Inspection and Quality Control In Manufacturing
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Lecture – 13
Leak Testing

Hello my friends today we are going to start our new subchapter that is leak testing. So, before going to start just let us know that what is leak. So, from the beginning or maybe what comes in our mind is that leak is nothing but any kind of pores or maybe any kind of holes through which the materials is coming out from the system itself.

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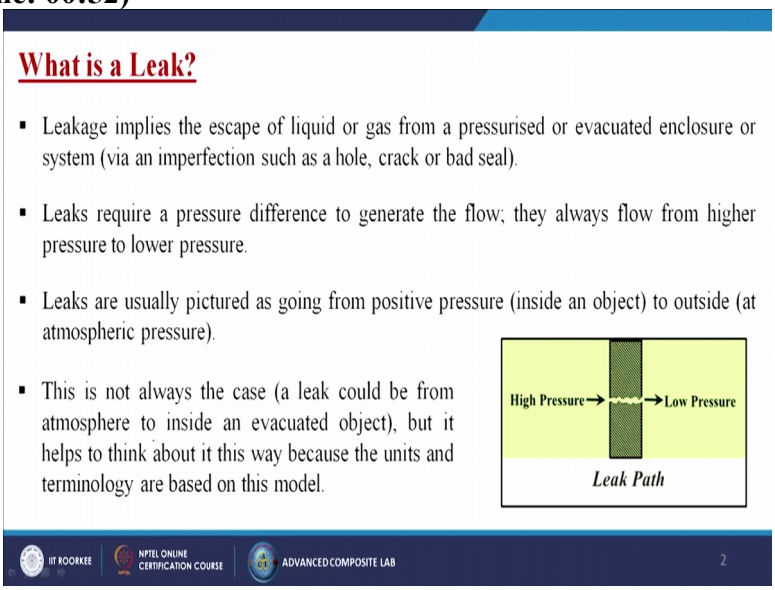

But if we talk about the technical term then the leakage implies the escape of liquid or gas from a pressurized or evacuated enclosure or system via an imperfection such as hole maybe the track or maybe the bad seal. So, bad seal generally for the engine blocks or maybe any kind of sealed equipment where you are using some oil inside it and we can find some kind of leakage over there.

Leaks require a pressure difference to generate the flow they always flow from higher pressure to the lower pressure. So, that is why I am talking about the leakage that when you are using a high pressure fluid into some container maybe into some vessels so due to that pressure difference the leak liquid is coming from that particular container and vessels through some holes or maybe the cracks or maybe some kind of seal leakage.

Leaks are usually pictured as going from positive pressure inside an object to outside at atmospheric pressure. So, simple we are having this one is the closed vessel this one is the closed vessel wall thickness. So, we are having any kind of cracks over there so from high

pressure the oil or maybe the liquid was there. Now it has got some kind of crack over there through that the liquid is coming outside the systems and which is the low pressure is simple but the atmospheric pressure over there.

So, this is not always the case a leak could be from atmosphere to inside an evacuated object also but it helps to think about is it this way because the units and terminology are based on this particular model.

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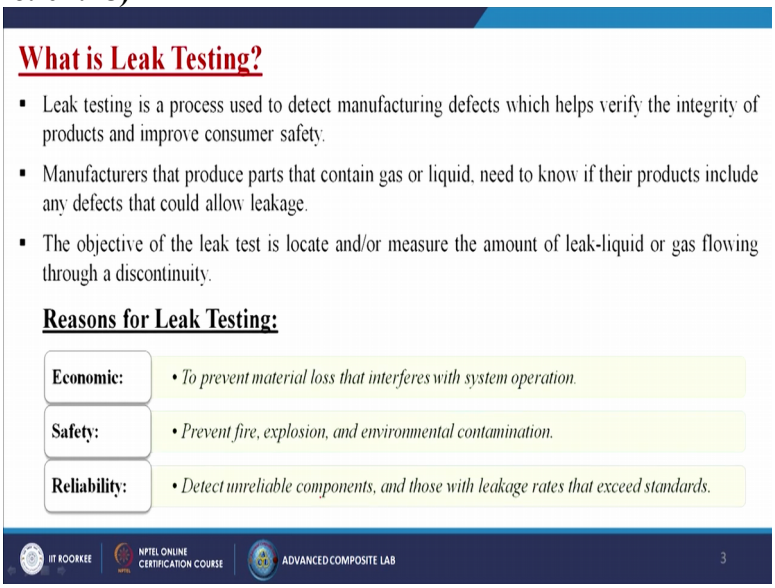

So, what is leak testing so from the name itself we can understand there are certain kind of testing techniques are available by which we can detect the leak. So, leak testing is a process used to detect manufacturing defects which helps verify the integrity of products and improve that consumer safety itself, manufacturers that produce the parts that content gas or liquid need to know if their products include any defects that could allow leakage.

So, now you can understand in the petroleum industry or maybe that gas industry where we are sending the liquid through the pipes or maybe the gas through the pipes then that time this kind of techniques is highly required. The objective of the leaks test will locate and to measure the amount of leak liquid or maybe the gas flowing through a discontinuity. Reasons, so generally an economical reason is that to prevent the material loss that interfaces with system operations.

If we talk about the safety prevent fire explosion and the environmental contaminations and when you are talking about the reliability we take the unreliable components and those with leakage rates that exceed our standard itself.

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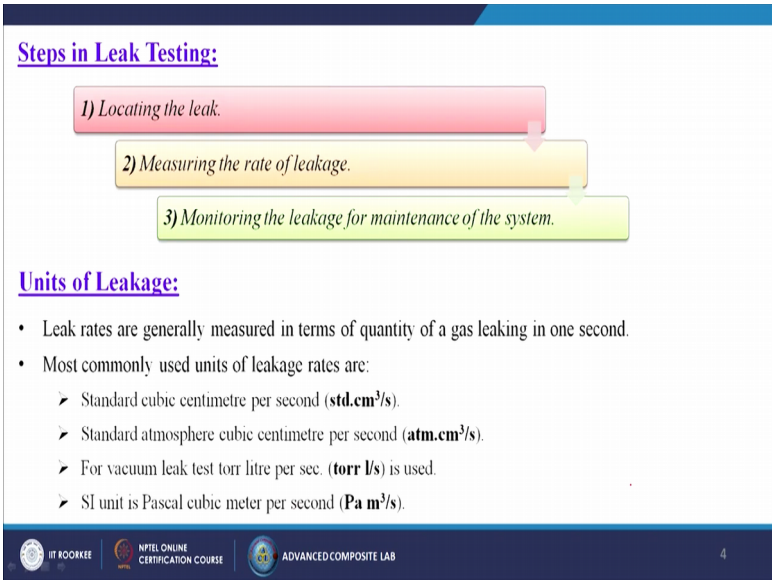

Now steps in the leak testing what are those first of course locating the leak means which exactly the locations where it has been formed. Then measuring the rate of leakage means how fast or maybe the how slow the material is coming out through this hole or maybe the ports and third one is the monitoring the leakage for maintenance of the system whether that leakage is within the permissible limit within the tolerance limit or maybe it is harming for our product point of view or maybe it is deteriorating our product or maybe the system so, depending upon that we need some kind of continuous monitoring over there.

