Air Pollution and Control
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture 58
Stack emission Monitoring using Isokinetic Sampling

Hello friends, as you know these days we are discussing about lab based experiments or field based experiments to monitor different air pollutants. So, today we will discuss about stack emission monitoring using isokinetic sampling. So, what are the emissions from the stack if you want to measure like particulate matter or gaseous components, so how do we measure these emissions, that is very important stack monitoring is very important.

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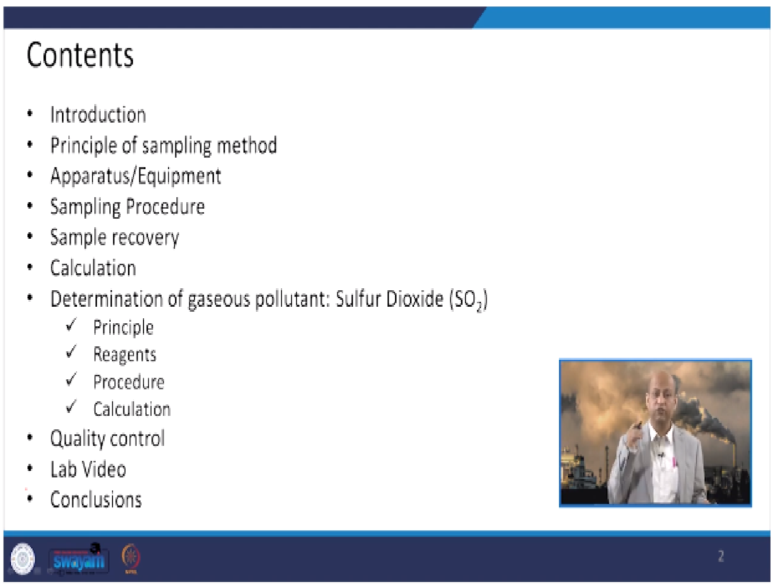

So, in this particular presentation we will first discuss about what is the need, why it is so important, then the principle of the sampling method for stack monitoring, what are the apparatus or equipment which are used for the sampling in stack monitoring and what is the procedure, then how do we recover the sample so that we can analyze in the lab, then how do we estimate the concentrations, what are the procedures of the calculation and the particulate matter as well as gaseous pollutants can be measured.

So, first we will discuss about particulate pollution monitoring method and then briefly we will also touch about gaseous pollutants like sulphur dioxide, we have given one example otherwise NOx emissions can also be monitored and explained, then after quality control related brief discussion we will show you the video which will further explain how this sampling is done at the stack emissions and we will conclude.

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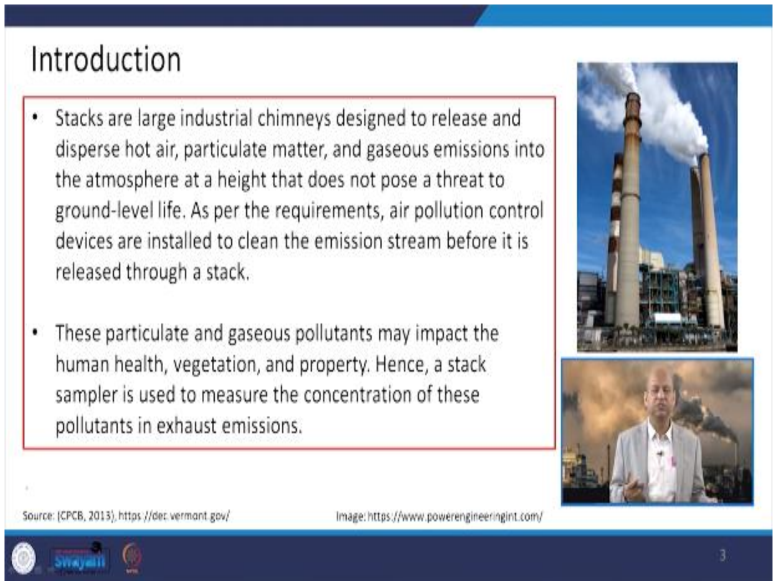

So, as you know these stacks which are quite large size chimneys where pollutions are coming as a kind of point source emissions you can say, so they are important in the sense because earlier they were used for giving the pressure difference in the draft velocity otherwise later on it was found that stacks also help in dispersion of the pollutants, so you can send directly it also helps in dilution of the pollutants and reducing the concentration at the ground level.

So, we should know how much emission is coming out of it because if there are so many stacks and emissions are multiplying then maybe even if they are diluting, ultimately the ground level concentration may exceed the standards which are prescribed by CPCB or MOEF Ministry of Environment Forest and Climate Change.

So, we need to monitor the emissions from the stacks that is the important thing and the particulate matter or the gaseous components, their properties like velocity, temperature, humidity and the concentration of particular pollutants, whether it is particulate matter or gaseous components we can measure and the importance is because the pollution if we do not measure and we do not compare then we cannot judge how much pollution is coming from those stack, so stack monitoring is very important thing.

