

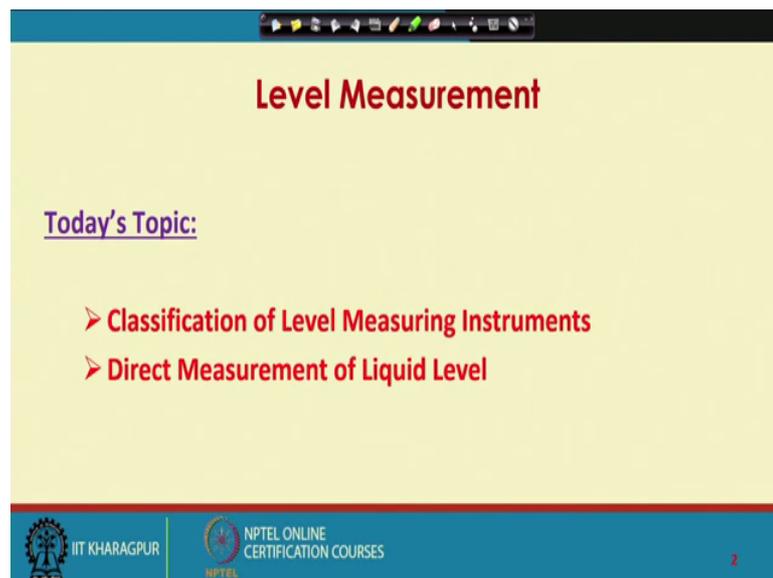
**Chemical Process Instrumentation**  
**Prof. Debasis Sarkar**  
**Department of Chemical Engineering**  
**Indian Institute of Technology, Kharagpur**

**Lecture - 46**  
**Level Measurement**

Welcome to 10; lecture 46. So, today will start our discussion on Level Measurements. Similar to Temperature pressure flow measurements, measurement of levels is also an important activity in any chemical process industries. Industries are required to store several liquids in large containers. There required to store several liquids such as sub various solvents, fuels, waters, other utility liquids etcetera.

So, it is required that industries keep a track of how much liquid or how much solvents, water etcetera is there in the large containers at any given point of time. So, that replacement can be done, whenever it is required. Although normally by level measurement, we talked about measurement of liquid level. Measurement of solid level is also important in certain industries. Particularly, measurement of level of powders, granular solids etcetera; So, today, we will start our discussion on Liquid Level Measurements.

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**Level Measurement**

**Today's Topic:**

- **Classification of Level Measuring Instruments**
- **Direct Measurement of Liquid Level**

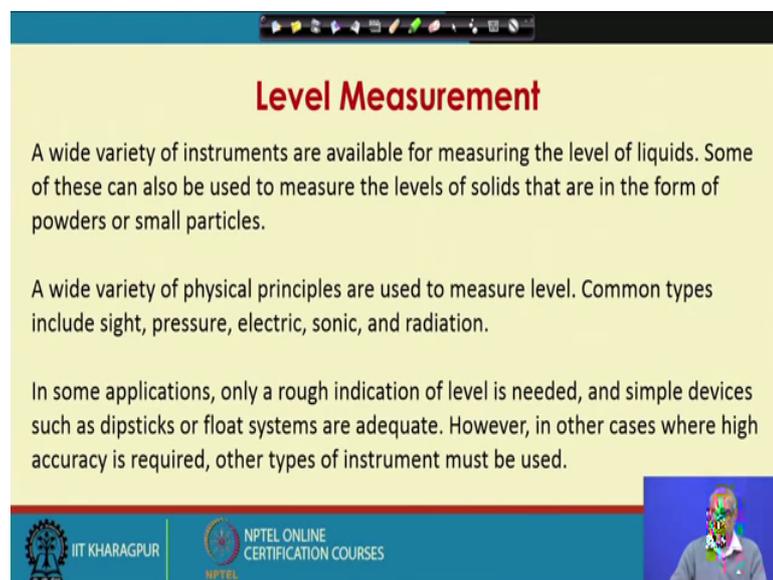
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So, today what will do is if first classify various level measuring instruments that are available. Some of these instruments can also measure level of solids or granular solids

and then, we will talk about some level measuring instruments that you call Direct Liquid Level Measuring Instruments.