Now what are the units of leakage so leak rates are generally measured in terms of quantity of a gas leaking in one second so that means in per second. Most commonly used units of leakage rates are generally the standard cubic centimeter per second standard atmosphere cubic centimeter per seconds. For vacuum leak test liter per second and SI unit is Pascal cubic meter per second. So any of the four units we can express the leak test results.

Now come to know as I told already when there is certain kind of leakage so you have to check whether it is within our acceptable limit are we within our that result we cannot be accepted. So, we have to take some kind of precautions or maybe some kind of detections over there.

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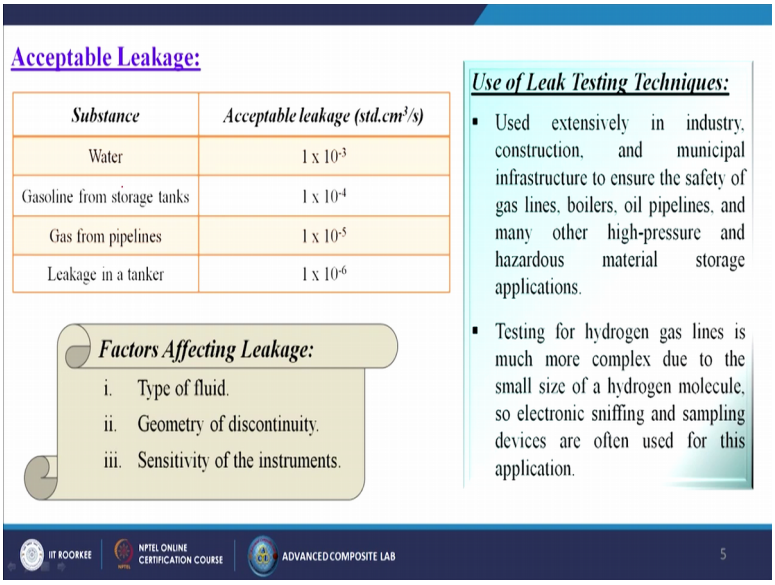

So, if we talk about the acceptable leakage then substance like water acceptable leakage is 1 into 10 to the power minus 3 STD centimeter cube per second so standard centimeter cube per seconds. If we talk about the gasoline from storage tank it is 1 into 10 to the power -4 gas from pipelines it is 1 into 10 to the power -5, leakage in a tank r1 into 10 to the power -6 just one thing keep in your mind that when we are making any kind of this kind of pipes or maybe the vessels of container we are trying to make it the hundred percent leak proof but sometimes it is not possible or maybe sometimes with time the material properties is getting deteriorated.

So, that the material is not having that much of capacity to give a 100% leak proof materials so that time some kind of gas or maybe the liquid is leaking from that particular systems but whether it is within the acceptable range or maybe the within it is beyond our control so that we have to check out. I have to; I can give you one very beautiful example that balloon when we are using some kind of gases over there may be the helium gas or may be the air after certain time when you are keeping those balloons inside our room.

So, after certain time what we are seeing that slowly its volume is getting contracted that means what? Now whatever the gas or maybe the air has been present inside it so automatically it is coming out through that particular rubber. So, now if I am having any ceremony in my home and that day I am doing it and if it is stable for some few days then after that slowly, slowly that is the natural phenomena that we cannot do anything.

But if I am sending some kind of gas or maybe the some kind of petroleum through the pipeline and within a fraction of seconds it is coming out the system. So, little bit that is a matter of OD so that time we have to take the necessary precaution. So, what are the factor

that affecting the leakage number is the type of fluid geometry of discontinuity and the sensitivity of the particular instruments.

So what are the use of leaks testing techniques so used extensively in industry, construction site means upon infrastructure to ensure the safety of gas lines, boilers, oil pipelines and many other high pressure and the hazardous material storage applications when you are talking about the testing so testing for hydrogen gas lines is much more complex due to the small size of hydrogen molecule.

So, electronic sniffing and sampling devices are often used for these applications because we cannot detect that hydrogen gas leakage very quickly.

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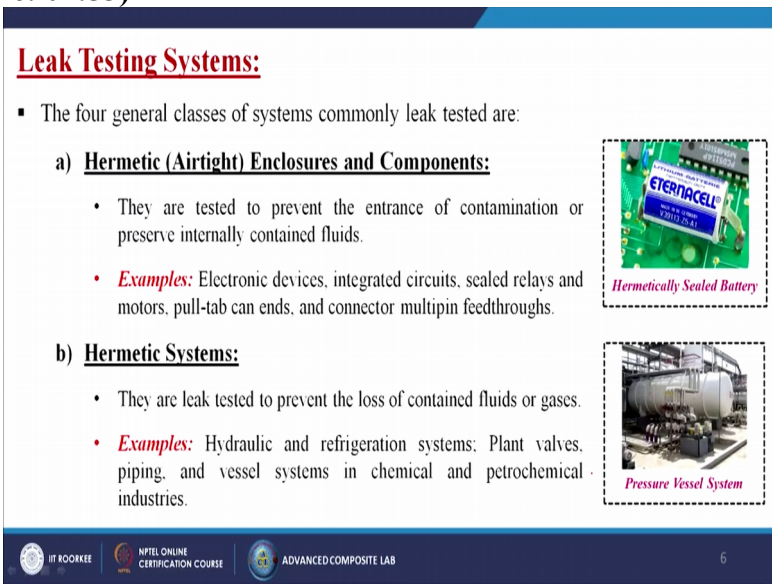

Now what are the leak testing systems so the four general classes of systems commonly leak tested are I will tell you all one by one. So, first one is called the hermetic or maybe the airtight enclosures and components. So, they are tested to prevent the entrance of contaminations or preserve internally content fluids. So, examples electronic devices, integrated circuits, sealed relays and motors pool tap can ends and connector multi beam feed through.

So, these are the examples next one is called the hermetic systems they are leak tested to prevent the loss of contained fluids or maybe the gases example hydraulic and refrigeration systems, planned valves, piping's vessel systems in chemical and petrochemical industries.