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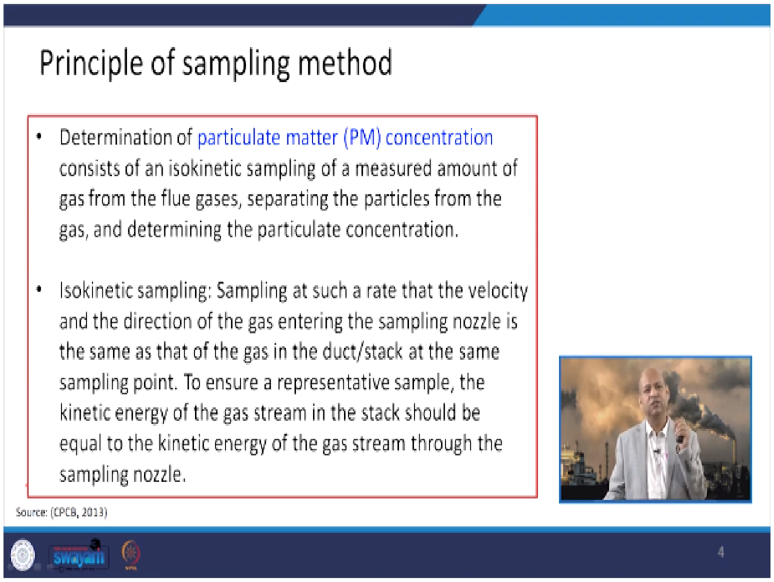

Now, if you talk about like the principle of sampling method for particulate matter monitoring, then this is basically the isokinetic sampling method which is given lot of emphasis, because in this we have to ensure that the velocity, temperature and other parameters are the same as it is in the stack, means the nozzle which we will be using for extracting the sample, so the velocity and the flow rate etc, all these kinetic parameters must be the same which goes into the probe or the nozzle which is in the entire stack, so that is the isokinetic fundamental thing which we should ensure.

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If we look into the apparatus or equipment which is used for this stack emission monitoring then basically it is like panel box, on front side you can see the pressure, the measurement of the pressure difference and the flow rate etc, on the back side we have out and inlet or those where we will put those probes you can say and then these pilot tubes which are used for guiding the probes etc, thermocouples are also there, then impinger tubes are needed for gaseous components basically so that we can have the knowledge about how much NOx or SOx are there, then vacuum pump is there for extraction, this is the sampling probe which is inserted in the stack basically.

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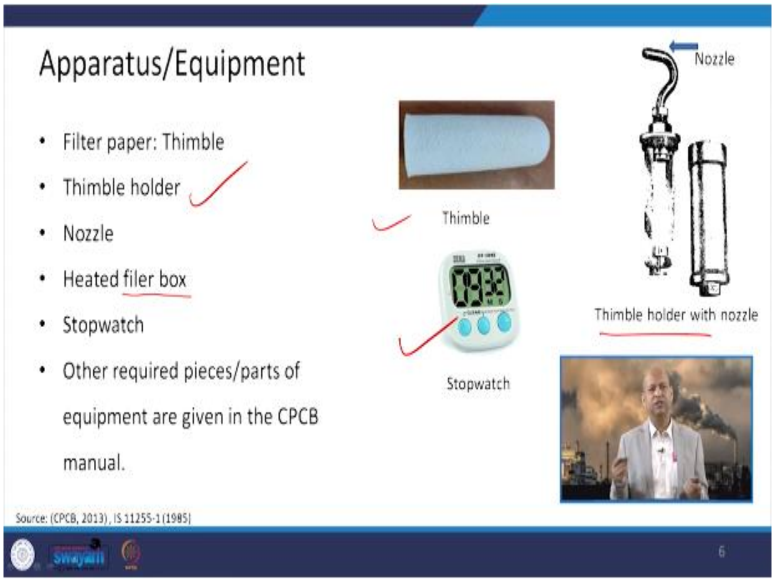

So, you can see there are other parts like filter paper or thimble which is known, then the thimble holder, nozzle is also there, then heated filler box, stopwatch is there and other parts of this equipment which are shown in CPCB manual basically you can go through that to learn more.

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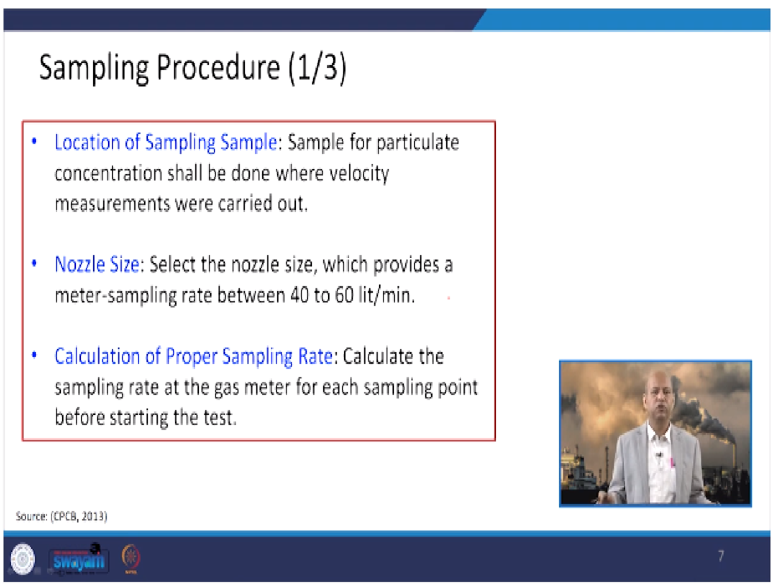

Then there are important aspects like location of sampling, the sample which is collected so that sample for particulate concentration shall be done where velocity measurement were carried out basically, that particular point is very important. The nozzle size is selected so that we can provide this meter sampling rate between 40 to 60 liter per minute, so that kind of nozzle size must be there, calculation of proper sampling rate is also very important which is done with the help of like gas meter for each sampling point before starting the test.