So, wide variety of instruments are available for measuring the level of liquids, some of these can also be used to measure the levels of solids that are in the form of powders or small particles; meaning granular solids. A wide variety of physical principles are used to measure levels. So, if you have various instruments various instruments will be based on different principles.

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**Level Measurement**

A wide variety of instruments are available for measuring the level of liquids. Some of these can also be used to measure the levels of solids that are in the form of powders or small particles.

A wide variety of physical principles are used to measure level. Common types include sight, pressure, electric, sonic, and radiation.

In some applications, only a rough indication of level is needed, and simple devices such as dipsticks or float systems are adequate. However, in other cases where high accuracy is required, other types of instrument must be used.

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So, a wide variety of physical principles are used to measure liquid levels. Common types include sight, pressure, electric, sonic and radiation; For example, will see later that the instrument based on radiation principle can be used for measurement of Liquid level as well as Solid level.

So, sight, pressure, electric, sonic and radiation; these are the various physical principles that are used to measure liquid level and some of these can also be used to measure solid level. In some applications only a rough indication of level is needed and simple devices such as dipsticks or float systems are adequate. However, in other cases for high accuracy is required other types of instruments must be used.

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**Liquid Level Measurement**

Liquid level may be expressed in terms of

- the pressure the column exerts over a datum level
- or
- the length of the liquid column

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Liquid level may be expressed in terms of the pressure of column that it exerts over a datum level or the length of the liquid column.

So, Liquid level can be expressed either in terms of the pressure the column exerts over a datum level; that means, in terms of head or the length of the liquid column.

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**Liquid Level Measurement: Classification**

A. Direct Measurement of Liquid Level:	B. Indirect Measurement of Liquid Level:
- Dipstick	- Hydrostatic head type
- Hook type	- Bubbler or purge type
- Sight glass	- Capacitance type
- Float type gage	- Ultrasonic type
- Displacer type	- Radiation type

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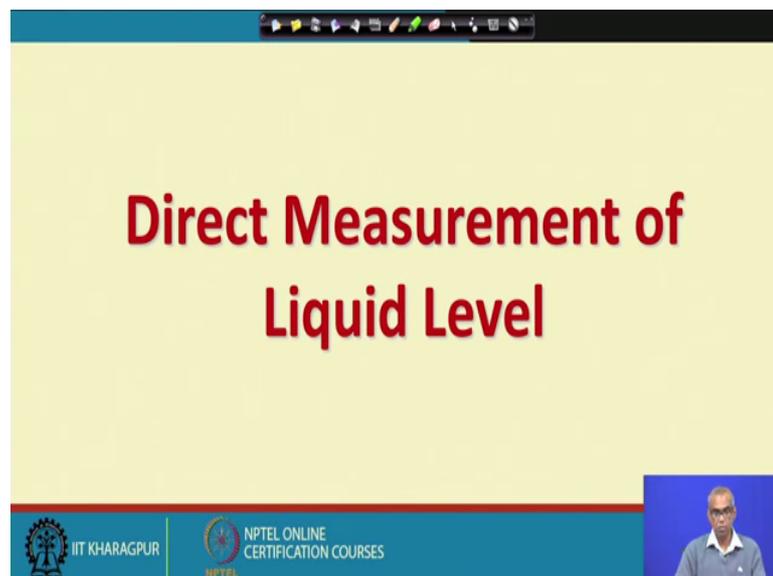
So, this is one possible classification of level measuring instruments. Broadly you classify them into two categories. Direct Measurement of Liquid Level, Indirect Measurement of Liquid Level. So, under Direct Measurement of Liquid Level, we have

Dipsticks, Hook type, Sight glass, Float type level measuring gage, Displacer type level measuring gage.

