Chemical Process Instrumentation
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Lecture – 58
Pneumatic Control Valve (Contd.) and P & ID

Welcome to lecture 58. This week you have started our discussion on Pneumatic Control Valve. So, today, we will complete our discussion on pneumatic control valve, and we will also briefly touch upon piping and instrumentation diagram.

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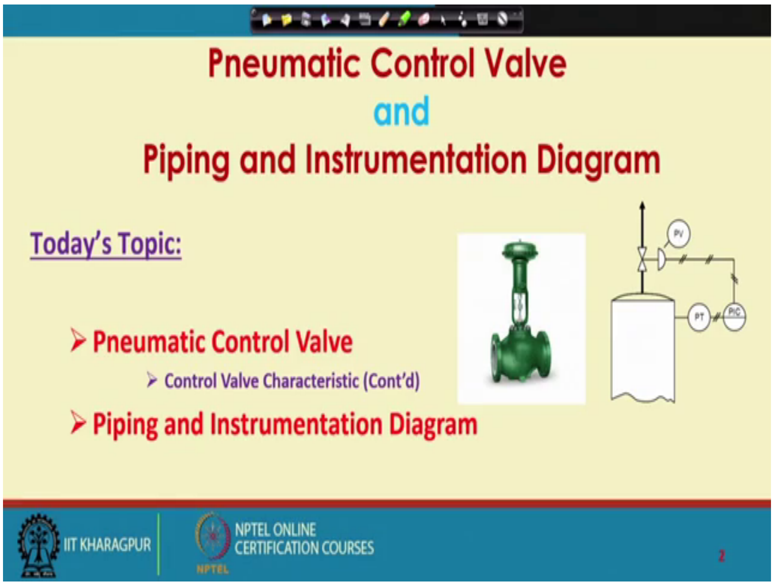

So, today's topic is pneumatic control valve, which we have been talking about for last 2 classes we will complete that today. And we will also discuss briefly piping and instrumentation diagram.

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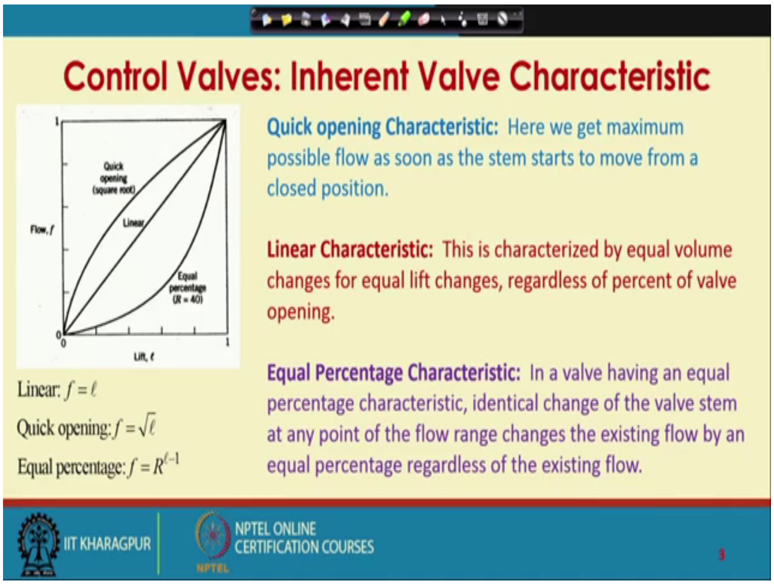

So, we have talked about inherent valve characteristics, we have talked about 3 characteristics, linear, quick, opening and equal percentage control valves. The characteristic plots are shown quick opening characteristics. Here we get maximum possible flow as soon as the stem starts to move from a closed position. In case of linear characteristic, this is characterized by equal volume changes for equal lift changes regardless of percent of valve opening.

Equal percentage characteristic in a valve having an equal percentage characteristic, identical change of the valve stem at any point of the flow range changes the existing flow by an equal percentage regardless of the existing flow.

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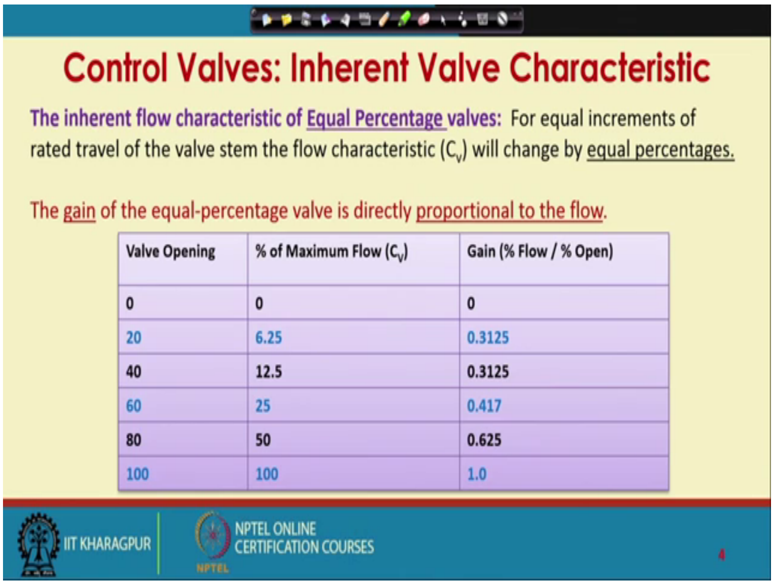

So, the concept will be more clear, if you look at this data. So, this is for equal percentage valves, as we know for equal increments rated travel of the valve stem the flow characteristic or Cv will change by equal percentages.

So, basically the flow will change by equal percentages for equal increments of the travel of the valve stem. So, if you look at here, when the valve opening goes from 0 to 20 and increment of 20, the percentage of maximum flow changes from 0 to 6.25. So, for 20 to 40, again the same increment of 20. So, here also you see 6.25, it goes to 12.5.

So, 100 percent increase so, 40 to 60 again increments of 20. So, again I would expect a 100 percent increase and that is what happen happens 12.5 goes to 25. Similarly, for the rest of the data shown the gain of the equal percentage valve is directly proportional to the flow. So, remember for equal increments operator travel of the valve stem the flow characteristic will change by equal percentages for equal percentage valves.