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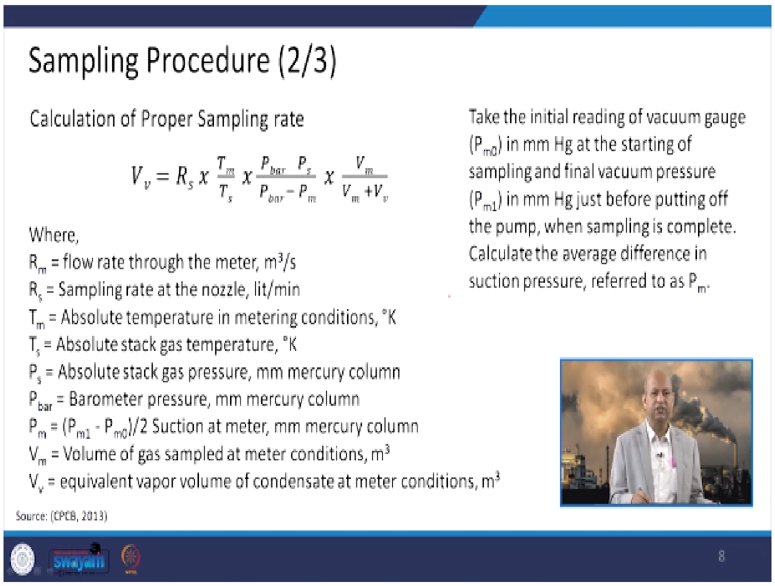

So, this is the calculation procedure for sampling rate basically where there are different parameters like flow rate, then the sampling rate, absolute gas temperature, absolute temperature of the metering conditions, then barometer pressure all these parameters are noted and we use those parameters here in this particular equation to calculate the sampling rate.

$$V_v = R_s \times \frac{T_m}{T_s} \times \frac{P_{bar} - P_s}{P_{bar} - P_m} \times \frac{V_m}{V_m + V_s}$$

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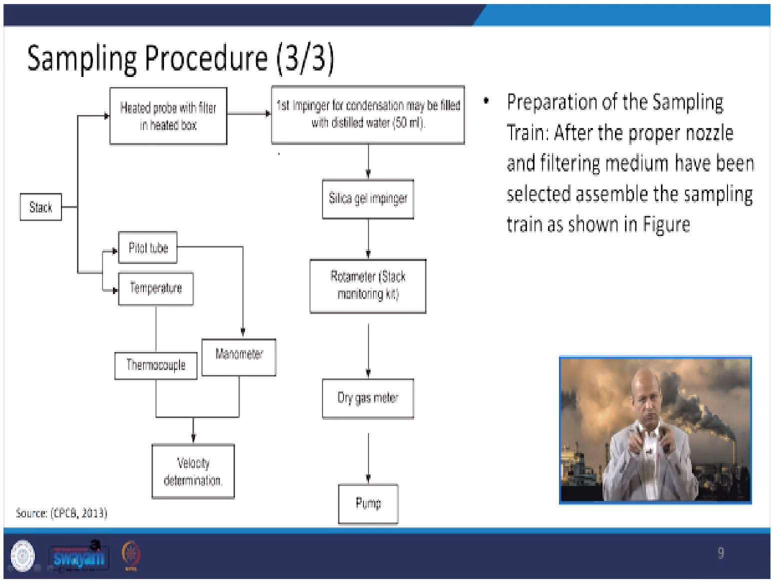

And if we talk about the sampling procedure basically so the two streams are there, one is like giving the temperature related, velocity related values, other one is giving us where this particulate matter will be collected, so the two streams you can look into in this procedure.

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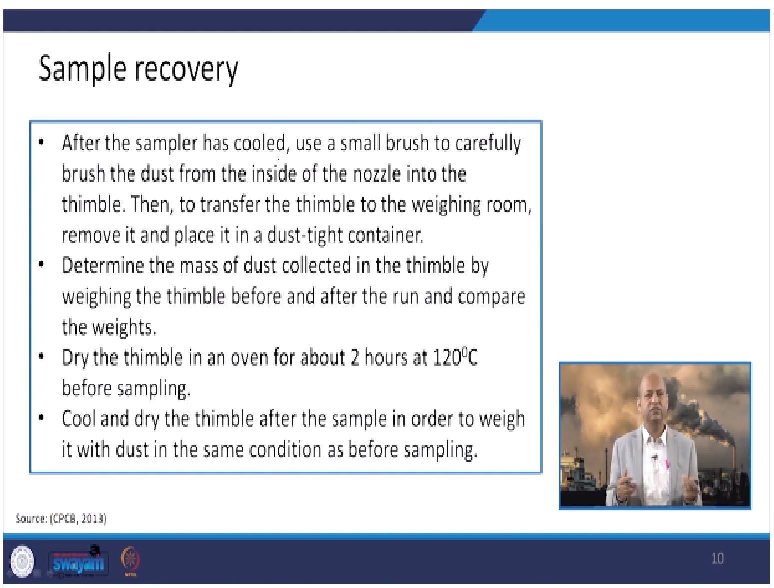

So, the sample is recovered when we have done the sampling so we need to collect that filter paper basically and we have to make sure that there is no addition of the particulate matter from outside, so we need to keep it in a proper way and then the mass of the dust collected on this filter paper or thimble is to be weight basically and it should be kept in oven about 2 hours at 120 degree Celsius to remove any kind of error which could be because of some moisture etc, so the before and after the sampling the way is taken and then the difference as in this high volume sampler case we have already seen, how the difference of these two values gives us the concentration.

