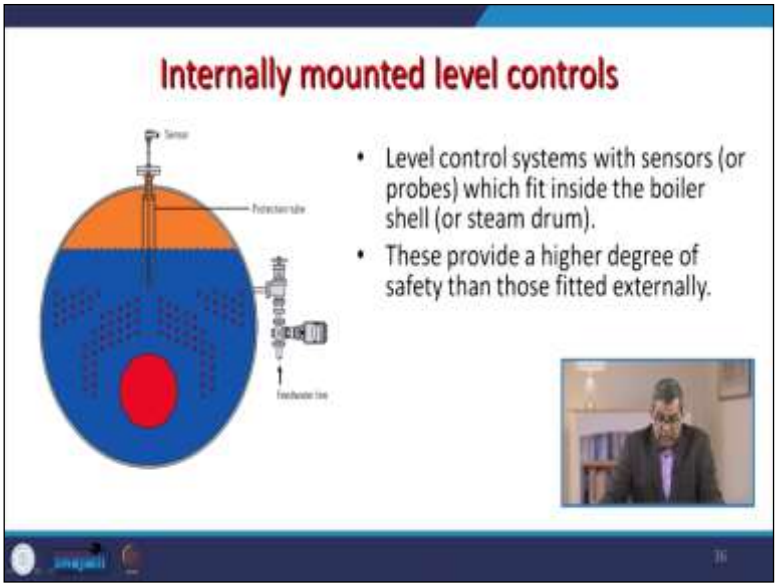

There are certain internally mounted level controls and usually are equipped with various types of sensors. So, the sensor level control systems are sometimes referred to as a probe duly supported by the protection tubes, as seen in this figure. These internally mounted level controls provide a high degree of safety than those fitted externally.

Sometimes may equip with a level alarm system. This may also provide a self-checking function on system integrity. And these protection tubes are fitted to discourage the movement of water ground around the sensor.

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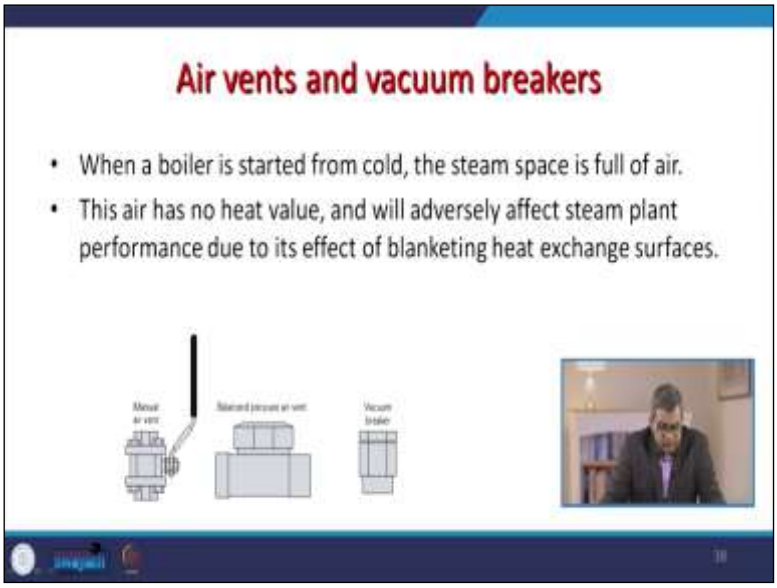

There are certain air vents, and vacuum breakers are also equipped in the boiler, and the reason is quite obvious when a boiler is started from cold the steam space is full of air and usually this and you know that this air does not carry any heat value. So, it adversely affects the steam plant performance due to its effect of blanketing heat exchange surfaces.

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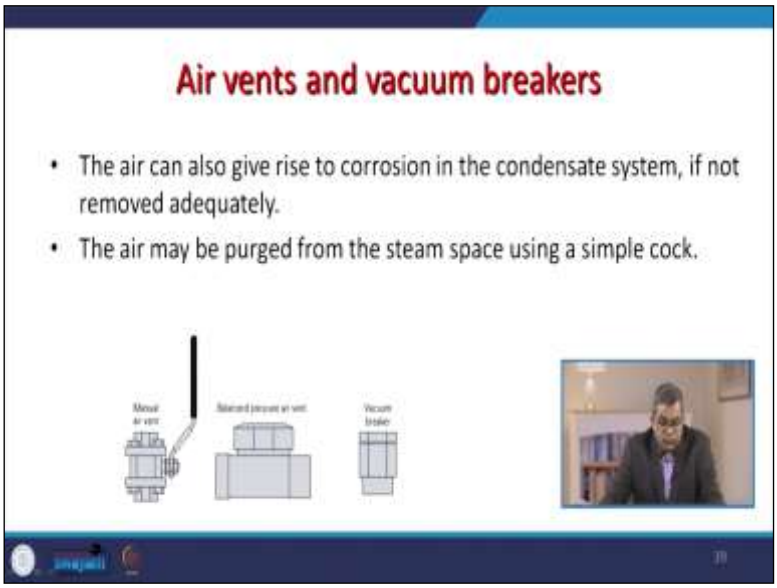

So, you need to remove this air, and this air can also give rise to corrosion in the condensate system if not removed adequately. And this air can be simply purged from the steam space using a simple. So, in this lecture, we discussed the different accessories and mountings attributed to the boiler, the economizers, and superheaters. We discussed about briefly about the other mountings here, vents and essential part like pressure gauges etc.

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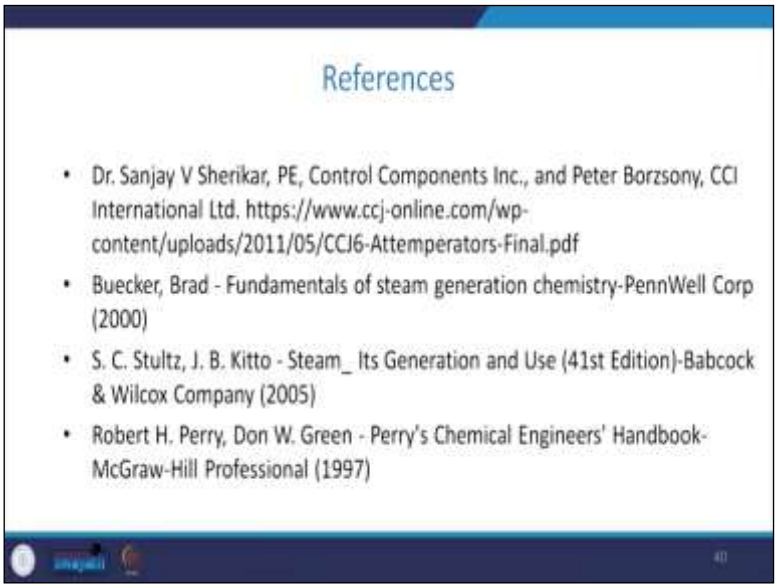

So, if you wish to have a further reading we have enlisted couple of references for your convenience, thank you very much.