Experimental Methods in Fluid Mechanics
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Lecture - 11
The aneroid barometer, Diaphragm and Bellows Gauges

Good afternoon, I welcome you to this session of Experimental Methods in Fluid Mechanics.

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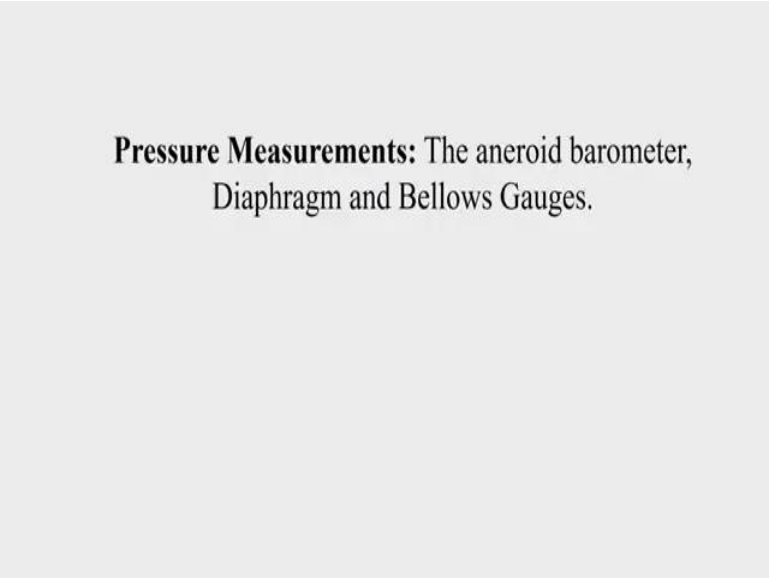

So, today we will discuss about the aneroid barometer and then we will briefly discuss about the diaphragm and the bellow gauges. So, we have seen in my last lecture that the aneroid barometer is very important because this barometer allows us to couple up measurement of atmospheric pressure with a gauge pressure measurement for most of the applications.

So, today we will see, how we can measure pressure using aneroid barometer and to start with I can tell you that this aneroid barometer is essentially a well type manometer with vertical seal arm and we will see its constructional features through a schematic depiction. So, now I will try to draw the schematic of a aneroid barometer and then slowly we will move to discuss about its operational principle and then we will see how we can measure pressure using this barometer. So, aneroid barometer is basically what I said that it is a well type manometer with a sealed, with a vertical sealed arm. So, if I draw the schematic.

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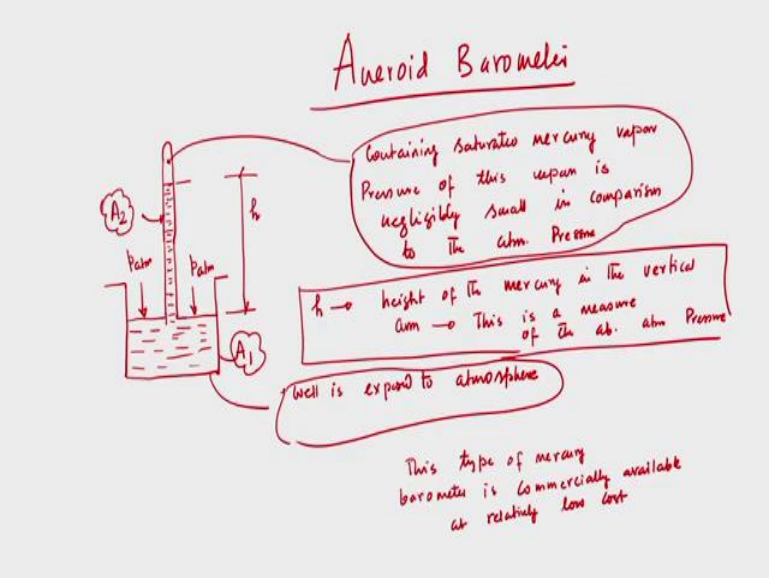

So, today we will discuss about aneroid barometer, I will try to draw the schematic it is a well type manometer. So, this is the schematic depiction, it is having a vertical sealed arm. And now we will try to see the dimension of the sealed arm and what are the other features of this aneroid barometer. Say, this is A1 that is cross section area of the well type manometer well and this vertical height is h. Say, this h is the vertical height of the sealed arm.