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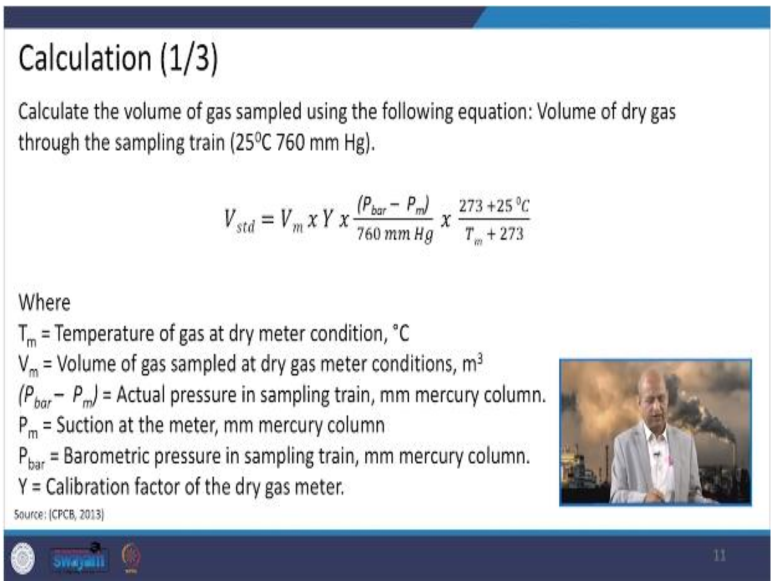

Well, so when we calculate the volume of the gas which has been sampled basically, so we need this particular relationship where pressure difference is there, volume of the gas sample at dry gas meter conditions and the temperature etc, so that correction can be applied according to their unit and then this gives the value of gas sample basically.

$$V_{std} = V_m \times Y \times \frac{P_{bar} - P_m}{760 \, mm \, Hg} \times \frac{273 + 25°C}{T_m + 273}$$

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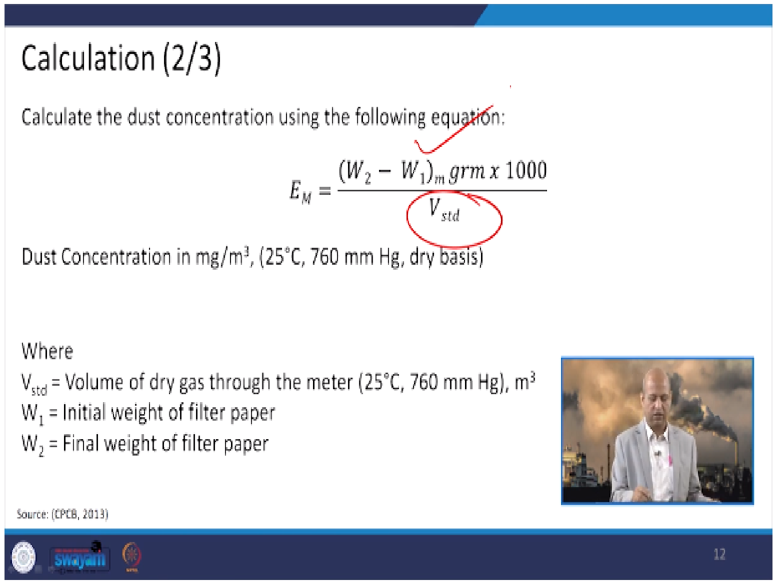

This value is used for like to divide this weight difference and it will give the concentration, concentration means weight divided by the volume flow rate, so this equation can be used for that purpose.

$$E_M = \frac{(W_2 - W_1)_m\ gram}{V_{std}} \times 1000$$

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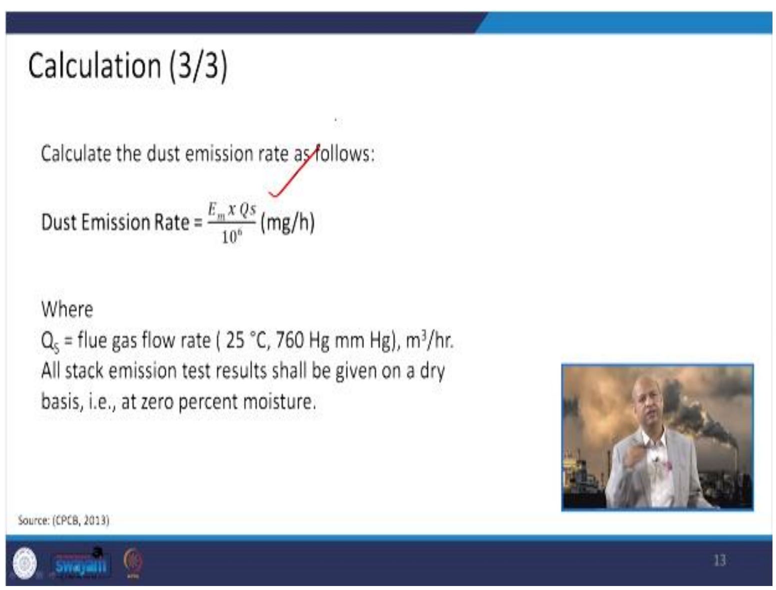

Then if you want to calculate the dust emission rate then we have to multiply it with the flow rate Qs, so that can give the emission rate.