So, Dipsticks, Hook type, Sight glass, Float type and Displacer type; all fall under the category of Direct Level Measuring Instruments. Indirect Measurement of Liquid Levels, here, we do not measure the liquid level directly, but we measure something else and infer the value of liquid level from that. For example, if you consider a liquid content in a tank let us say open tank of non dimensions and if I measure the pressure at the bottom of the tank using a pressure measuring instrument; I know that this pressure  $p$  equal to density of the liquid tanks acceleration due to gravity times the length of the liquid in the tank.

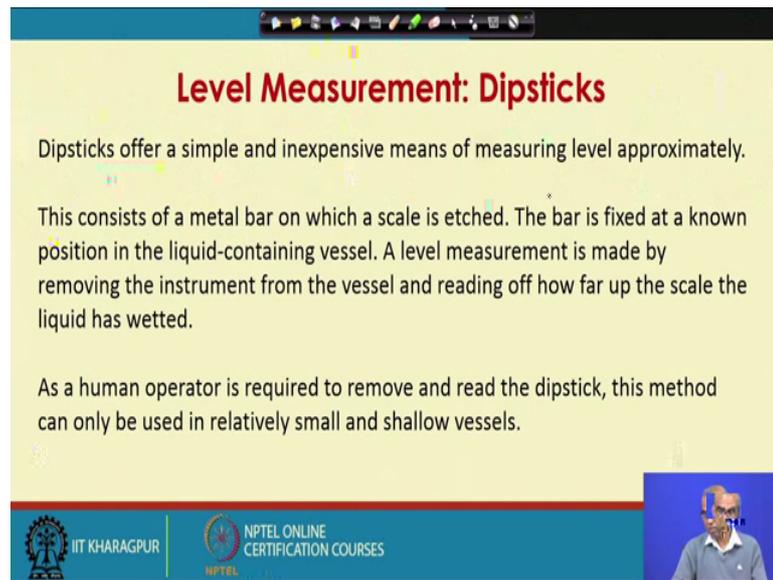
So,  $p$  equal to  $\rho g h$  is a familiar equation. So, if I know if a measure pressure, I know the density of the liquid; then, I can calculate easily the level of the liquid in the tank that is gage. So, I measure some property related to the pressure and then, infer the value of the level from this information. So, under Indirect Measurement of Liquid Levels will have Hydrostatic pressure type, Bubbler or purge type, Capacitance type, Ultrasonic type, Radiation type.

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So, let us start with Direct Measurement of Liquid Level, will start with Dipsticks.

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**Level Measurement: Dipsticks**

Dipsticks offer a simple and inexpensive means of measuring level approximately.

This consists of a metal bar on which a scale is etched. The bar is fixed at a known position in the liquid-containing vessel. A level measurement is made by removing the instrument from the vessel and reading off how far up the scale the liquid has wetted.

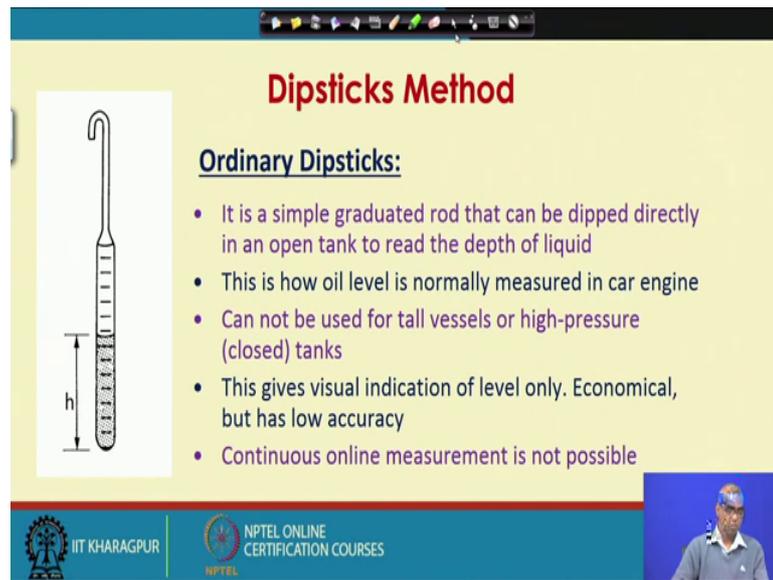
As a human operator is required to remove and read the dipstick, this method can only be used in relatively small and shallow vessels.