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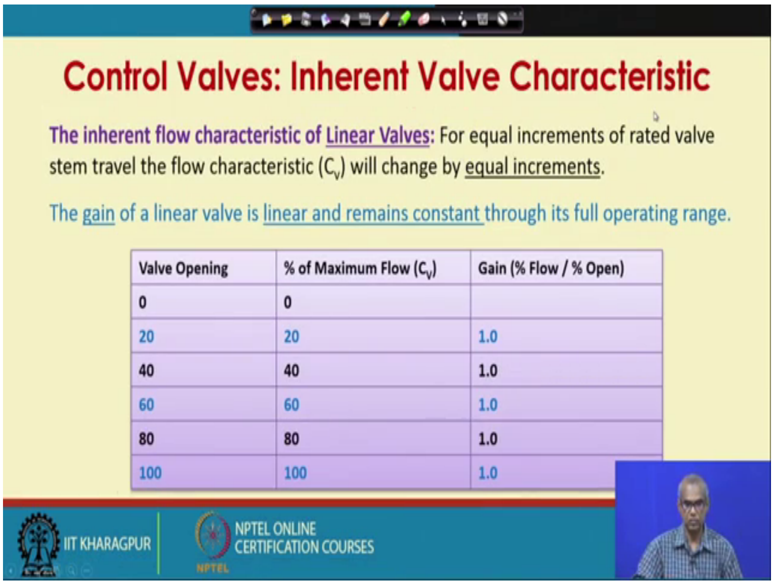

This is for linear valves, for equal increments of rated valve stem travel the flow characteristics will change by equal increments. So, as the data source, for valve opening going from 0 to 20, Cv goes from 0 to 20. For 20 to 40, the percentage of maximum flow also changes from 20 to 40. So, for equal increments, operated valve stem travel the flow characteristics changes by equal increments.

The gain of the linear valve is linear and remains constant throughout it is full operating range.

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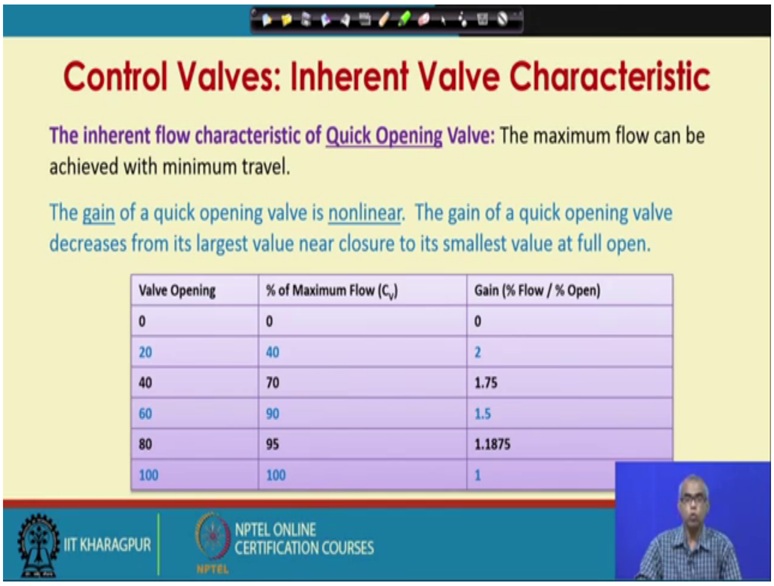

This is for quick opening valve; the maximum flow can be achieved with minimum travel. Again, look at the data for the valve opening 0 to 20, the percentage of maximum flow or cv changes from 0 to 40. Whereas, valve opening 80 to 100, same increment by 20, but the cv changes only from 90 5 to 100.

So, the maximum flow can be achieved with minimum travel. The gain of a quick opening valve is non-linear, the gain of a quick opening valve decreases from it is largest value near closer to it is smallest value at full open.

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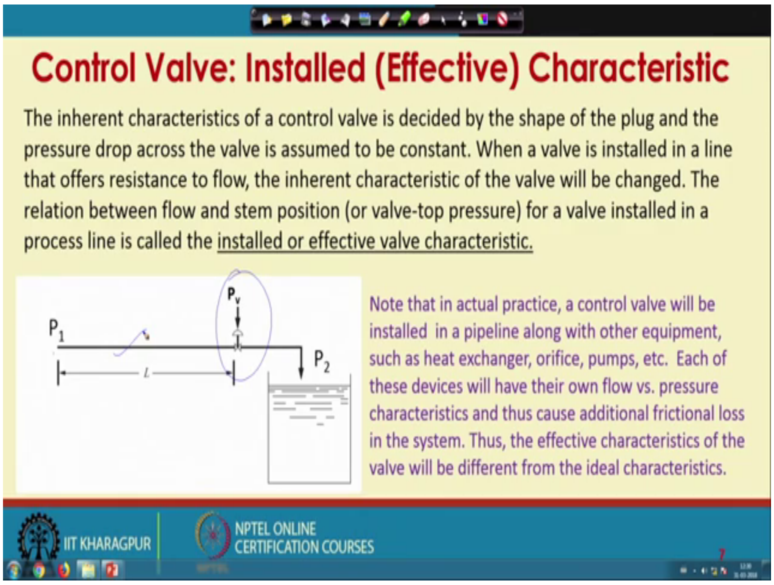

As of now you have talked about inherent characteristics. So, we talked about control valves in isolations, control valves were not installed in a pipeline along with other devices. The inherent characteristics of a control valve is decided by the shape of the plug, and the pressure drop across the valve is assume to be constant.

When a valve is installed in a line that offers resistance to flow the inherent characteristic of the valve will be changed. The relation between flow and stem position or valve talk pressure, for a valve installed in a process line is called the installed or effective valve characteristics. So, as the diagram suggest, this is the control valve which is installed in a line.

And that is what we will happen in reality. The control valve will be installed in a pipeline along with other equipment such as heat exchanger orifice pumps etcetera. Each of these devices, we will have their own flow versus special characteristic, and thus cause additional frictional loss in the system.