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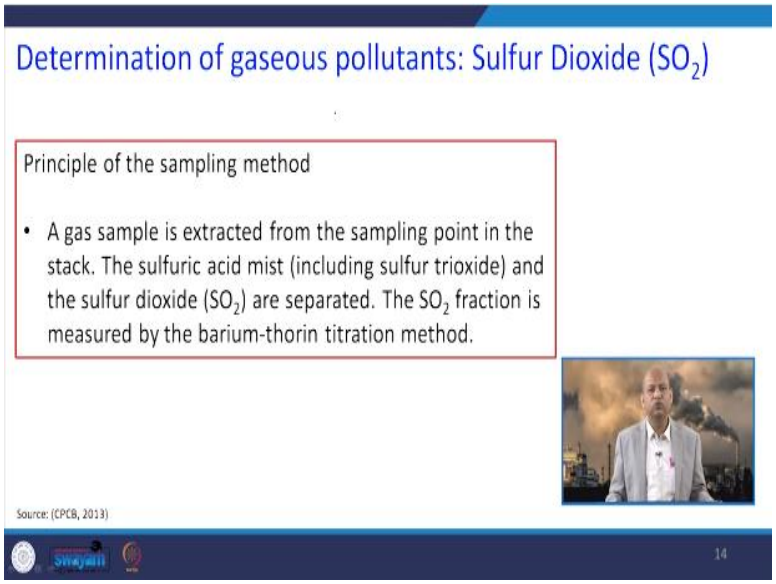

So, we know the concentration as well as the emission rate and if you want to use this particular device for monitoring the gaseous pollutant that is also possible by using some impingers, so for SO_2 or NOx. So, for SO_2 we have given some information so that gas sampling is done through extraction from the sampling point where we are using the probe in the stack basically, so in this case of SO_2 sulphuric acid mist including the sulphur trioxide and the sulphur dioxide are separated so that there is no error, the SO_2 fraction is measured by the barium-thorium titration method.

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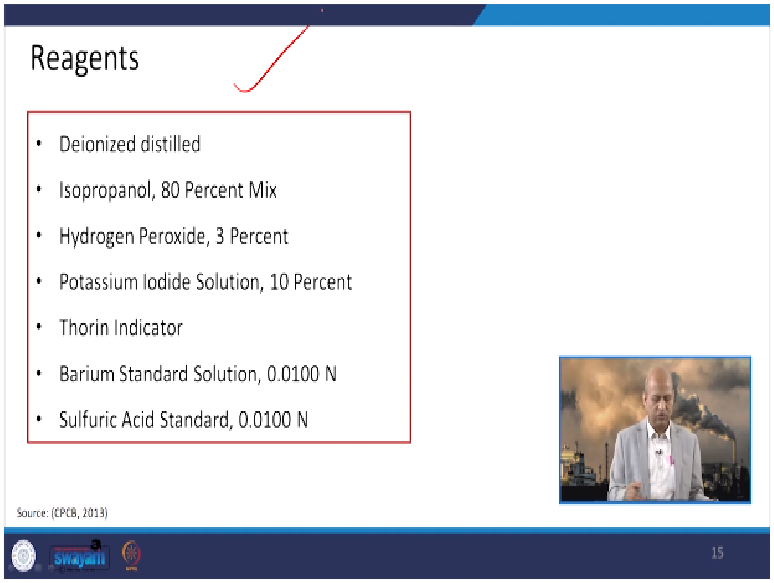

And there are reagents which are used for this particular purpose and deionized distilled water, then isopropanol, then hydrogen peroxide, 3 percent all these stuff is being used for that calculation and sampling method.

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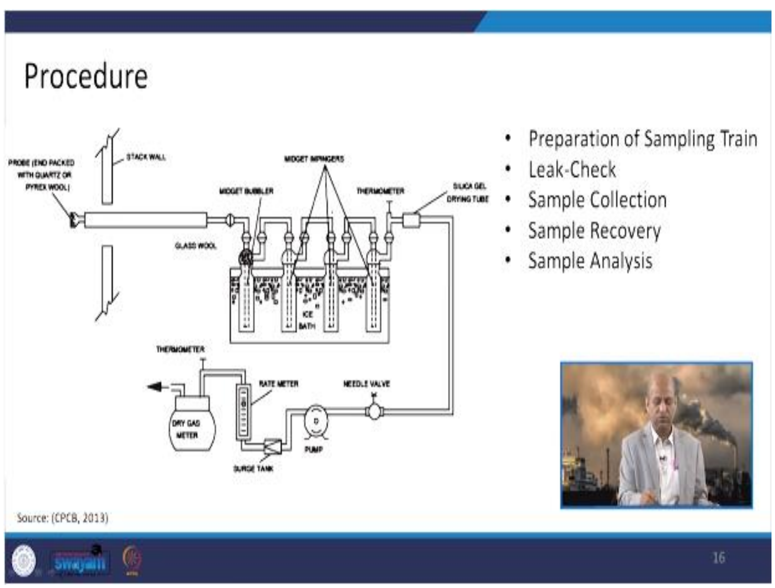

Then the procedure is shown in this particular figure, a schematic diagram you can see here, so the sample is collected and then sample is recovered and then it is analyzed in the laboratory. So, here you collect the sample it goes through these impingers and it is absorbed and then it is taken to the lab.