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Dipsticks offer a simple and inexpensive means of measuring level approximately. It can measure liquid level only approximately. Dipstick consists of a metal bar on which a scale is etched. The bar is fixed at a known position in the liquid-containing vessel. A Level Measurement is made by removing the instrument from the vessel and reading of how far up the scale the liquid has wetted.

So, this is an extremely simple way of measurement of liquid level. It is something like putting a scale in a container which contains the liquid level and we see that how far the scale is wetted by the liquid. As a human operated is required to remove and read the dipstick, this method can only be used in relatively small and shallow vessels.

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**Dipsticks Method**

**Ordinary Dipsticks:**

- It is a simple graduated rod that can be dipped directly in an open tank to read the depth of liquid
- This is how oil level is normally measured in car engine
- Can not be used for tall vessels or high-pressure (closed) tanks
- This gives visual indication of level only. Economical, but has low accuracy
- Continuous online measurement is not possible

The slide includes a diagram of a dipstick with a curved top and a graduated scale. A vertical line labeled 'h' indicates the height of the liquid level in the dipstick. The slide also features logos for IIT KHARAGPUR and NPTEL ONLINE CERTIFICATION COURSES, and a small video inset of a presenter in the bottom right corner.

So, an Ordinary Dipstick is shown here. It is a simple graduated rod that can be dipped directly in an open tank to read the depth of liquid. You can see the graduations on the dipstick. This is how oil level is normally measured in car engine. A dipstick cannot be used for tall vessels or high-pressure tanks because high pressure tanks must be closed tanks.

Dipsticks gives visual indication of level only. It is Economical, but has low accuracy. It is not possible to have continuous online measurement using such a simple method of measurement, but where only a rough indication of the liquid level is necessary this will give you an approximate indication of the liquid level in the tank or the container.

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**Level Measurement: Optical Dipsticks**

If the level of liquid is below the optical dipstick, due to total internal reflection, the light from a source is reflected from a mirror, passes round the chamfered end of the dipstick, and enters a light detector after reflection by a second mirror.

When the chamfered end comes into contact with liquid, its internal reflection properties are changed and light is transmitted into the fluid and no longer enters the detector.

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This is a slightly improved version of dipsticks; we call it Optical Dipsticks. So, what is done is as follows. You have a Light source here.

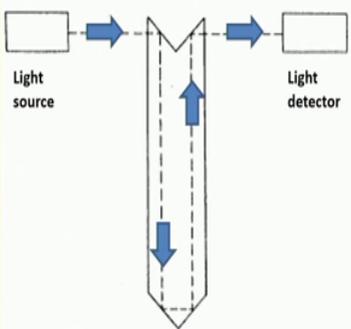
So, he send the beam of light which gets reflected by this mirror. Then, it goes down passes round the chamfered end. This is the chamfered end passes round the chamfered end of the dipstick and the beam returns again gets reflected by another mirror and enters the light detector. So, if the liquid level is below the Optical Dipstick due to total internal reflection the light from a source is reflected from a mirror passes round the chamfered end of the district and enters a light detector after reflection by second mirror.

Now, if the liquid level is say here; then, what happens is liquid level now will not reach sorry the light will not now reach the detector. When the chamfered end comes into contact with liquid, its internal reflection properties are changed and light is transmitted into the fluid and no longer enters the detector.

So, if the liquid level is below the chamfered end of the dipstick, the light detector will receive the light. When the liquid level is above the chamfered end or when the dipstick is in contact with the liquid level; then, the liquid will be transmitted into the fluid and the detector will not get the life. So, if I can bring this dipstick or if I can move this dipstick, move dipstick up and down; it should be possible for me to find out the level of the liquid by noting when the detector does not receive light.

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### Level Measurement: Optical Dipsticks



By using a suitable mechanical drive system to move the instrument up and down and measure its position, the liquid level can be monitored.