Thus, the effective characteristics of the valve will be different from the inherent characteristics or ideal characteristics. So, the installed or effective valve characteristics is the relation between flow and stem position for a valve which is installed in a process.

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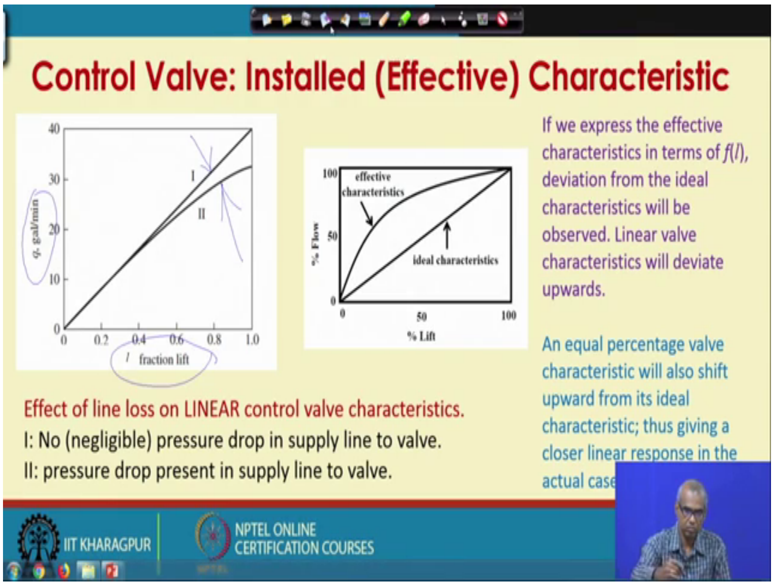

What you see in the diagram is effect of line loss on linear control valve characteristics. So, for a linear control valve, if there is no pressure drop in supply line to valve, the flow rate will have a linear relationship with the fractional lift so, that is he shown by this.

But when this valve will be installed in a process, and there is pressure drop present in supply line to valve, there will be deviation from this linearity, and you will get the flow rate versus fractional lift relationship like this which is a non-linear one. If you express the effective characteristics in terms of f of l, where l is fractional lift deviation from the ideal characteristics will be observed. Linear valve characteristics will deviate upwards. So, this is the characteristics or the ideal characteristics for the linear valve, and this is the effective characteristics for the linear valve.

So, the linear valve characteristics deviate upwards when it is installed in a process. And equal percentage valve characteristic will also sit upwards from it is ideal characteristic; thus, it will give a closer linear response in actual case.

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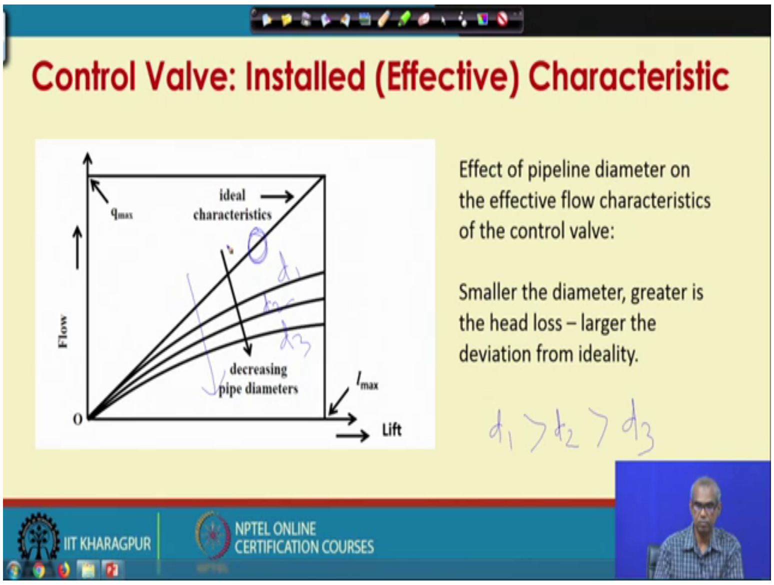

The figure shows the effect of pipeline diameter on the effective flow characteristic of the control valve. We have already seen that when a controlled valve in installed in a process, it is effective flow characteristics deviates from ideal characteristics; now, if you go and decreasing the diameter of the pipeline there will be greater and greater head loss.

So, there will be larger deviation from ideality. So, if here the diameter of the pipe is d 1 here the diameter of the pipe is d 2, and here the diameter of the pipe is d 3, as the pipe diameter decreases; that means, d 1 is greater than d 2 which is greater than d 3, the deviation happens in this direction. Because smaller diameter pipe will cause greater head loss and there will be larger deviation from ideality, which is this.

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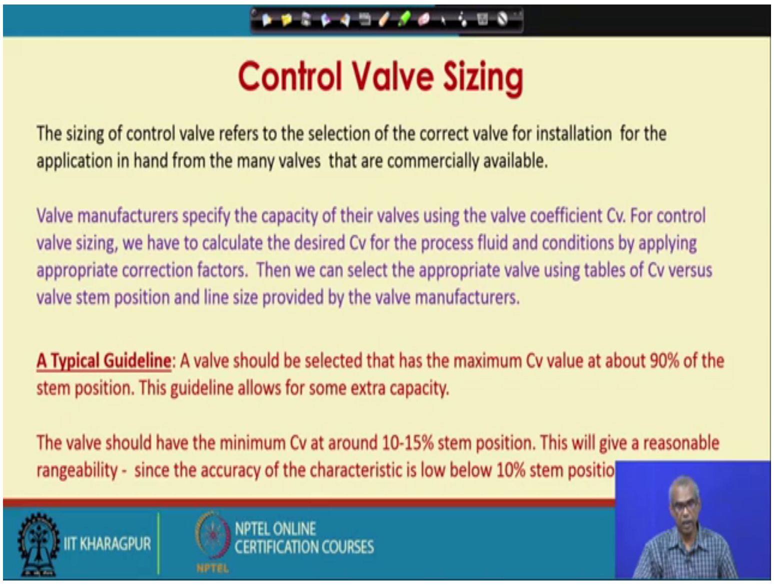

Control valve sizing, the sizing of control valve refers to the selection of the correct valve for installation for the application in hand from the many valves that are commercially available.