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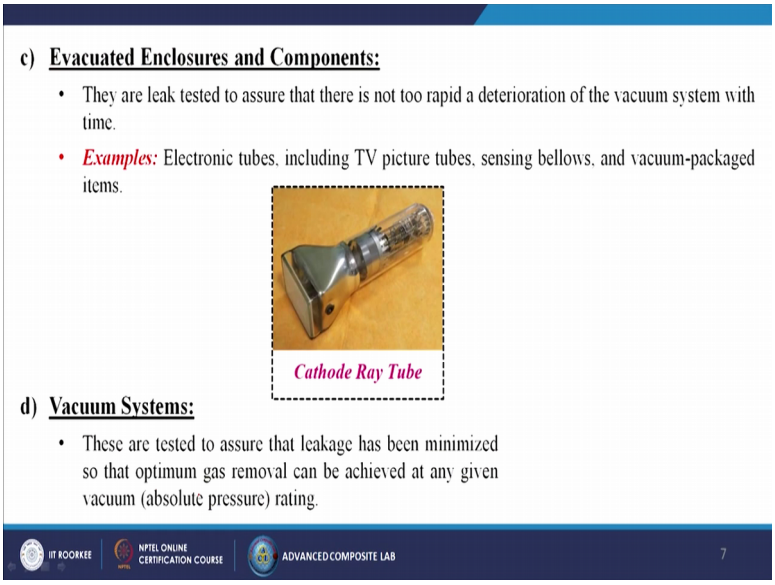

Next third one is the evacuated enclosures and the components they are leak tested to assure that there is not too rapid a deterioration of the vacuum system with time examples like electronic tubes including TV picture tubes sensing bellows and vacuum packets items. Number d is that vacuum systems these are tested to assure that the leakage has been minimized so that optimum gas removal can be achieved at any given vacuum like absolute pressure rating.

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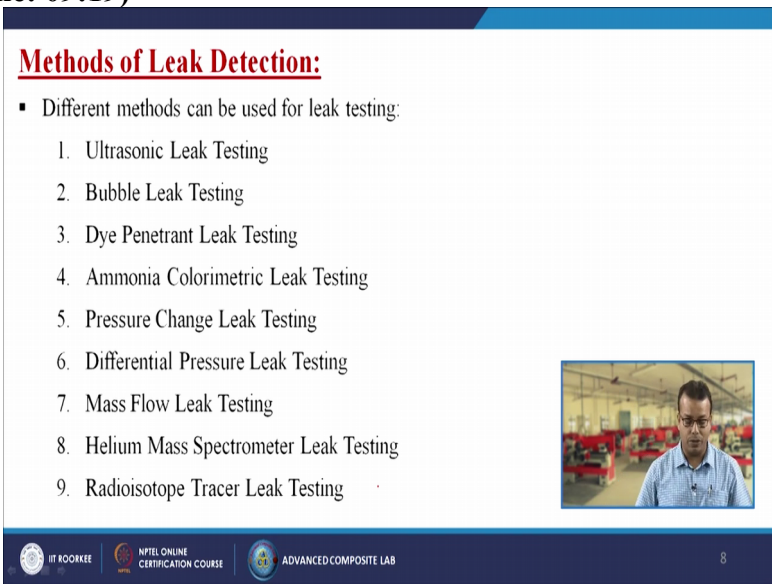

Next what are the methods that by which we can do the leak detection. So, there are different methods like ultrasonic leak testing, bubble leak testing, dye penetrant leak testing, ammonia calorimetric leak testing, pressure change leak testing, differential pressure leak testing, mass flow leak testing, helium mass spectrometer leak testing and the radioisotope treasure leak testing. So, now we are going to discuss one by one so first let us go through ultrasonic leak testing.

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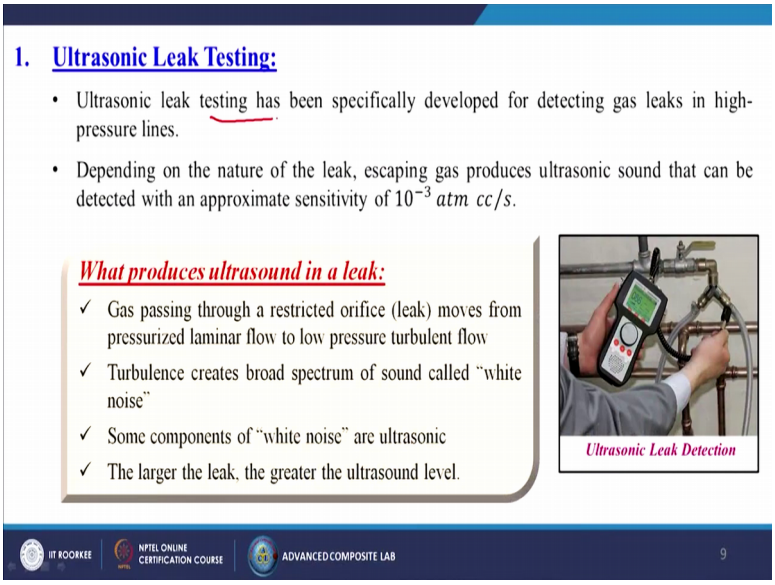

So, in the ultrasonic leak testing has been specifically developed for detecting the gas leaks in high-pressure lines. Depending on the nature of the leak escaping gas produces ultrasonic sound that can be detected with an appropriate sensitive of 10 to the power -3 atom centimeter cube per second. So, what produces ultrasound in a leak gas passing through a restricted orifice leak moves from the pressurized laminar flow to low-pressure turbulent flow.

Turbulence creates brought the spectrum of sound called white noise some components of white noise are ultrasonic. The larger the leak the greater the ultrasound level, so one the pressure difference is there when the gas is passing from the high pressure to low pressure it is creating some kind of noise in between that one kind of noise is the ultrasonic noise and we are detecting that particular ultrasonic noise from there.

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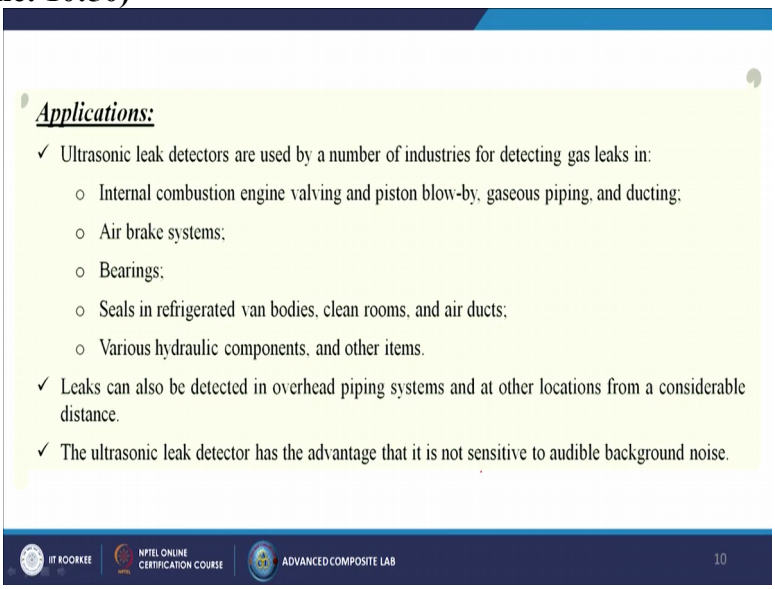

What are the applications generally ultrasonic leak detectors are used by a number of industries for detecting the gas leaks in like internal combustion engine valving and piston blow by gaseous piping and ducting air brake systems bearings, sealed in refrigerated, van bodies, clean rooms and air ducts various hydraulic components and other items. Leaks can also be detected in overhead piping systems and at other locations from a considerable distance itself. The ultrasonic leak detector has the advantage that it is not sensitive to audible background noise.