The optical dipstick allows a reading to be obtained without removing the dipstick from the vessel. Therefore it is applicable to larger and deeper tanks.

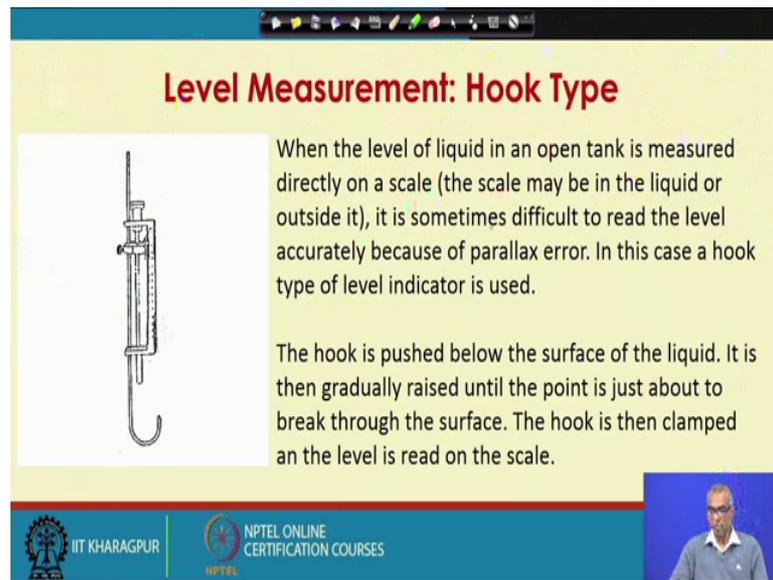
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So, by using a suitable mechanical drive system to move the instrument up and down and measure its position, the liquid level can be monitored. The optical dipstick allows a reading to be obtained without removing the dipstick from the vessel. Therefore, it is applicable to larger and deeper tanks. Unlike ordinary dipstick, it is not necessary that we have to remove the dipstick from the tank.

But of course, there should be a mechanical drive system to move the instrument up and down. So, that the liquid the chamfered end of the dips of the optical dipstick comes in contact with the top surface of the liquid level and the light translate into the fluid and does not come back to the detector.

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**Level Measurement: Hook Type**

When the level of liquid in an open tank is measured directly on a scale (the scale may be in the liquid or outside it), it is sometimes difficult to read the level accurately because of parallax error. In this case a hook type of level indicator is used.

The hook is pushed below the surface of the liquid. It is then gradually raised until the point is just about to break through the surface. The hook is then clamped and the level is read on the scale.

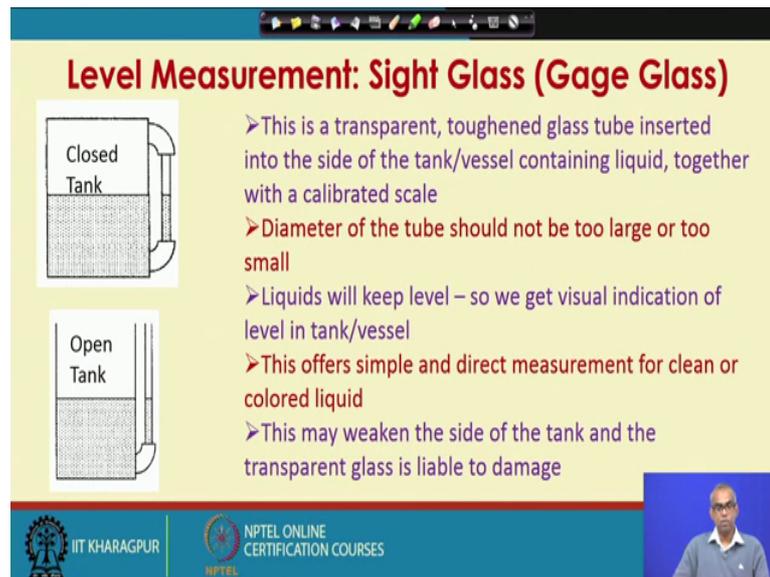
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The slide features a diagram of a hook-type level indicator on the left, which consists of a vertical scale with a hook at the bottom. The hook is shown partially submerged in a liquid. The text on the right explains the principle of operation and the purpose of using this type of indicator to avoid parallax error. The slide is part of an NPTEL online certification course from IIT Khargapur, as indicated by the logos at the bottom. A small inset video of the presenter is visible in the bottom right corner.