So, say this is h and this is the atmospheric pressure P atm, this is also P atm and the cross section area of this sealed arm is A2 and this is A1 for the well and this is the height h. This person which this empty part or this blank portion which is this portion containing saturated mercury vapour, vapour which is, and pressure of this vapour is negligibly small in comparison to, in comparison to the atmospheric pressure.

And what we can see from the schematic that the well is exposed to atmosphere. So, the well is exposed to atmosphere and this h is the height of the mercury in the vertical arm and this is essentially a measurement of the, this is essentially the, or this is, the height h is a measurement of the atmospheric pressure. So, this is measure of the absolute atmospheric pressure.

So these three are the important point to be noted, these three are the important points to be noted. This is a well type manometer which is having a sealed vertical arm, top a portion of the vertical arm is filled up with saturated mercury vapour and the pressure of that portion is negligibly small as compared to the atmospheric pressure. And the well is exposed to (atmosphere) atmospheric pressure that is what is clearly seen from the schematic.

And the height h is measured and this h is a measure of the absolute atmospheric pressure and one scale should be calibrated along the vertical arm through which we can measure the distance traversed by the mercury. Now, this is essentially the constructional feature of a aneroid barometer. And if you can recall that we are discussed, we are fortunate to have this, because fortunately this aneroid barometer allows us to measure rather allow us to couple a measurement of the atmospheric pressure with a gauge pressure measurement for most of the applications.

Now, this type of mercury barometer of these types are very commonly used and are available at a relatively low cost. So, I can write that this type of mercury barometer is commercially available at relatively low cost. One important point that I will mention here that one should take every effort to use temperature correction at each and every measurement.

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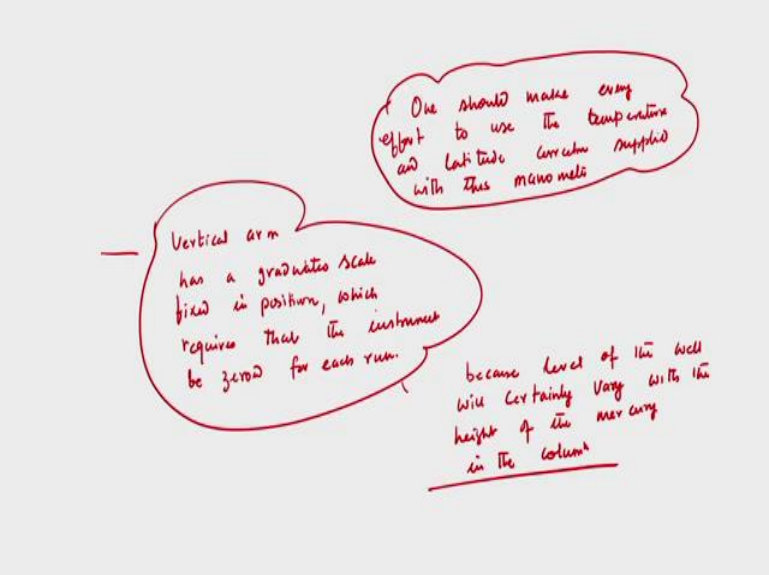

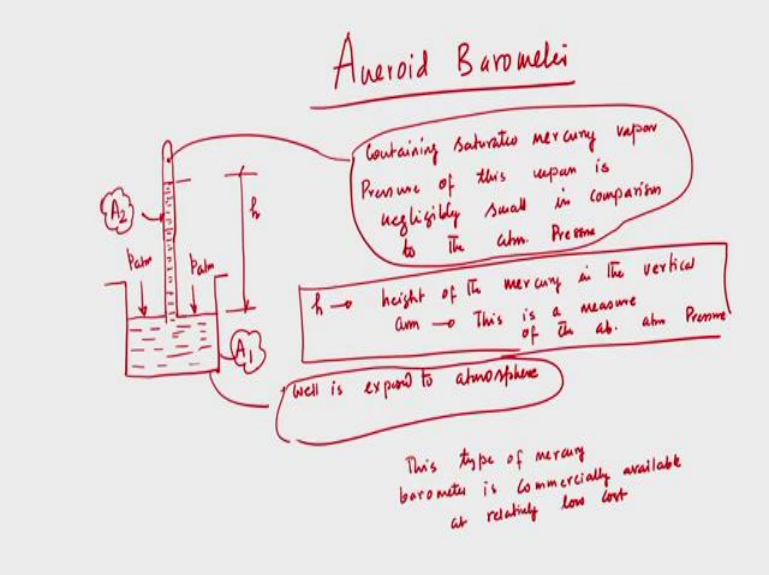

So, I am writing that one should make every effort to use the temperature and latitude correction supplied with this, supplied with this manometer. So, this is important one should make every effort while using this mercury manometer that is aneroid barometer. Now, if we go back to my previous slide here this column of the liquid mercury in the vertical arm that h height that we need to measure.