Basically, as an engineer you have to choose the correct control valve for your application from the many commercially available valves. Valve manufacturer is specify the capacity of their valves is in the valve coefficient Cv. For control valve sizing, we have to calculate the desired Cv for the process fluid and the condition by applying appropriate correction factors. Then you can select the appropriate valve using tables of Cv versus valve stem position valve, and line size provided by the valve manufacturers, here is a typical guideline.

A valve should be selected that has the maximum Cv value at about 90 percent of the stem position. This guideline allows for some extra capacity, the valve should have the minimum Cv at around 10 to 15 percent of stem position. This will give a reasonable rangeability, since the accuracy of the characteristic is low below 10 percent stem position.

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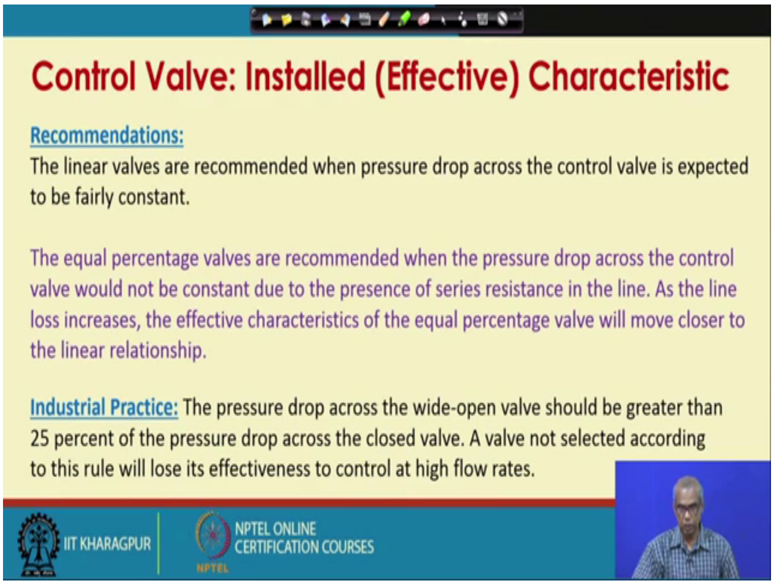

Here are some recommendations, the linear valves are recommended when pressure drop across the control valve is expected to be fairly constant. The equal percentage valves are recommended, when the pressure drop across the control valve would not be constant due to the presence of series resistance in the line. As the line loss increases, the effective characteristic of the equal percentage valve will move closer to the linear relationship.

Remember, in a few slides back we will discuss that the installed or effective characteristics of the equal percentage valve will also move upwards; that means, in actual practice it will be closer to the linear valve. A note on industrial practice, the pressure drop across the wide-open valve should be greater than 25 percent of the pressure drop across the closed valve. Valve not selected according to this rule we will lose it is effectiveness to control at high flow rates.

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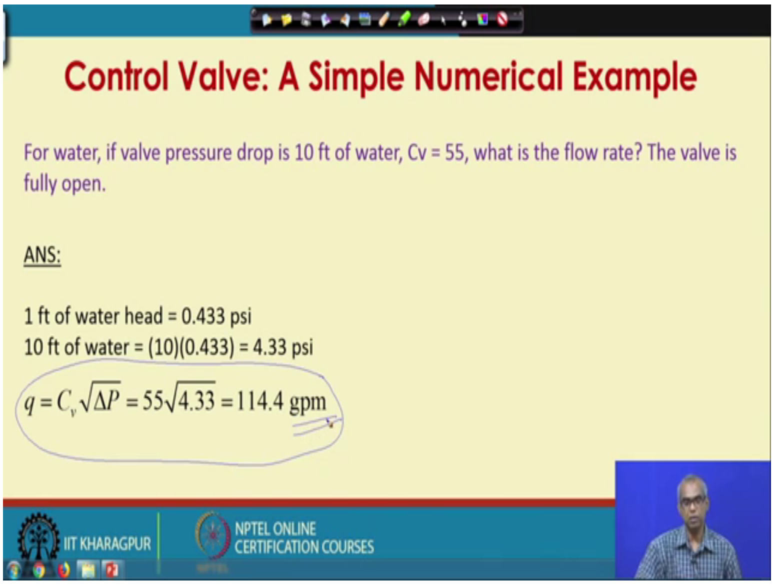

Let us look at a very simple numerical example. For water, the valve pressure drop is 10 feet of water and Cv equal to 55, what is the flow rate, assume the valve is fully open. So, it is a straight forward application of flow rate k v equal to Cv into square root of delta P 1 feet of water head is 0.433 psi. So, 10 feet of water equal to 10 into 0.433 equal to 0.433 psi. Then you just put the values into the formula q equal to Cv into square root of delta P.

Note that valve is fully open. So, this gives you the flow rate equal to 114.4 gallon per minute, take care of the unit the unit is gallon per minute.

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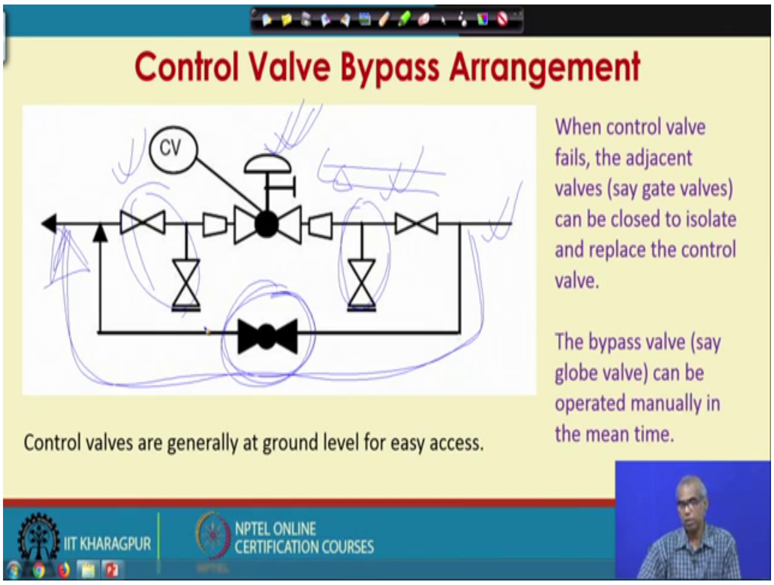

The figure shows a control valve by pass arrangement. When control valve fells, the adjacent valves can be close to isolate and replace the control valve. So, in a process the control valve is typically install as shown in the diagram. This is the control valve which is connected in this line. Note, there are 2 more valves adjacent to the control valve. And also, there is another valve in this bypass line.