Next we talk about Hook Type level measuring instrument. So, this is another very simple way of measuring liquid level. When the level of liquid in an open tank is measured directly on a scale, the scale maybe in the liquid or outside it, it is sometimes difficult to read the level accurately because of parallax error. In this case a hook type of hook type of level indicator is used. What you see is a hook type of liquid level measuring instrument.

So, this is the hook and here, you have scale. The hook is pushed below the surface of the liquid. It is then gradually raised until the point is just about to break through the surface. The hook is then clamped and the level is read on the scale.

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**Level Measurement: Sight Glass (Gage Glass)**

**Closed Tank**

**Open Tank**

- This is a transparent, toughened glass tube inserted into the side of the tank/vessel containing liquid, together with a calibrated scale
- Diameter of the tube should not be too large or too small
- Liquids will keep level – so we get visual indication of level in tank/vessel
- This offers simple and direct measurement for clean or colored liquid
- This may weaken the side of the tank and the transparent glass is liable to damage

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Next we will talk about Sight Glass or Gage Glass as level measuring instruments. We are talking about direct measurement of liquid level. Sight glass or gage glass is another very simple level measuring instruments. It can be used to measure level of open tank as well as close tank. So, sight glass or gage glass is nothing but a transparent, toughened glass tube inserted into the side of the tank or vessel containing the liquid and there is a calibrated scale etched on the toughened glass tube which is the sight glass. So, this is the sight glass.

So, sight glass or gage glass is a transparent toughened glass tube inserted into the side of the tank or vessel containing the liquid, together with a calibrated scale. Diameter of the side glass tube should not be too large or too small. If it is too small, there can be capillary effect. Liquids will keep level - so, the liquid level in the tank as well as in the sight glass will be same and we can get the visual indication of the level in the tank or the vessel.

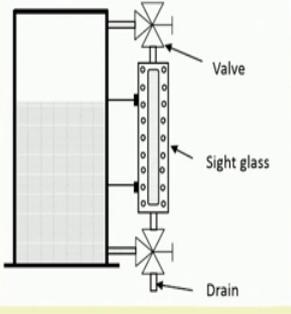
So, sight glass offers simple inexpensive and direct measurement for clean or colored liquid. Since, we are inserting this sight glass to the tank; this may weaken the side of the tank. Also the transparent glass is liable to be broken or damaged.

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### Level Measurement: Sight Glass (Gage Glass)

Usually, the sight glass gages are installed with manual shut-off valves at both ends. This is useful as we can isolate the gage easily during maintenance/failure/replacement.

Usually, ball-check valves are used as the shut-off valves.

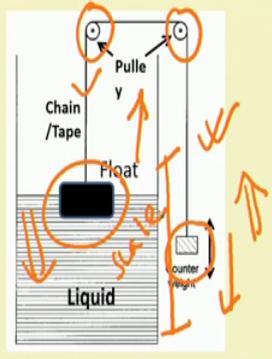


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Usually, the sight glass gages are installed with manual shut-off valves at both ends. So, you have a shut-off valve you have another shut of valve. This is useful as you can isolate the gage easily during maintenance or failure or quite replacement is necessary. Usually, ball-check valves are used as the shut-off valves.