Now, this column will have a graduated scale fixed in position. So, I am writing this vertical arm has a graduated scale fixed in position. Number two is when requires, sorry, I can write in a different way that this vertical arm, this vertical arm has a graduated scale fixed in position because we need to measure height.

And this measurement which requires that the instrument be zerod for each run. Why? This is the important point that I am mentioning here, why it is important? Because we need to be, vertical army is there, vertical arm and graduated scale is there which is fixed in position but this requires, which requires that the instrument must be zerod for each run.

That means, it indicates that or I can write that because level of the well will certainly vary with height of the, with the height off the mercury in the column. So, at each and every run we must ensure that the instrument must be that scale position, must be zerod because the level, because level of the well will certainly vary with the height of the mercury in the column.

So, this is the aneroid barometer and by knowing the height we can tell what is the absolute atmospheric pressure. And height we can measure using the scale which is fixed with the

vertical arm. Now, we can move to see, another two important types of measuring, pressure measuring instrument is the diaphragm and the bellow gauges.

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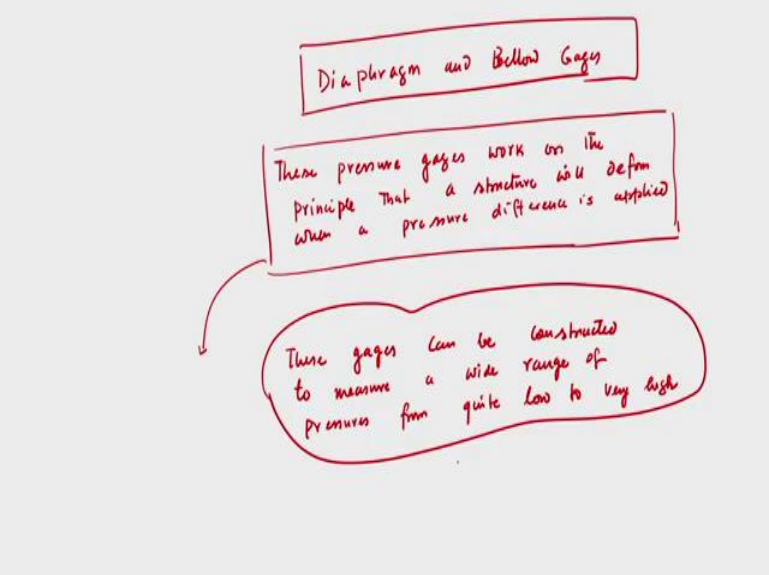

So, diaphragm and bellow gauges, these two types are also there to measure pressure and of course they find applications in different, they find this kind of diaphragm and bellow gauges, find applications in different areas. So, again I will tell you that these pressure gauges work on the principle that a structural deform under the application or when a pressure difference is applied.

So, till now we have seen that, we have seen U-tube manometer, inclined well type manometer and finally aneroid barometer. And we have seen in all the, all these three instruments we have mercury and the change in height of the mercury essentially used to measure pressure.

Now, in the aneroid barometer we have seen that the top portion which contains mercury vapour, but the pressure of the mercury vapour is negligibly small as compared to the atmosphere pressure, so we have ignored that. So, by only measuring the height of the mercury column in the vertical are we can measure the absolute atmospheric pressure.

Now, diaphragm and the bellow gauges, these two types are again used to measure pressure in different applications. But the principle, the working principle of these two different gauges are directly related to the fact that the, a structure is there and that structure will deform one of the application of pressure difference.

So, I can write that this pressure gauge, these pressure gauges work on the principle of, on the principle that a structure will deform when a pressure difference is applied. So, this is the principle by how these two instruments, these two gauges work. Now, construction wise they are bit different but they can be constructed to measure a wide range of pressure from quite low to very high.

So, construction wise these two gauges are not same, but they can be constructed to measure pressure for a wide range starting from a quiet low to very high. So, these two gauges, these two gauges can be constructed, these gauges can be constructed to measure a (pres), to measure a wide range of pressure, to measure a wide range of pressure from quite low to very high. I will discuss them one by one and when I will be discussing diaphragm and bellow gauges I will draw the schematic diagram essentially to have better understanding.