This arrangement is necessary for the following reason. Imagine, the control valve fails and it is necessary that the control valve has to be isolated and replaced or repair. So, these 2 valves can be used to close the flow through this line, and then the control valve can be isolated.

In the meanwhile, this bypass valve can be operated manually as long as this control valve is not put back in the line. So, what you do is, these 2 valves which may be get valve can be used to close the flow through this line, and then we can isolate the control valve for replacement.

In the meantime the normal flow will be there, along this bypass line, and this valve which may be a glow valve can be operated manually. Control valves are generally at ground level for easy access.

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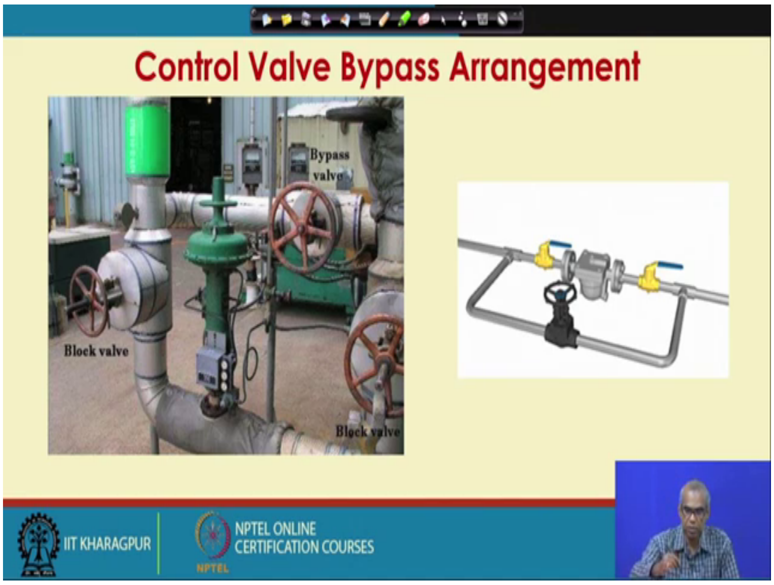

So, this is an actual example, actual image so, this is the control valve, and this is at the valve block valves, which can be used to close the flow in this line when the control valve fails. During that time this is the bypass valve which can be operated manually for normal operation.

The same thing is shown here. This is the control valve, and these 2 valves can be used to close the flow, in this pipe when the control valve fails and this is the bypass valve which can be used during that period of time.

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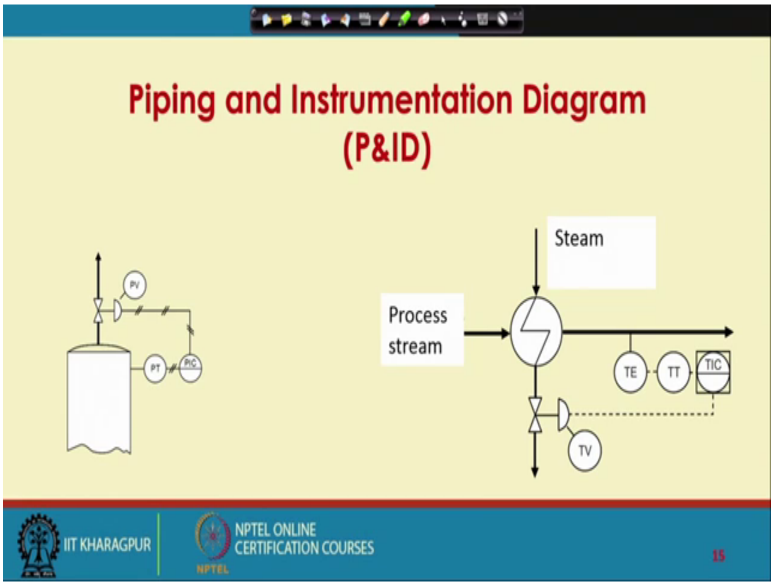

Now, we will briefly talk about piping and instrumentation diagram. What you see on the screen at typical very, very simplified example of piping and instrumentation diagrams. For a very small part of an equipment for example, on the left what you see is a part of piping and instrumentation diagram for the top of the distillation column.

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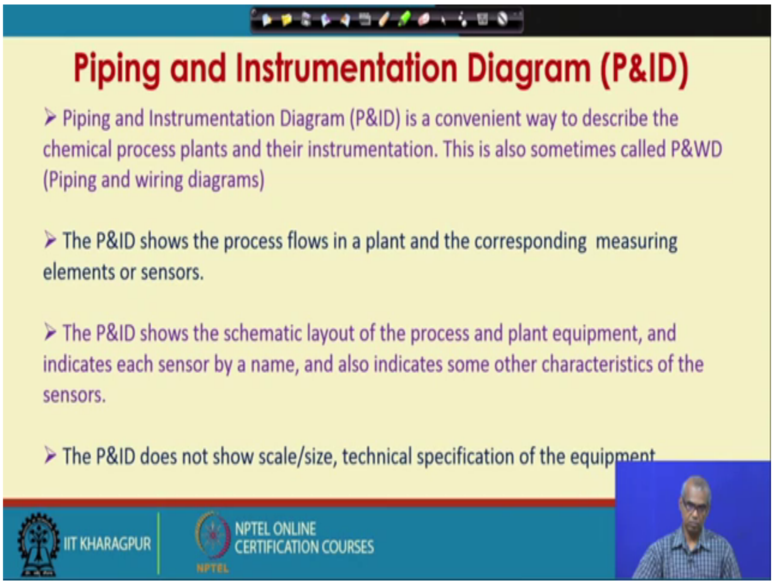

So, what is piping and instrumentation diagram? Piping and instrumentation diagram is a convenient way to describe the chemical process plans and their instrumentation. This is also sometimes called P and WD; that means piping and wiring diagrams. The P and ID shows the process flows in a plant, and the corresponding measuring elements or sensors.