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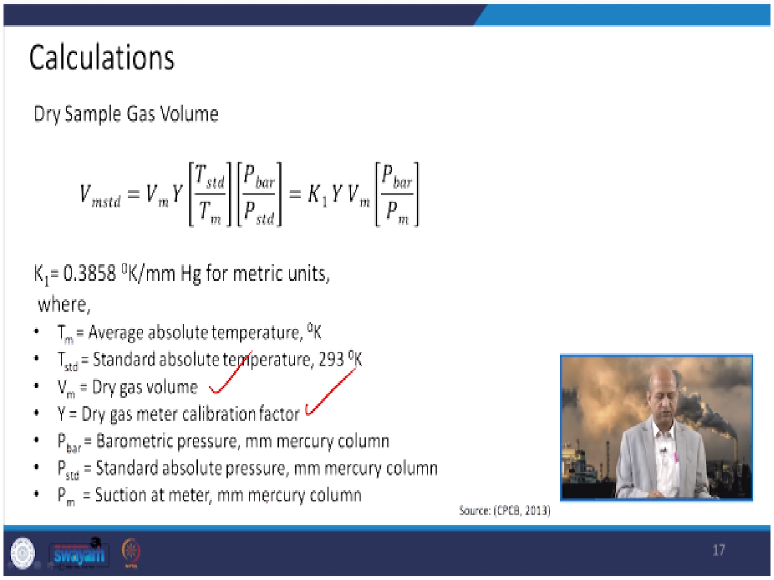

Calculation is done in this case also as we have done particulate matter, so this is the, these are the temperature, then the volume and this calibration factor, pressure related factor all these parameters are to be used for gas volume calculation.

$$Vmstd = Vm\,Y \left[\frac{Tstd}{Tm}\right]\left[\frac{Pbar}{Pstd}\right] = K1\,Y\,Vm \left[\frac{Pbar}{Pm}\right]$$

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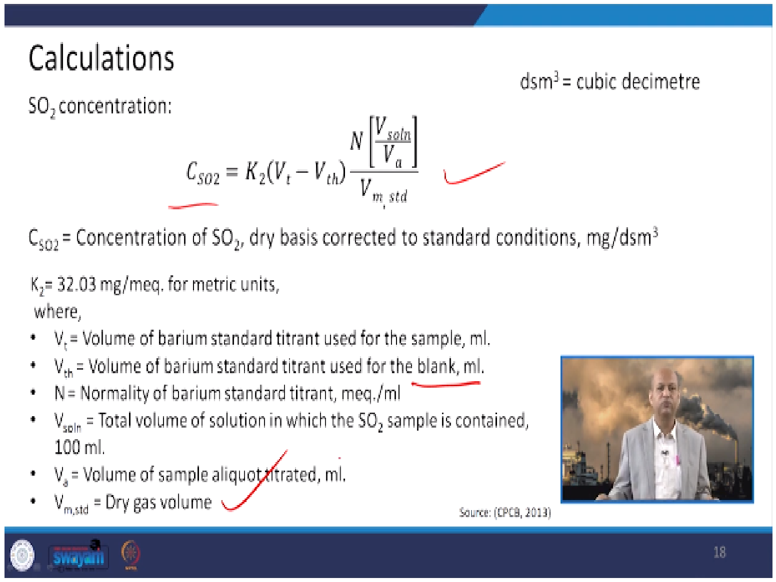

Then the concentration, so concentration is to be calculated by this particular relationship where volume of barium standard titrant used for the sample is used and similarly for the blank is used so that difference can be noted and other the like dry volume, volume of the sample this kind of values are to be used for this particular relationship.

$$C_{SO2} = K_2(V_t - V_{th}) \times \frac{N\left[\frac{V_{solution}}{V_a}\right]}{V_{m,std}}$$

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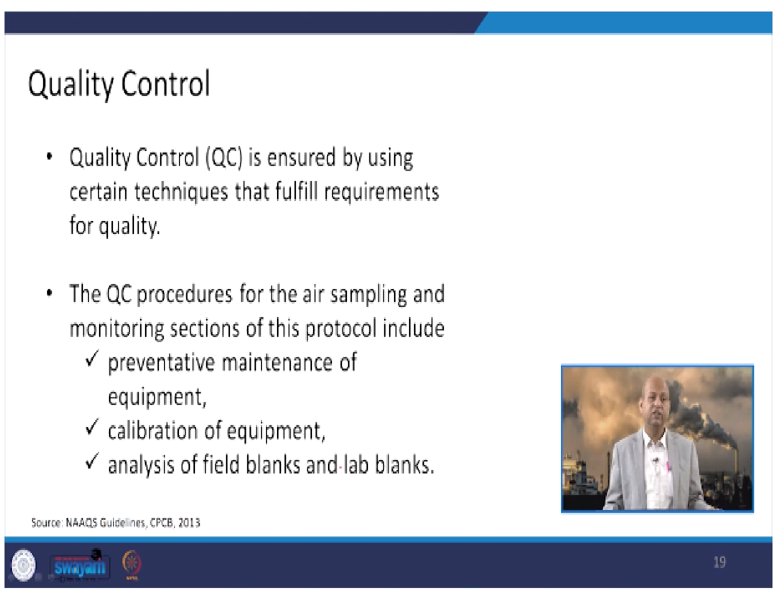

Also the quality control is important as we have seen in each experiment we have to follow the strict guidelines or those mandatory procedure or protocol so that quality is ensured, otherwise the monitoring values can be different, and calculation may also be different than what is the real one.

So now we present a short video which will give you better perspective about how the sampling of gaseous components or particulate matter is to be done using the isokinetic sampling method and this video has been recorded in air pollution laboratory of civil engineering department IIT Roorkee, so enjoy the video please.