We have seen the working principle, then we have seen that these gauges can be constructed to measure a wide range of pressures starting from a quiet low to very high, not only that these two gauges also enjoy an advantageous features.

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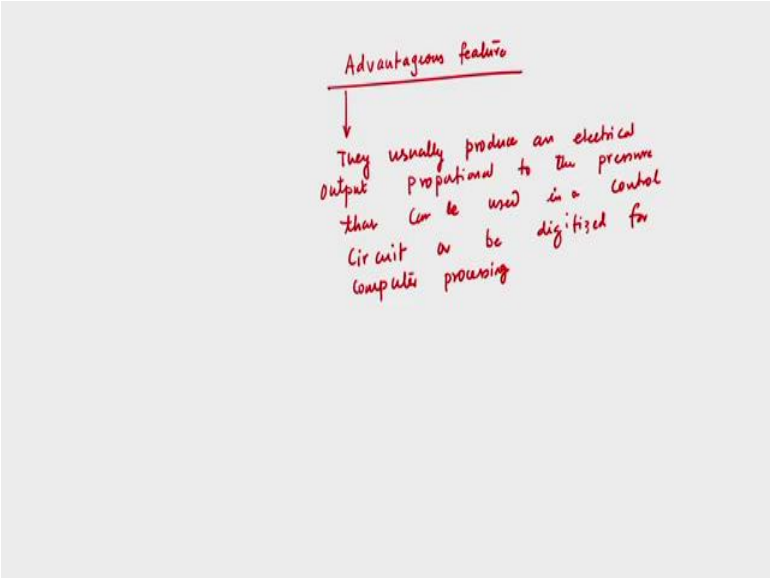

So, what is that? That is, that I am writing here rather I can write on the next page that advantageous feature of these two gauges that they usually produce an electrical output proportional to the pressure that can be used in a control circuit, control circuit or be digitized for computer processing.

So, this is the advantage these two gauges have that they usually produce an electrical output which is proportional to the pressure that can be used in a control circuit or be digitized for the computer processing. So, knowing this now we will see the schematic of a diaphragm gauge and then we will come to see the schematic of a of the bellow gauges rather I will take one example. And then we will see how we can measure pressure using the diaphragm and the bellow gauge.

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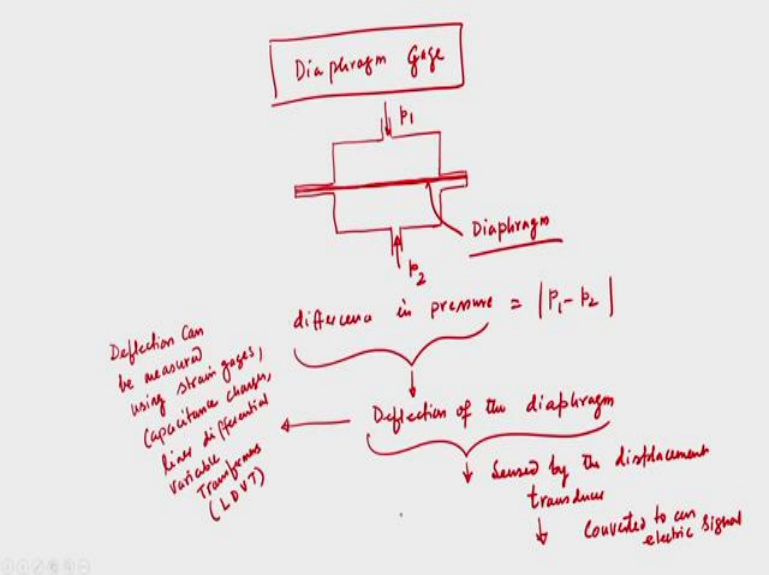

So, I am now drawing the schematic of a diaphragm gauge, diaphragm gauge. If a draw the schematic differential pressure transducer like this. So, we have and so this is say p1 and this is p2 and this is diaphragm, this is diaphragm and so difference in pressure is see p1 minus p2, that is what I said at the beginning that, that is what I said in the beginning that these two gauges work on the principle that there will be a deflection when a pressure difference is applied.

So, now the pressure difference is p1 minus p2. Now, because of this pressure difference there will be a deflection of the diaphragm. So, because of this pressure difference we have seen the, there is a diaphragm, so there will be a deflection of the diaphragm. Now, this deflection will be sensed by the displacement, suitable displacement transducer, and this deflection will be sensed by the displacement transducer.