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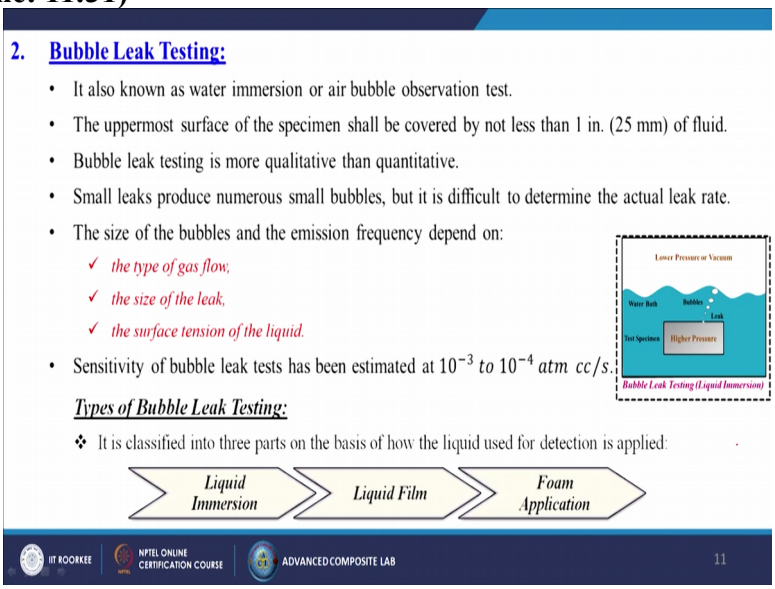

Next second one is called the bubble leak testing so it is also known as water immersions or air bubble observation taste. The uppermost surface of the specimen shall be covered by not less than one inch like 25 millimeter of fluid bubble leak testing is more qualitative than the quantitative. Small leaks produce numerous small bubbles but it is difficult to determine the actual leak rate. The size of the bubbles and the emission frequency depend on the type of the gas flow, the size of the leak, the surface tension of that particular liquid used.

Now sensitivity of bubble leak test has been estimated at 10 to the power -3 to 10 to the power -4 atmospheric centimeter cube per second. So, types of bubble leak testing it is classified into three parts on the basis of how the liquid used for detection is applied like liquid immersions, liquid flame or maybe the form applications. So, from this particular image who we are having that substance is high in pressure here is the low pressure or maybe the vacuum we are inserting our material inside the water and that distance is also not too so far or maybe the too high.

And then from that particular crack the bubble is creating and then easily we can detect the actual point of the leakage.

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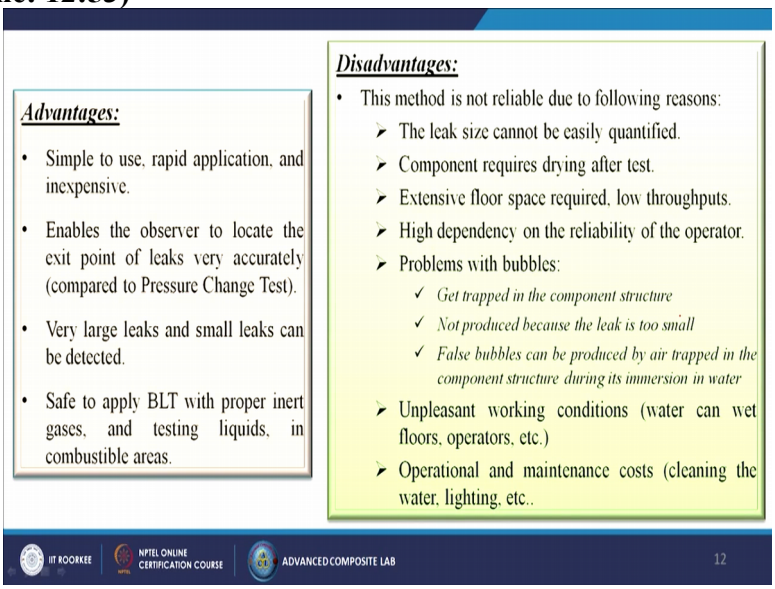

What are the advantages simple to use rapid applications and inexpensive rather to tell all these things I can give you one examples can you tell me that where maximum cases we are using or may be that we are doing this kind of testing's in our normal life. The first one is that when our bicycle tire or maybe the, our motorbike tire or maybe any kind of automobile tire is getting punctured.

So, that time just to find out that exact locations what we are doing we are putting a high air pressure inside the tube and then that tube we are inserting into the water and then easily we are detecting that where the actual leakage or puncture has been taken place. Next advantages is enables the absorber to locate the exit point of leaks very accurately compared to pressure change test. Third very large leaks and small leaks can be detected, fourth set to apply BLT with proper inert gases and testing liquids in combustible areas.

But of course there is certain disadvantages this method is not reliable due to the following reasons what are those? The leak site cannot be easily quantified component requires drying up the test, extensive floor space required low throughputs, high dependency on the reliability of the operator, problems with the bubbles get trapped in the component structure yes of course because when you are inserting certain kind of pipe maybe some air has been trapped on the surface of that particular materials.

Then when we are inserting it inside the water these bubbles or maybe the these air is also coming out then that time really it is very difficult that whether that is coming for this particular crack or maybe these bubbles are coming that is a one kind of shortcomings of this

particular test. Not produced because the leak is too small false bubbles can be produced by air trapped in the component structure during its immersion in water.

Unpleasant working conditions water can wet floors operators etcetera operational and maintenance costs including cleaning the water, lightning etc.

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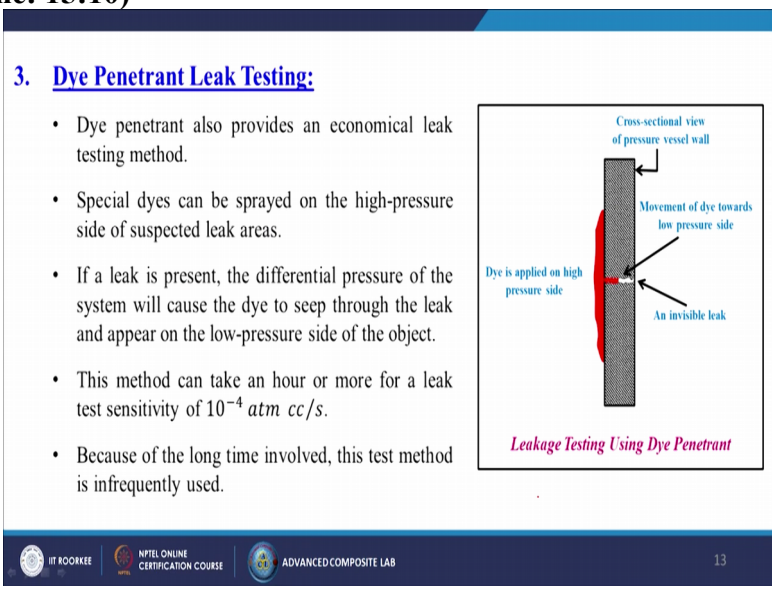

Next third one is called the dye penetrant leak testing. So, dye penetrant also provides an economical leak testing method special dyes can be sprayed on the high pressure side of suspected leak areas. If a leak is present the differential pressure of the system will cause the dye to seep through the leak and appear on the low pressure side of the object itself. This method can take an hour or more for a leak test sensitivity of 10 to the power -4 atmospheric centimeter cube per second.