The P and ID shows the schematic layout of the process and plant equipment, and indicates each sensor by a name and also indicates some other characteristics of the sensors. The P and ID does not show scale size technical specification of the equipment.

So, P and ID shows process flows in a plant, it shows the measuring elements of sensors. It shows the schematic layout of the process plant equipment. Indicates a sensor by a name, also indicate some other characteristics of the sensors. Like, whether the sensor is indicating type or transmitting type etcetera. However, process piping and instrumentation diagram does not show the scale or size as well as technical specification of the equipment.

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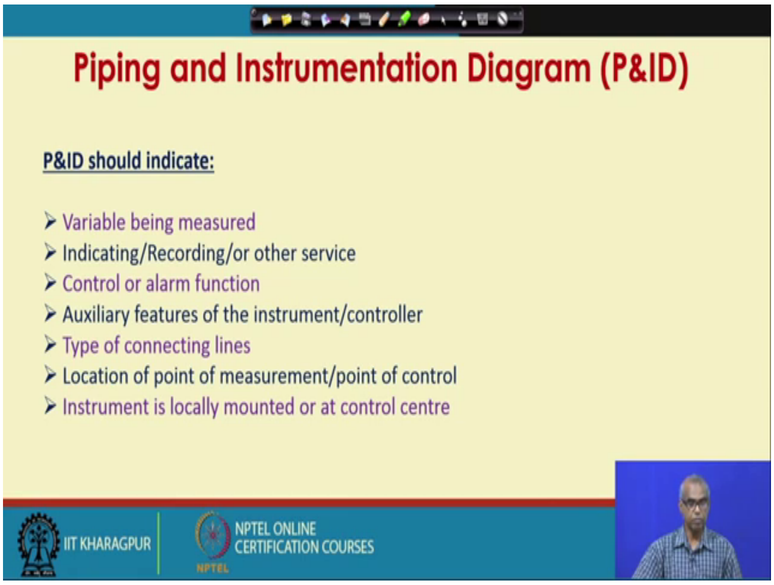

P and ID should indicate variable being measured indicating recording or other services, control or along function auxiliary features of the instrument or controller, types of connecting lines whether it is pneumatic lines or hydraulic lions or electric lines.

Location of point of measurement or point of control; that means, whether the instrument of the transmitter is mounted locally at the plant site or it is located at the control room, instrument is locally mounted or at control centre.

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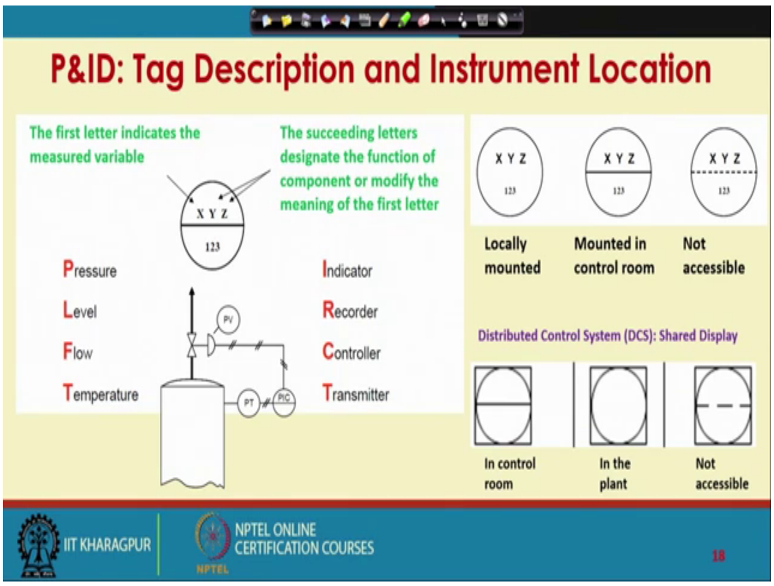

Now, let us look at the tag description and the instrument location, what do you mean by tag description. Look at this simple diagram, simple P and ID focus your attention here. Within a circle, what is written is PT. These 2 letters indicates what kind of sensor is this P stands for pressure, and T stands for transmitter, so, this is a pressure transmitter.

So, the sensors are indicated by a circle like this, and it will have a tag which consists of letters, and their significance of the first letters and the succeeding letters, the first letter indicates the measured variable. So, in the first let first letter is P it indicates pressure if the first letter is l it indicates level. Similarly, if the first letter is f it means flow, first letter is TEM T means temperature. So, the first letter indicates the majored variable, the succeeding letters designate the function of component or modify the meaning of the first letter. In this example the second letter is T.

So, it means it is a transmitter, here, there are 3 letters, the first letter is the measured variable so, it is P it means pressure. Second meaning indicator, third c means controller. So, it is a pressure indicating controller, pressure indicator as well as controller. So, remember these letters as well as these letters. So, first letter indicates the measured variable, the succeeding letter designated the function of the component or modify the meaning of the first letter. Now so, these 3 letters indicate the measured variable and whether it is indicating con recording controlling transmitting etcetera, function of the component.

Now, look at this 3 different representation. There is no line such as this in the first example. Whereas, here we have been unbroken line, here you have a broken line. So, when there is no line, horizontal line like a diameter, this means, this instrument is locally mounted.

If there is a line horizontal line, such as this, it means it is mounted in the control room. And if the line is broken line, it means that this instrument is not accessible. I will show you an image to indicate what I mean by this instrument is not accessible.

Also look at there is a number, this indicates the loop number in the control system. If the instrument is a part of distributed control system, then this indicates that the instrument is in control room, this indicates it is in the plan, and this indicates it is not accessible. So, the difference is that there is a bounding box around these schematics.