And this displacement, this displacement can be converted to the electrical signal. Now, this can be converted to an electrical signal. So, this is clear that this gauge is having one diaphragm that is what I said in the beginning, the deformation of the diaphragm will be there

if we apply pressure difference, the deformation will be, and because of this deformation rather there will be deflection of the diaphragm and that (deflec) because of the deflection there will be displacement and that displacement will be sensed by the displacement transducer.

And that displacement can be converted into the electric signal and we will measure the electric signal in the as a output. Now, this is the diaphragm gauge. Now, this deflection how can we measure? So, deflection of the diaphragm can be measured and that could be sensed by displacement transducer. This deflection of the diaphragm, this deflection can be measured, deflection can be measured by or I can say using strain gauges or capacitance changes or which we know commonly that is known as LDVT that is linear differential variable transformer that is LDVT.

So, diaphragm gauge if we apply pressure difference, there will be a deflection of the diaphragm the deflection of the diaphragm can be measured using strain gauges or by measuring the change in capacitance or by using a linear differential variable transformer, if we measure the deflection that will be sensed by the displacement transducer and then equivalently if you can convert into the electric signal and which is the output of the device that is a measured pressure difference.

So, this is the operational principle of a diaphragm gauge and again I am telling this gauge is used to measure pressure difference which is of course as we said a long back that in most of the fluid dynamic applications, we are interested in to measure gauge pressure, not the absolute pressure, while in most, rather all the thermodynamic applications we are interested in to measure the absolute pressure.

So, this gauge pressure that is the pressure difference that is what we have defined in one of my lectures that; what is absolute pressure, what is gauge pressure? That can be measured using this diaphragm gauge. Now, next I will discuss about the bellow gauges, I mean we will discuss taking a typical example and showing a schematic depiction, schematic depiction of the bellow gauge.

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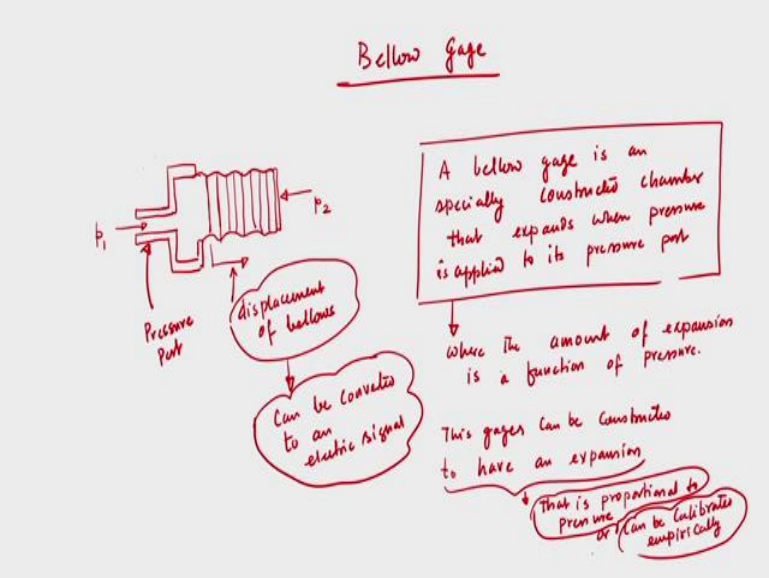

So, bellow gauge again if I draw the schematic then, like this, so this a bellow gauge, this is schematic depiction of a bellow gauge, again we can see that it works on the principle of a displacement or deformation of a structure where you apply pressure difference that is p1 minus p2.

Now, we can see that here this is a schematic, this typical bellow gauge and the (schema) schematically I have drawn here. Now, a bellow gauge is and I am writing a few lines about this, then I will explain. A bellow gauge is an specially constructed chamber that expands when pressure applied to its pressure port. So, this is pressure port and when you apply it pressure at its port, so when you apply pressure at its port, then it is a specially constructed chamber and that chamber will try to (exp) will expand upon experiencing this applied pressure.

And we have to measure now something so that we can now measure the pressure difference as a function of something that is what we will get from the bellow gauge. Now, we will, we have seen that we have written bellow gauge is an specially constructed chamber that expands when pressure is, pressure is applied, when pressure is applied, when pressure is applied to its pressure port where, where I said that something we need to measure that we will measure the expansion where the expansion rather where the amount of expansion is a function of pressure.