Because of the long time involved this test method is infrequently used so simple this is the system's over there. Now I am having my trills now I want to check it so what is that die is applied on the high pressure site so automatically the dye will go from high pressure to the low pressure side and then simple movement of the dye towards the low pressure side and then after that simple we can detect that the wire is the dye locations over there. So, simple we can see that cracks or maybe the leaks.

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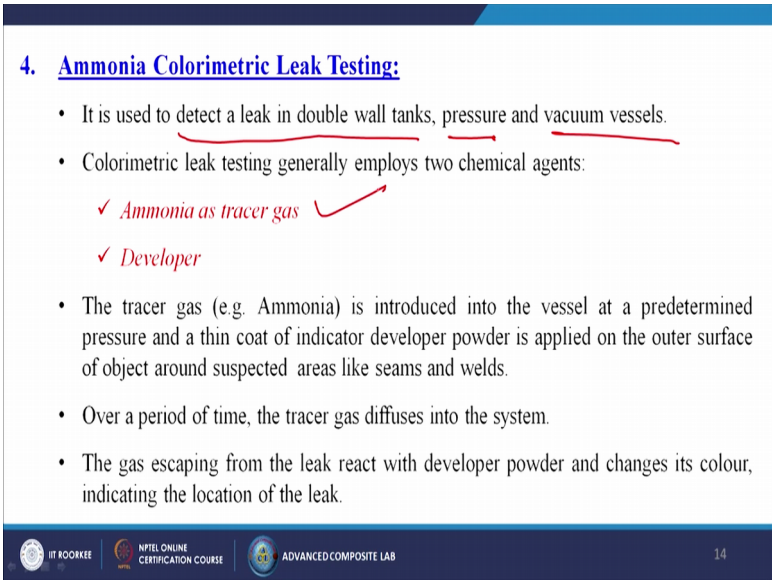

Next fourth one is the ammonia calorimetric leak testing. So, generally it is used to detect a leak in double wall tanks pressure and the vacuum vessels. Keller metrically testing generally employs two chemical agents one is called the ammonia as a treasure gas and the second one is called a developer so how we are doing it? The tracer gas like ammonia is introduced into the vessel at a predetermined pressure and the theme coat of indicator developer powder is applied on the outer surface of object and on suspected areas like seams and welds.

Over a period of time the tracer gas diffuses into the system. The gas escaping from the leak reacts with the developer powder and changes its color indicating the locations of the tank itself. I am having the tank inside is the ammonia gas over there outside I am putting the detector over there when there is a crack the ammonia gas is coming and it is changing the color of that particular positions.

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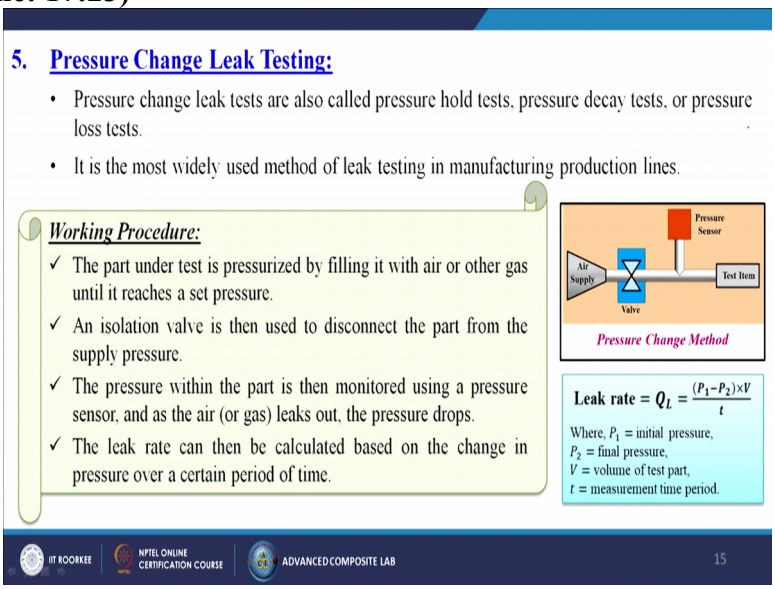

Next fifth on is called the pressure change leak testing. So, pressure change leak tests are also called pressure hole tests pressure decay tests or pressure loss tests. It is the most widely used method of leak testing in manufacturing production lines. So, what is the working procedure the part under test is pressurized by filling it with air or other gas until it reaches a site pressure or maybe the set value.

And isolation valve is then used to disconnect the part from the supply pressure the pressure within the part is then monitored using a pressure sensor and as the air leaks out the pressure drops. The leak rate can then be calculated based on the change in pressure over a certain period of time. So, simple you are having the systems inside you are putting a particular pressure now we are having one pressure gauge over there so through that gauge you are changing that whether the pressure is dropping or not.

If drops that means there is certain kind of leakage or maybe cracks are present. So, what is the leak rate that is capital QL = P1 - P2 into V by T where P1 is equal to the initial pressure P2 is the final pressure V is the volume of the test part and t is the measurement time period. So, by this way we can easily measure.

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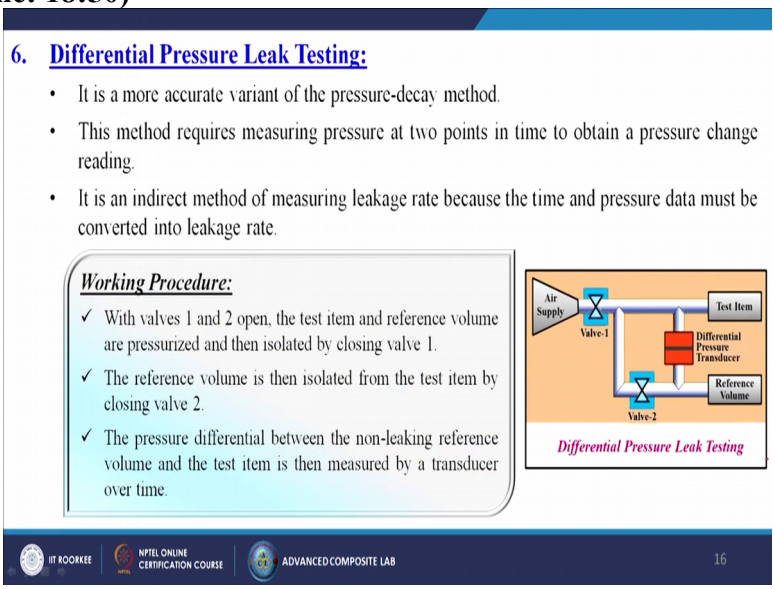

Number 6 is called the differential pressure leak testing. So, it is a more accurate variant of the pressure decay method. This method requires measuring pressure at two points in time to obtain a pressure change reading. It is an indirect method for measuring the leakage rate because the time and pressure data must be converted into leakage rate, working procedure with valves 1 and 2 open.