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### Level Measurement: Float-Chain Type



- The design shown here is for open tank.
- A flexible chain or tape passes over a drum type pulley holds the float on one side and a counter weight on the other end.
- Density of float material is less than the density of liquid.
- Float rides the surface level to provide the measurement. Range: 15 cm to 20 m
- The float is usually made of copper with nickel plating to avoid rusting.
- Gage is almost independent of liquid

Many different designs are available

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Next we talk about Level Measurement by Float. There are various different designs available which makes use of Float for indication of liquid level in a tank or in a large tall vessel. The design that is shown here is for open tank. A flexible chain or tape passes

over a drum type pulley holds the float on warning and a counter weight on the other end. So, we have a float that I have put on the surface of the liquid level in the tank and there is a counter weight and this float and counter weight are connected by a flexible chain or tape and chain stay in a tape passes over this pulley. So, a flexible chain or tape passes over a drum type pulley and this flexible chain or tape holds the float on one side and a counter weight on the other end. Density of float material is less than the density of the liquid.

So, the so, float will always be on the surface of the liquid. So, as the liquid level changes, the float rides the surface level. So, as the liquid level goes down, the float also comes down with the surface of the liquid level. As the liquid level goes up, float also goes up with the surface level increasing. So, float rides the surface level to provide the measurement. So, as the float goes up, the counter weight will come down. As the float comes down, the counter weight will go up. So, if I attach a scale here, the position of the counter weight against the scale will tell me the position of the float inside the tank and the position of the float is nothing but the measure of an indication of liquid level. So, this scale can be calibrated directly in terms of liquid level in the tank.

So, from the position of the counter right against the scale, I can know the position of the float inside the tank and position of the float will tell me the level of the liquid inside the tank. As the float goes up the level of the liquid inside the tank is more. As the float comes down, the level of the liquid inside the tank is less. The typical range is around 15 centimeter to 20 meter. If you visit a chemical process industry most likely you will see this float chain type liquid Level Measurement as attached to very tall large storage tanks. So, typical range is up to 20 meter. The float is usually made of copper with nickel painting to avoid rusting. Note their Gage is almost independent of liquid density.

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**Level Measurement: Float-Chain Type**

Another design is shown.

Standard floats are spherical or cylindrical.

Use bigger diameter float for low density liquid, and vice versa.

Spherical float diameter: 75 mm to 175 mm

The diagram illustrates a float chain mechanism. A float, labeled 'Ball/Float', is connected to a weight, labeled 'Weigth'. The float is shown in a liquid container, and the weight is shown above it. A chain or tape connects the float and the weight, passing through a pulley. A pointer is attached to the chain, moving against a scale as the float rises or falls. The diagram is annotated with orange handwritten marks, including a checkmark and a scribble.

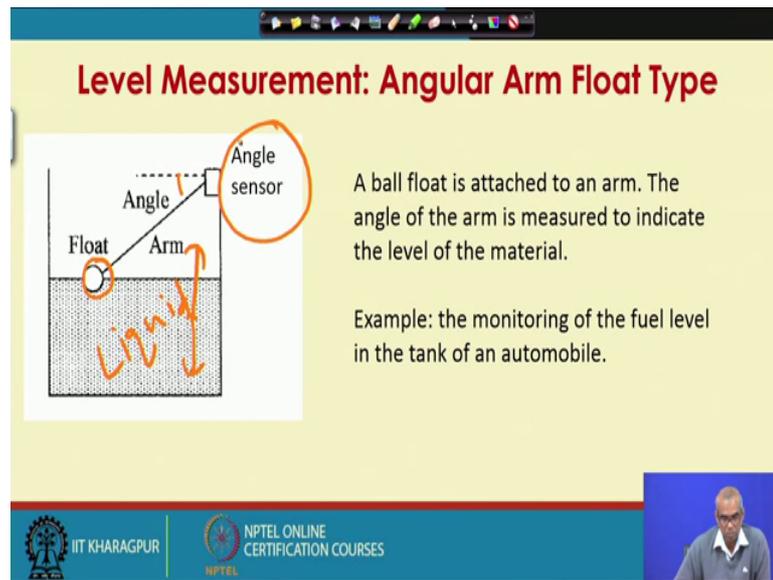
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As you mentioned that there are various designs available.

So, this is another variation. So, here this is the float which is usually a spherical ball. This is the weight float and ball. Float and the weight of the counter weight is connected by this flexible tape or chain. This passes through this pulley and here, I have a pointer. Here, I have attached the pointer which moves against this scale as the float goes up or comes down. Standard floats are spherical or cylindrical.