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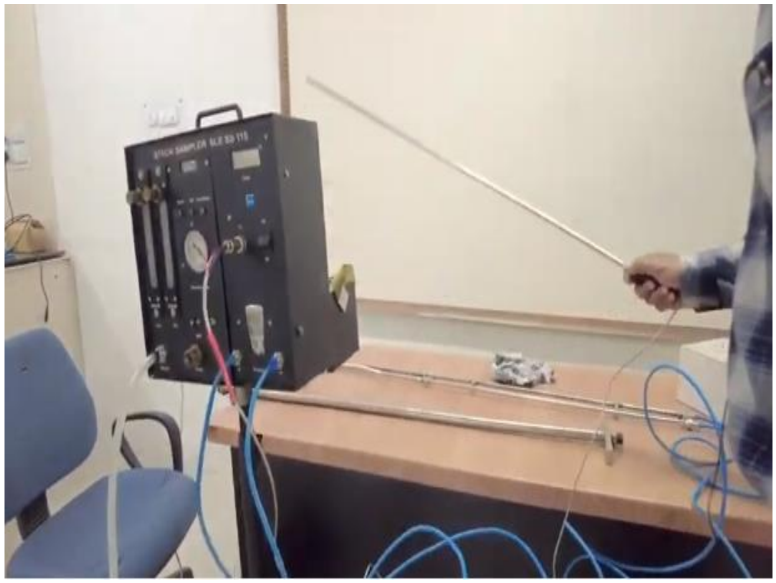
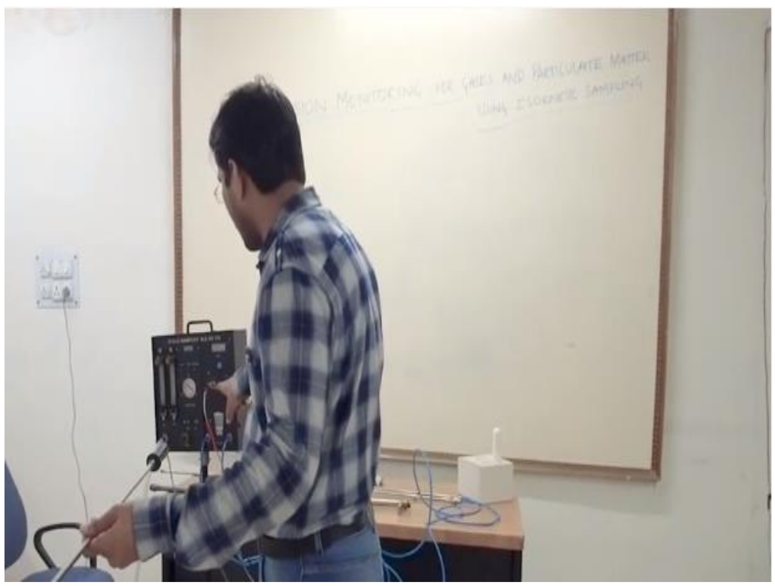
STACK SAMPLER SLE SS 115






STACK SAMPLER


STACK EMISSION MONITORING FOR GASES AND PARTICULATE MATTER
USING ISOKINETIC SAMPLING


STACK EMISSION MONITORING FOR GASES AND PARTICULATE MATTER
USING ISOKINETIC SAMPLING


STACK SAMPLER SLE SS 115
Reset
Set
Start/Stop
Temp
SPECTRO
SPECTRO
Spm
Gas
SPM
Gas


EMISSION MONITORING


EMISSION MONITORING

Good morning friends, I welcome you in another experiment of our subject air pollution and control and in today's experiment I am going to explain you the method of sampling of emissions which are coming out from the stacks and that is called as the stack monitoring and for that we use the stack monitor and stack monitoring is generally used when we are going into the power plants or industries and the emissions which are coming out from the height of the different height of the stacks.

So, from those stacks through which the emissions are coming out we measure the how much of the particulate and polluting gases are there which are coming out from the emissions of these stacks. So, this is the experimental setup that we use for measurement of emissions from the stacks and first of all I will explain you the different component of this device.

So, basically like we have seen in our previous experiments also, like we have to suck the ambient air to measure the pollutants or particular matter inside it, so here also we need to have a suction device. So, here you can see this is the stack monitor and to suck the ambient air we have here a vacuum pump which is connected through this hose and it is attached at this point, so when we start this vacuum pump it sucks the air through this instrument, so this is the suction pump part and this stack monitor is having the different components.

So first of all I will tell you this is the thermocouple sampler and this long road is there so the purpose of this road is like when we are going to measure the temperature inside the stack we have to insert this probe into the stack through the sampling port and this probe or thermocouple is connected through this pipe at this point, so this is the thermocouple for measurement of temperature inside the stack as well as ambient air.

Another component of this instrument is your pitot tube this is called as S type of pitot tube and the purpose of this pitot tube is to measure the velocity and the fundamental principle or the physics which are used in this sampling is called as isokinetic sampling, what is the isokinetic?

Basically like when we are sampling the emissions through the stack whatever the velocity of the emissions which are coming from the stack or coming out from the stack the same velocity should be maintained when we are sampling the sample through this probe of the pitot tube, if the velocity is different then it will not be isokinetic sampling.

So, in order to maintain uh the constant velocity or the isokinetic sampling so that like velocity which are coming out from the stack and which is passing through this of the gas should have a constant value or it is the same value so we have this rotameter here through which we can regulate, so this is your pitot tube for measurement of the velocity of the stack emission and it has a long probe, so we just insert it through the port wherever we are doing the sampling in the stack and it has a two pipes here and which are connected here in the stack sampler.

So, what is the purpose of this two pipe? When we are keeping this pitot tube like this then if from bottom to up it is the gas which is coming out then it has a two probe so there will be some difference in the pressure, like coming the velocity of the gas which is coming up here it will be higher and here it will be lower, so the difference of these two will be here and using this fundamental equation of the pitot tube we will be able to measure the velocity because by using the pressure drop. So, this is the purpose of the pitot tube to measure the velocity in the stack.