So, with valve 1 and 2 open the test specimen and the reference volume are pressurized and then isolated by closing the valve 1. The reference volume is then isolated from the test item

closing the valve 2. The pressure differential between the non leaking reference volume and the test item is then measured by a transducer over time. So, simple thing here you see first we are giving the air the air is going into this test specimen as well as into the reference volume.

Then we are closing this valve so automatically the air is not going into the systems then after that we are closing these valves also that mean what whatever the pressure in this test item is equal to the same as an inference item. Then we are using some differential pressure transducer over there just to check the pressure difference in between that if there is any leakage there if there is not any leakage or maybe the pores or cracks are present.

So, automatically the pressure of this and this will remain same for a longer time if there is some leakage so automatically this pressure is going to be reduced.

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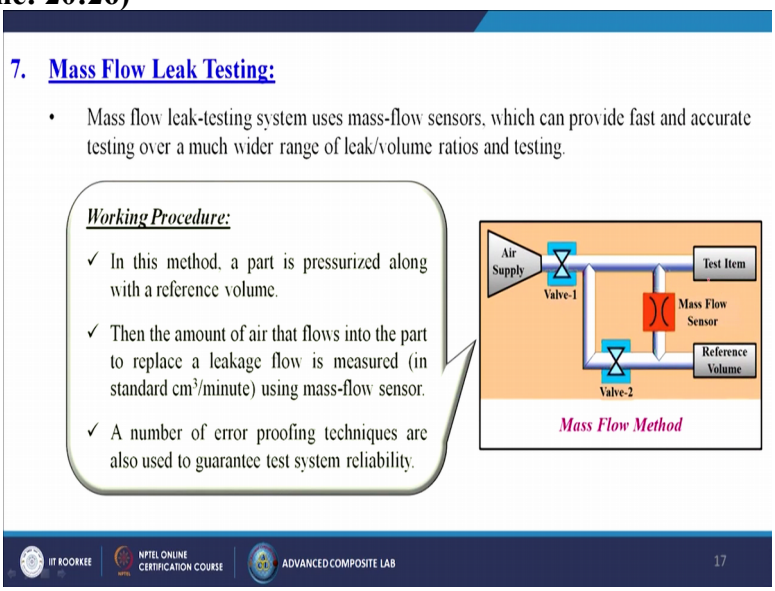

Next number 7 is called the mass flow leak testing. So, mass flow leak testing systems uses mass flow sensors which can provide fast and accurate testing over a much wider range of leak volume ratios and testing so what is the working procedure? In this method a part is pressurized along with a reference volume when the amount of air that flows into the part to replace a leakage flow is measured in standard centimeter cube per minute using mass flow sensor.

A number of error proofing techniques are also used to guarantee test specimens reliability that to locate the exact leakage and that quantify it. So, here your supply the valve 1 and valve2 same thing here also we are using the test item and the reference volume over there and then we are having on mass flow sign sensor. So, now initially when we are injecting the

air throughout this particular system the pressure of the test item and the pressure of the reference volume a reference item is same.

Now after that if this test item is having some leakage and all these things so what will happen this will be into the higher pressure this will be become into the lower pressure. So, automatically from higher pressure to lower pressure the gas will flow to the systems. How much gas is flowing from higher pressure to lower pressure that we can measure by the mass flow sensor over there so, by this way simple we can measure the leakage rate over there.

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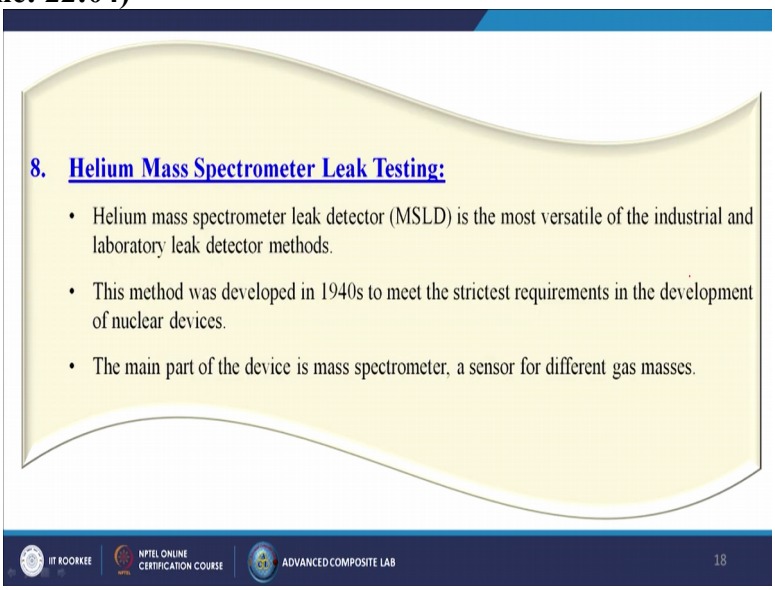

Next 8th one is the helium mass spectrometer leak testing. So, generally the helium mass spectrometer leak detector in short general it is called the MSLD is the most versatile of the industrial and laboratory leak detector methods. These methods were developed in 1940s to meet the strictest requirements in the development of nuclear devices. The main part of the device is mass spectrometer a sensor for different gas masses helium that is a one kind of inert gas so that will not react with any kind of other gases or maybe the liquids.