We should use bigger diameters float for low density liquid and vice versa. So, use bigger diameter float for low density, use smaller diameter float for high density liquid. Typically a spherical float will have diameter in the range of 75 millimeter to 175 millimeter.

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**Level Measurement: Angular Arm Float Type**

A ball float is attached to an arm. The angle of the arm is measured to indicate the level of the material.

Example: the monitoring of the fuel level in the tank of an automobile.

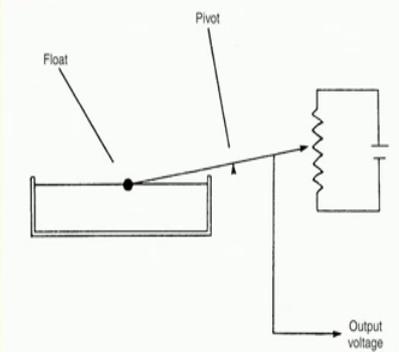
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Another variation of Float type liquid Level Measurement, what you see is known as Angular Arm Float Type liquid level measuring instrument. So, a ball float is attached to an arm. The angle of the arm is measured to indicate the level of the material. So, you have the Liquid in this tank and I have a float and this angle will change with change in the liquid level.

So, if I can measure this angle using an angle sensor, I can take that as an indication of the liquid level. The monitoring of the fuel level in the tank of an automobile uses this principle.

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### Level Measurement: Float Type Transducer



Movement of the float can be tracked by attaching a potentiometer or LVDT to it.

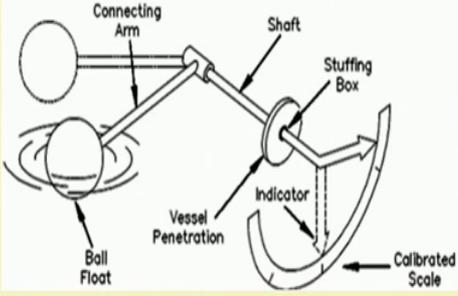
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It is possible to have a Float Type liquid level measuring Transducer; A Float Type liquid level Transducer. As of now what we have seen is float chain type instrument; where, we use a chain to connect the float and a counter weight. And now, I read the position of the float either by looking at the position of the counterweight against the scale or it is also possible to activate the movement of a pointer against the scale as the pulley brings this float up or the float goes down with the change in the liquid level. Now, it is also possible to track the movement of the float by and electromechanical sensor such as LVDT or with help of a potentiometer.

So, what will do is as the figure shows this is the float. We have a pivot here and this is an arm in this potentiometer. So, movement of the float can be tracked by attaching a potentiometer or LVDT to it.

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**Level Measurement: Float-and-Shaft Type**



Usually meant for closed pressure vessel. But it can also be adapted for open vessel.

Float → Connecting arm → Rotary shaft passing through vessel wall through a Stuffing box → Pointer travels over a circular scale.

For a spherical float, highest sensitivity is obtained when float is half immersed.

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Next we talk about Float and Shaft Type liquid Level Measurement. Float and Shaft Type liquid Level Measurement is usually meant for closed pressure vessel. But it can also be adapted for open vessel. I have this float which is often a spherical ball float. Then, this connecting arm is attached to this float at one end and this connecting arm is attached to the rotary shaft at the other end.

This rotary shaft passes through the wall of the tank through a stuffing box and the other end of this rotary shaft is connected to a pointer which will travel over a circular scale. So, as the float changes its position, the rotary shaft will cause the pointer to travel against the circular scale.

So, float is connected to the connecting arm and the connecting arm is connected to the rotary shaft which passes through the vessel wall through the stuffing box. A pointer is attached to the rotary shaft. Thus, as the float changes its position with change in liquid level the pointer travels against a circular scale and the circular scale can be directly calibrated in terms of level units.

Note that with help of the stuffing box, it is possible for me to take the shaft outside the tank. For spherical float, highest sensitivity is obtained when float is half immersed; So, will stop our discussion today here.