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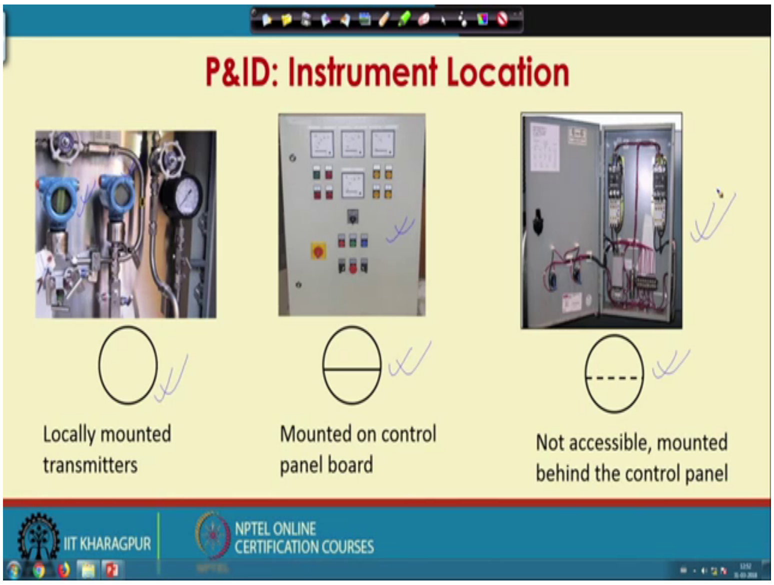

So, this is locally mounted transmitters so, these are locally mounted transmitter, the operator has easy access to this in the plant.

This indicates the transmitter is mounted on the control panel board so, this is a control panel board. Whereas, this indicates the transmitter is not accessible to the operator. Because it is mounted behind the control panel, and this is shown in this image.

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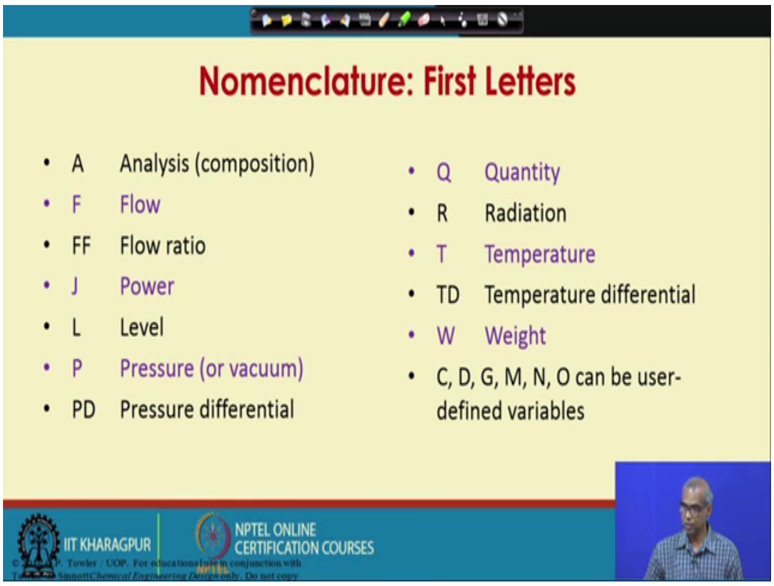

Here as the more examples of what first letter indicates, A analysis of composition, F flow, F F flow ratio, J power, L1evel, P pressure or vacuum PD pressure differential, K quantity, R radiation, T temperature, TD temperature differential, W weight. C, D, G, M, N, O can be user defined variables.

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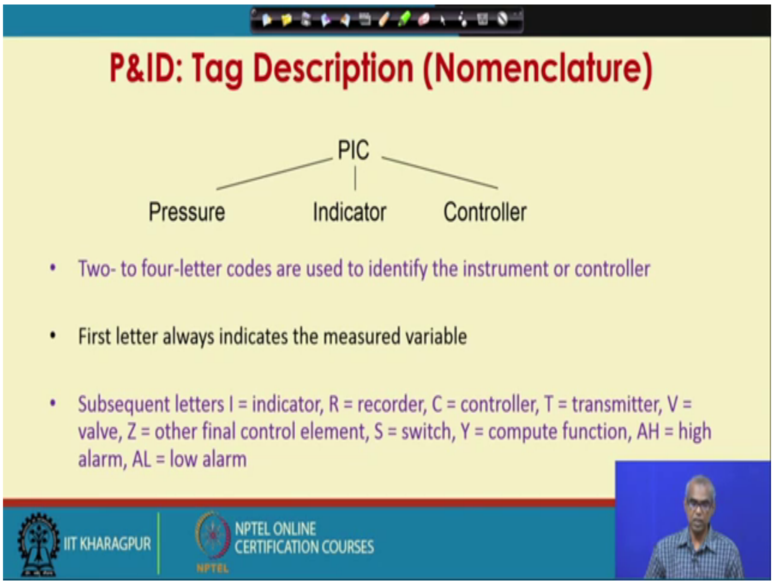

So, giving an example pic first letter P stands for pressure. Second letter I stands for indictor, third letter C stands for controller. So, 2 to 4 letter codes are used to identify the instrument or controller. First letter always indicates the measured variable. Subsequent letters I indicator or recorder, C controller, C transmitter, V valve, Z are the final control elements, S switch, Y compute function, AH stands for high alarm, AL stands for low alarm.