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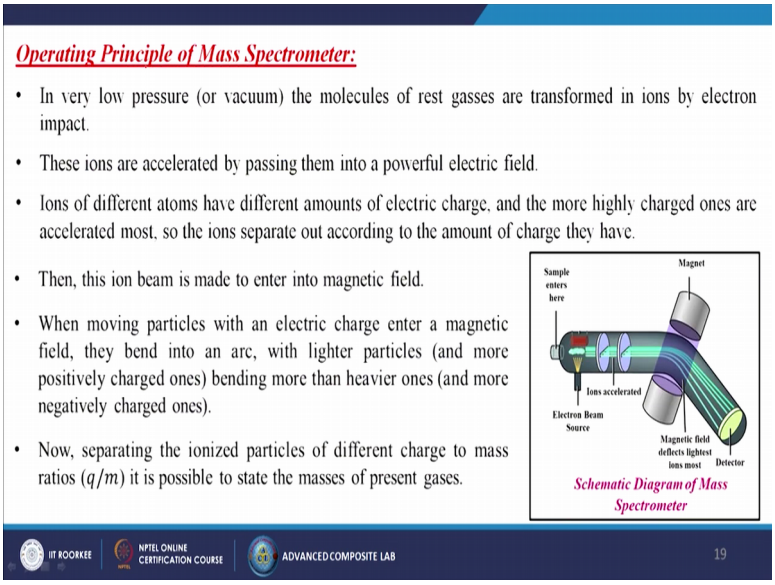

So, operating principle of the mass spectrometer how it is working. In very low pressure or vacuum the molecules of raised gases are transformed in ions by electron impact. These ions are accelerated by passing them into a powerful electric field. Ions of different atoms have different amounts of electric charge and the more highly charged ones are accelerated most so the ions separated out according to the amount of charge they have.

Then this ion beam is made to enter into the magnetic field when moving particles with an electric charge enter a magnetic field they bend into an arc with lighter particles and more. Positively charged once bending more than heavier ones and more negatively charged ones now separating the ionized particles of different charges to mass ratios like q/ m it is possible to state the masses of present gas so here this is the thing samples enters from here over there now we are having that electron beam source.

Now we are having that ion accelerated so now different gas is having the different ion densities and the different electrical conductivity and all those things then after that we are using the magnets. So, here the magnetic field deflects the lightest ion mode so that will bend more and the of course the heavier ions so it will not bend properly so it will pass through this and this is our detector where we are measuring.

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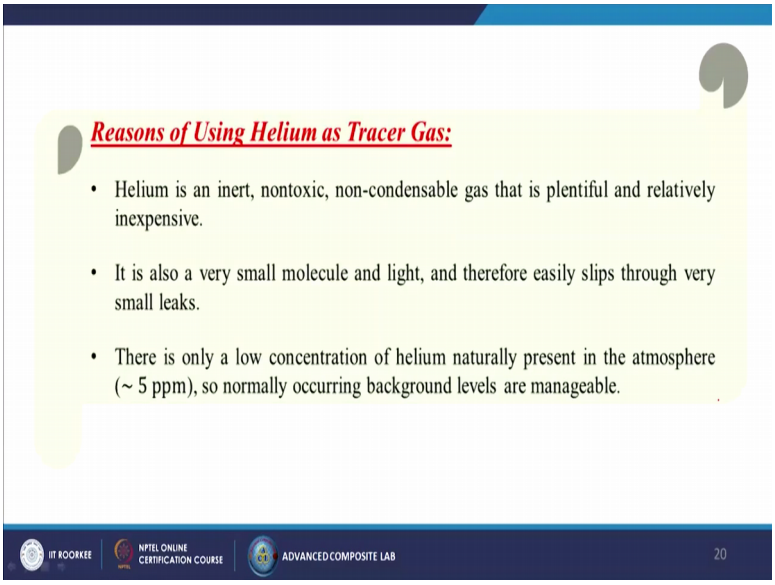

A reason of using the helium as tracer gas helium is an inert non toxic as I told already non condensable gas that is plentiful and relatively inexpensive in nature. It is also a very small molecule and light therefore easily slips through very small leaks. There is only a low concentration of helium naturally present in the atmosphere that is more less 5 ppm. So, normally occurring background levels are manageable.

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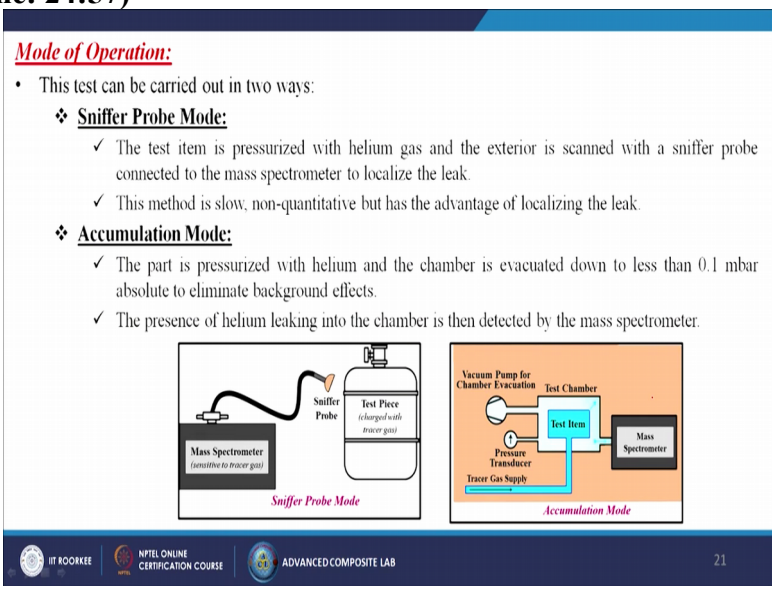

Mode of operations these tests can be carried out in two ways what are those first one is called the sniffer probe method. In this particular method the test item is pressurized with helium gas and the exterior is scanned with a sniffer probe connected to the mass spectrometer to localize the leak. This method is slow non-quantitative but has the advantage of localizing the leak itself.

And the second one is called the accumulation mode so the part is pressurized with helium and the chamber is evacuated down to less than 0.1 Millie bar absolute to eliminate the

background effects. The pressure of helium leaking into the chamber is then detected by the mass spectrometer. So, this one is the sniper method and this is known as the accumulation mode. So, these two are the different mode by which we are doing this testing.

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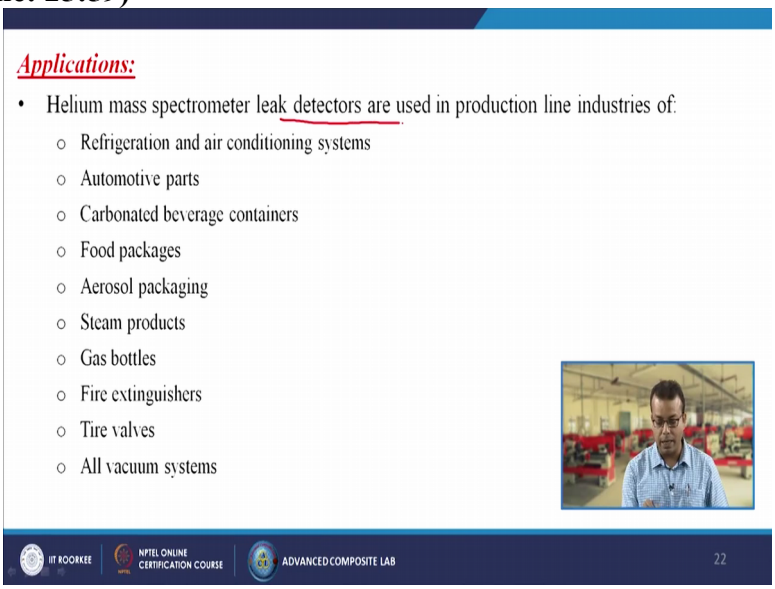

Now what are the applications helium mass spectrometer leak detectors are used in production line industries of refrigeration and air-conditioning systems, automotive parts carbonated beverage containers like our Coca Cola bottles or maybe the Pepsi bottles, food packages, aerosol packaging, steam products, gas bottles, fire extinguishers, tire valves and all vacuum systems.