So, this amount of expansion is a function of pressure and these are the bellows and with time it will expand that is what we have seen that we have drawn a few lines, so with time it is

expanding, is expanding. Now, the arrow shows the movement of the bellows under the application of pressure.

So, now this displacement of bellows that is what we need to measure that is what is the expansion of the chamber. Now, this expansion we have to correlate and that is with, that expansion we need to correlate with certain quantities so that we can measure because expansion is a function of the pressure.

Now, this displacement of the bellows that can be converted, can be converted to an electrical, electric signal that is what we have seen for the last case as well. So, now if we convert the displacement to an electric signal, then from there we can measure the amount of expansion and which will, which will give us the measured pressure difference that we have, pressure difference that we have applied, that is a gauge pressure essentially.

So, now another one important thing is that these gauges can be constructed to have an expansion and that is proportional to the pressure or can be calibrated empirically. So, I can write that this gauges can be constructed in such a way that we will have expansion. That means, the constructional feature of this gauge will allow to have expansion of the, expansion of a system and by measuring the expansion of the system and converting that measurement into an electric signal, we can measure the gauge pressure.

So, provision should be there rather these gauges can be constructed to have an expansion, to have an expansion, not only that provision will be there to have an expansion when we apply pressure at its port so the gauges can be constructed to have expansion, not only that this expansion is proportional to rather this expansion that is proportional to pressure, that is proportional to the pressure, if it is proportional pressure we can directly get, if it is not proportional to the pressure that expansion then we can calibrate empirically to have the measured value of the pressure. That is proportional to the pressure or can be calibrated empirically.

So, these are the important points that we should know about the working principle of a bellow gauge that first of all this is a bellow gauge, first a fall a bellow gauge is an specially constructed chamber and that chamber will have provision of expansion under the application of pressure that we, that we would like to measure.

So, when we apply pressure at the port, the system will allow us to have, the system will, the design will be such that a system will expand and that expansion will measure and the expansion maybe the, can be the proportional to the pressure so that we can get direct measurement or if the expansion is not proportional to the pressure then at least the expansion can be calibrated empirically to obtain the pressure that is what we are interested in.

So, today what we have seen that, today discussed about three important pressure measurement instruments rather pressure measuring instrument. One is the aneroid barometer, where we have seen that we have mercury the well, the aneroid barometer is essentially a well type manometer, where it is having extra one vertical arm, sealed arm rather and atmospheric pressure allows to move mercury into the sealed arm and the sealed arm will have a calibrated scale fixed with it.

And by measuring the height we can directly measure the (abs) absolute atmospheric pressure. And we have seen that we need to have temperature latitude correction and at the, at for each and every run we need to make sure that the instrument must be zerod because the, that is what we have seen that level of the well will certainly vary with the height of the mercury in the column.

Next, we have discussed about the diaphragm and bellow gauges, diaphragm and bellow gauges they are working on the principle of that, a system will rather deform when a pressure difference is applied, in a diaphragm gauge one diaphragm is there and when we apply pressure difference diaphragm will deflect, the deflection will measure using either using strain gauge or by measuring the capacitance change or by linear differential variable transformer LDVT or.

And then we can measure that displacement that will be converted to electric signal and from there we can measure the pressure. And finally, we have discussed about the constructional feature of a bellow gauge and we have seen that the bellow gauge is an specially constructed device where if we apply pressure at the port the gauge will have a system that will expand and while it is expanding we will measure the displacement.

Now, so provision will be there for the expansion of a system if we have that expansion is directly proportional to the pressure we can directly get it or if it is not the case that at least the expansion that is what we are measuring that can be calibrated empirically to know the pressure that is what we are going to measure.

These three pressure measuring devices or instruments we have discussed that these are used typically to measure rather is to measure a wide range of pressures, basically from a very low to very high, I cannot say from very low but from quite low to very high. But we need to know that if we need to measure pressure which is very small, then whether the devices, instrument we have discussed so far, we can measure pressure using those devices or equipment that is fine.

If we cannot measure using those devices then what will be the extra or additional feature to measure, to be equipped with a device to measure such a low pressure and also their working principle. So, we will discuss that aspects rather how we can measure low pressure using other pressure measurement, pressure measuring devices or instrument and we will see to measure the low pressure what are the constructional features there and whether these constructional features are different from those what we have seen in the manometer, inclined well type manometer and this diaphragm and bellow gauges. So, with this discussion, I stop here today and we will continue our discussion in next class. Thank you.