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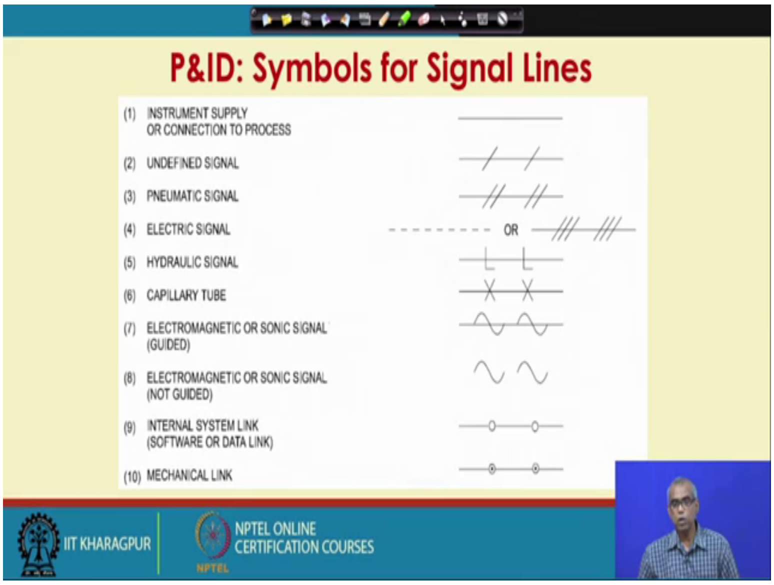

These are symbols for signal lines, this is instrument supply or connection lines, this is undefined signal, this is pneumatic signal. This is electrical signal, sometimes this is also used as electrical signal. Hydraulic signal capillary tube electromagnetic or sonic signal which is guided, and this is unguided electromagnetic or sonic signal.

Internal system link, software or data link, this is mechanical link, this is an example of orifice.

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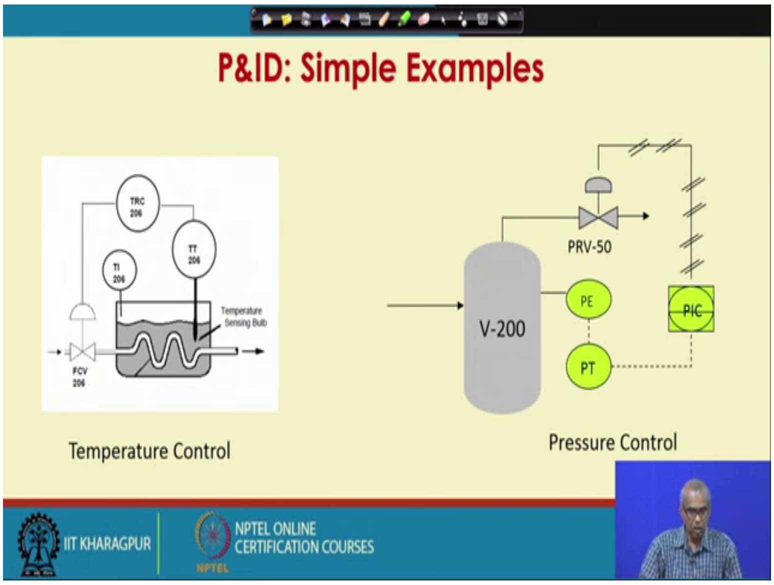

Now, a very simple example on the left you see temperature control. So, the control loop is shown. You sense the temperature, that temperature is transmitted to the controller. This controller changes the steam flow through this control valve. So, TT stands for temperature transmitter. Loop number 206. There is no horizontal line broken or continuous. So, this is locally mounted. This is TRC, temperature recorded controller.

Again, locally mounted, this is FCV flow control valve. Not here, this is T I temperature indicator. So, it only indicates, it does not transmit the data. So, it only indicates to him and operator. About the measured temperature, but temperature transmitter terms transmits the information about the measured data to the controller. Similarly, you have the pressure control of the system.

P is pressure element, PT is pressure transmitter, electrical line, PIC pressure indicator control. Note, this is a part of distributed control system. Because there is a bounding box and also there is the horizontal line continuous line.

So, this is mounted in the control panel. This is the pneumatic single line which is received by PRV pressure release valve. So, these are very simple examples, and I would like to advise you to look at more complicated examples from books or any other internet sources. But we will be able to analyze the P and ID diagram, if you keep the information's that we just talked about.

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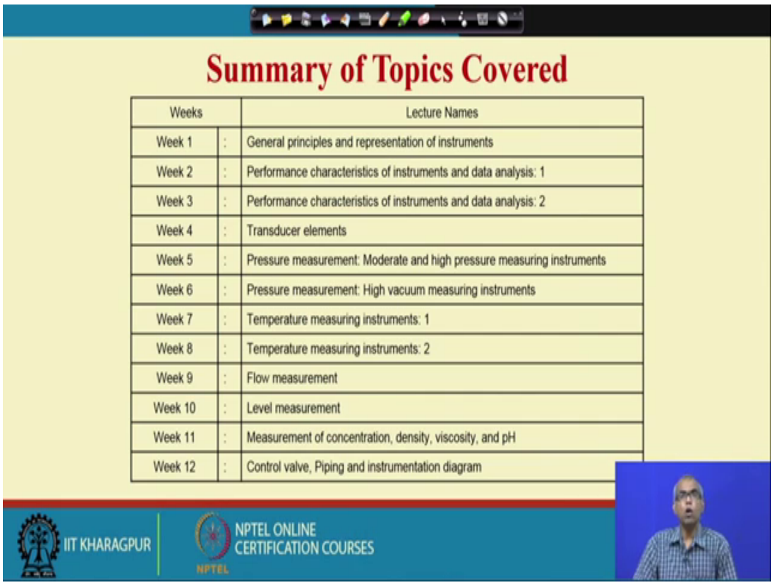

So, these are the summary of the topics that we have covered in this course, we have talked about general principles and presentation of instruments then over 2 weeks we have talked about performance characteristics of instruments and data analysis. We have talked about transducer elements; we have talked about pressure measuring pressure measuring instruments for 2 weeks moderate and high pressure measuring instruments as well as high vacuum measuring instruments.

We have talked about various temperature measuring instruments over 2 weeks, we have talked about flow measurements for one week, 11 measurement for one week. We have also talked about various or miscellaneous measurements such a concentration measurement density viscosity and pH for one week. And this week we talked about control valve and piping and instrumentation diagram. So, we have 2 more lectures left, and what I plan in these 2 lectures. That I will discuss lot of GATE questions that are related to process instrumentation and process dynamics.

So, what the next 2 classes, I will discuss various gate questions that appeared in previous years from the process instrumentations or first order and second order dynamics. These are the topics the gate questions that come that they gate questions that are relevant to this particular course we will discuss in the next 2 classes.