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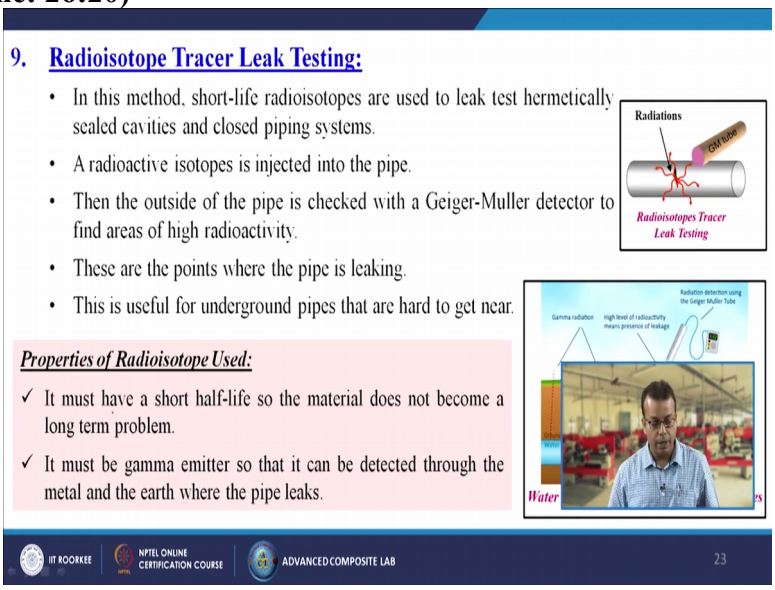

Next 9th one is the radioisotope tracer big testing. So, in this particular method short-life radioisotopes are used to leak tests hermetically sealed cavities and closed piping systems. A radioactive isotopes is injected into the pipe itself then the outside of the pipe is checked with a Geiger mullah detector to find areas of high radioactivity. So, automatically the radiation

will come out so the radiation of course will come out through the cracks or may be through the pores.

Now I am having the sensor by which we can easily measure that where the tracks are we the pores are present. These are the points where the pipe is leaking this is useful for underground pipes that are hard to get near. Properties of the radioisotope used it must have a short half-life so the material does not become a long-term problem so after certain time it can finish.

It must be gamma emitter so that it can be detected through the metal and the earth where the pipe leaks. So, generally this is the ground after certain distance so the pipe is situated inside the ground inside the soil and then we are injecting our radioisotope small a half-life radioisotope or maybe the very less type radioisotope materials and then through that it is giving some kind of radiations and from outside we are measuring that radiation itself.

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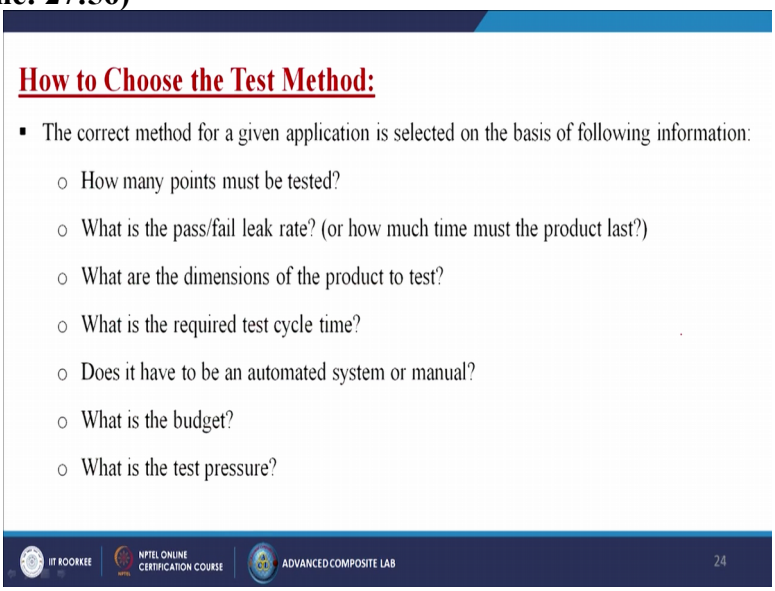

Now how to choose the test method what are the conditions. The correct method for a given application is selected on the basis of following information's what are those? How many points must be tested, what is the pass/fail leak rate or how much time must be product last, what are the dimensions of the product to test, what is the required test cycle time, does it have to be an automated system or normal, what is the budget and what is the test pressure.

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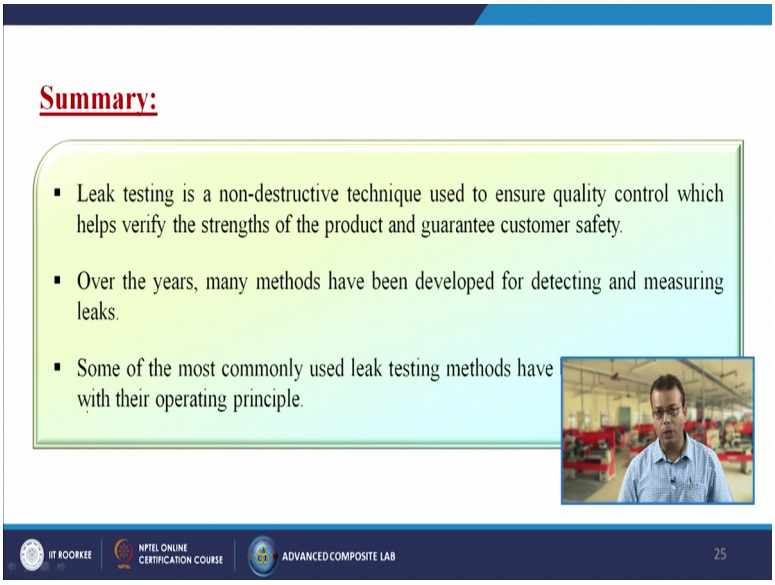

So, now we have come to the last slide of this particular lecture. So, as a summary we can conclude that leak testing is a non-destructive testing used to ensure quality control which helps verify the strengths of that particular product and guarantee the customer safety. Say suppose our home gas cylinder it is highly required that it should be the leak proof. So, it can save the thousands of human life. Over the years many methods have been developed for detecting and measuring the leaks. Some of the most commonly used leak testing methods have been discussed in this particular lecture along with their operating principles and proper applications or maybe the suitable applications. Thank you.