So, until now I have tell you the temperature through the temperature probe or thermocouple using which we can measure the temperature inside the stack as well as outside and through the pitot tube we are able to measure the velocity of the stack emissions.

So, now as I said like we need to maintain the isokinetic sampling, now how do we do this and in order to do this like we have to have a rotameters, so here you can see in this device we have a rotameter, two rotameter, one is corresponding to the SPM and one is corresponding to gas, the purpose of saying this for SPM like when we are doing the sampling for SPM or suspended particular matter then we maintain the flow rate through this and when we are measuring the gases only then we control the flow rate through this.

Now, how what is the purpose of controlling? The purpose of controlling is like when we are measuring the velocity through the pitot tube we can use the formula and estimate the velocity and then we can calculate the flow rate, now that flow rate if we are able to control through the suction pump and through regulating here then by regulating that flow rate we will be able to maintain a constant velocity and therefore this will ensure the isokinetic condition of sampling.

And so this is the purpose of these two rotameters and here we have another opening and the purpose of this opening is like when we are doing for the sampling of particles along with gas then we use this probe, actually this probe is having at the front a filter assembly through which when the stack emissions is coming and it is passing through the filter, so whatever the dust particle or suspended particles that will be collected inside the filter and only gas will be allowed to pass, so this probe is used when we are doing sampling of SPM also.

And this probe will be connected at this point, so for measurement of stack temperature we use the probe and when we also use this switch, so when this switch is on for the stack temperature, the temperature of stack will be recorded and when we are using this switch to switch up so that the ambient temperature will be recorded from here, so this is how using this switch we can measure the stack temperature as well as the ambient temperature.

Professor: So, on this basis we can calculate all those parameters whether particulate matter or SO_2 you know the procedure sampling as well as calculation.

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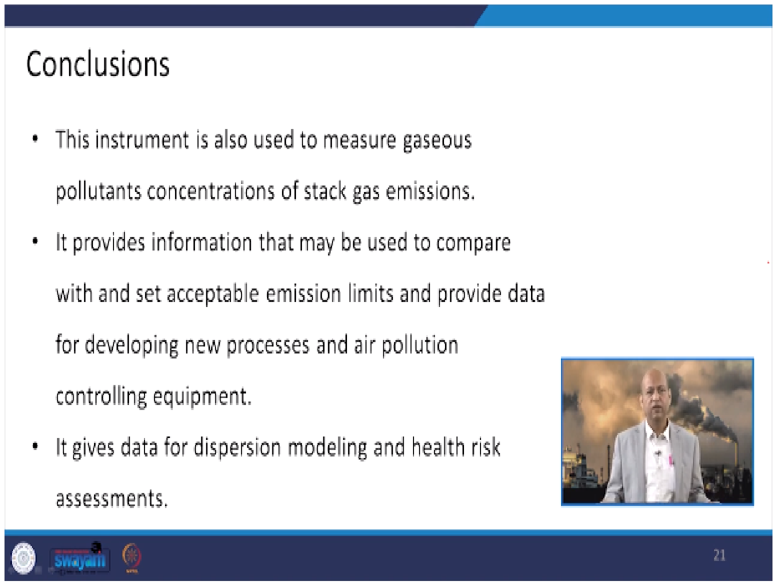

So, in conclusion we can say that these kind of methodologies or instruments can be used for measurement of gaseous and particulate pollution which is emitting out of a particular stack and those values are very much required because there are norms how much pollution emission standards are there which has to be met, so we can compare with the help of those particular monitoring data, those monitoring data are also used for dispersion modeling purpose, health risk assessment, etc.

So, stack monitoring is very important activity and environmental engineers they should know the methodology how to do stack monitoring, so this is the explanation about the stack sampling, stack emission sampling and the calculation. I hope you have enjoyed this so thank you for your kind attention.

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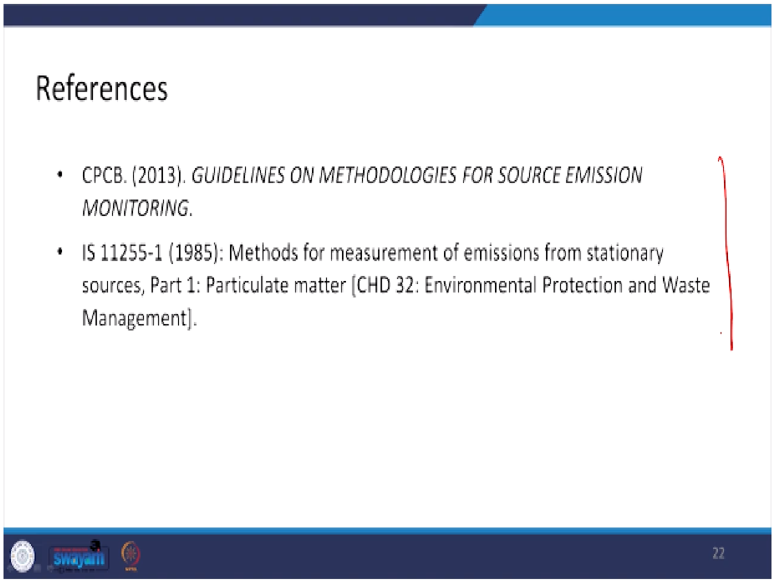

And these are the references where we have taken matter and thanks again and see you in the next lecture.