Noise Management & Its Control
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Lecture - 35
Classification of Microphones – II

Hello welcome to noise control and its management today is the 5th day of this week and what we planned to do today is discuss 2 remaining types of microphones one is the piezoelectric microphone and the second one is fibre optic based microphones.

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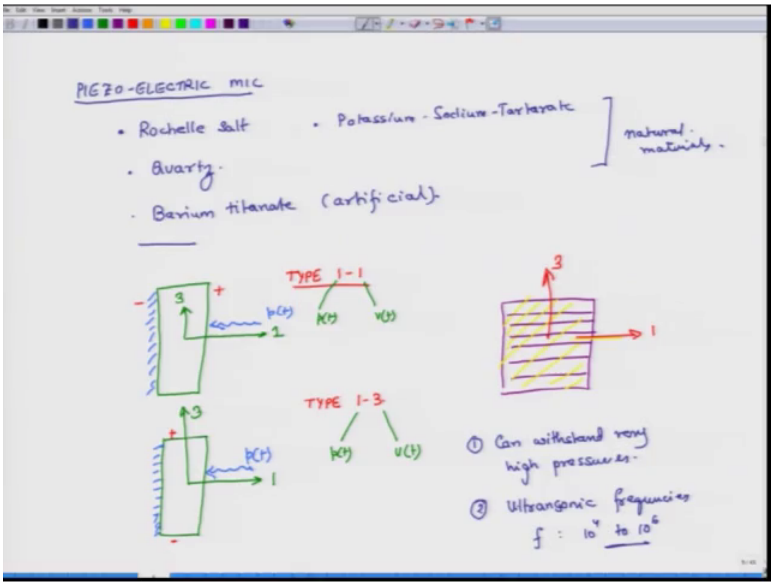

So, as I had mentioned earlier piezos or piezo electric microphone it exploits the piezoelectric nature of some materials. So, what so what is the nature of piezoelectric materials that if they are subjected to external pressure then they cross the material some voltage gets generated that is one effect, the inverse effect is that if you apply voltage across these materials they shrink or expand. So, this is the piezoelectric effect, some materials which are which depict this effect.

So, some natural materials which depict this effect are. So, one is Rochelle salt it is a particular type of salt it comes in crystals Rochelle salt, then another material is potassium sodium tart rate, this is also salt tartaric salt of potassium sodium. Another natural material which exhibits this effect is quartz and one material which is artificially synthesized is bar barium titanate. So, this is artificial or synthetic material it is made in labs, these guys they are all naturally available materials. Now, there are 2 categories of these materials so to understand that lets draw a picture.

So, suppose this is a crystal a piezoelectric crystal and a crystal has specific material axis. So, let us say this is axis 1 and this is axis 3, how do I decide the axis I have to actually under a microscope look at the structure of the material and the particles and molecules will be aligned in a particular direction and they will be ordered in a particular directions. So, based on the ordering of these molecules in a crystal like structure I will figure out based on my micro, observations in the microscope which one is a natural axis of this crystal and I can label one axis, a particular axis as axis number 1, this is axis number 2 and the axis which goes in this direction is axis number 3. I will give you an example to make things clearer suppose I have a piece of cloth and it is not and it is a very special type of cloth where all the fibres are lined up like this. So, I take a lot of fibres and I, what I do is I glue all these fibres I dip all these fibres in a sheet where all the fibres are in a particular direction and I dip it in some glue and then I take it out right. So, my sheet of cloth is what? It is having all the fibres in one particular direction and they are bonded together by this glue.

Now, now so when I look the structure fibres are in one particular direction I can call this direction as 1, because this a material direction, direction of the material and I can call the other direction as 3 and the perpendicular direction is 2 or whatever. Similarly when we look at the structure of a piezoelectric crystal we will see some patterns and based on that pattern how crystal are organised we can figure out which one is 1 direction and 2 direction and 3 direction. So, there are 2 types piezoelectric crystals, the first one is type 1, 1. So, this is type 1, 1 what is type 1, 1 what; that means, is that if I apply.

So, let us say that this end of the crystal is fixed and if I apply pressure here, then the potential difference which gets generated is also in this direction. So, my potential difference gets generated on these two surface, across these two surfaces which are normal to 1, 1 axis. So, this is type 1, 1 the other type of piezoelectric crystals are type 1, 3 what is there in 1, 3. So, suppose this is axis 1, this is axis 2 and suppose I fix this end of the crystal and I apply pressure here suppose sound hits it. So, pressure is being applied here. So, pressure is being applied in the one direction, but the voltage gets generated on the other two surfaces.

So, this is type 1, 3, what does this mean? Here this one represents the surface on which pressure is getting generated and the other one the represents voltage across which the it is being generated, but here pressure is generated on surface 1 or is applied on surface 1, but voltage gets developed across surface 3. So, you can have different types of piezoelectric crystals 1, 1 and 1, 3 these are the 2 categories and based on this lots of different types of microphones have been developed. Couple of important things about these microphones one is because these are solids they can take very large pressures very large pressures.

So, suppose you want to measure sound at the bottom of an ocean if you take a regular microphone and put it at the bottom the ocean it will get crushed because its hallow from inside, but these are solids. So, they can take a lot of pressure. So, can withstand very high pressures, second thing is they work well at, not they do not work that much well at audible frequencies. So, they work well at ultrasonic, ultrasonic frequencies. So, the frequency could be something like 10 to the power of 4 to 10 to the power of 6 hertz, 30000, 40000 hertz to mega hertz range ok.

And they are very robust devises, they are very robust devised.

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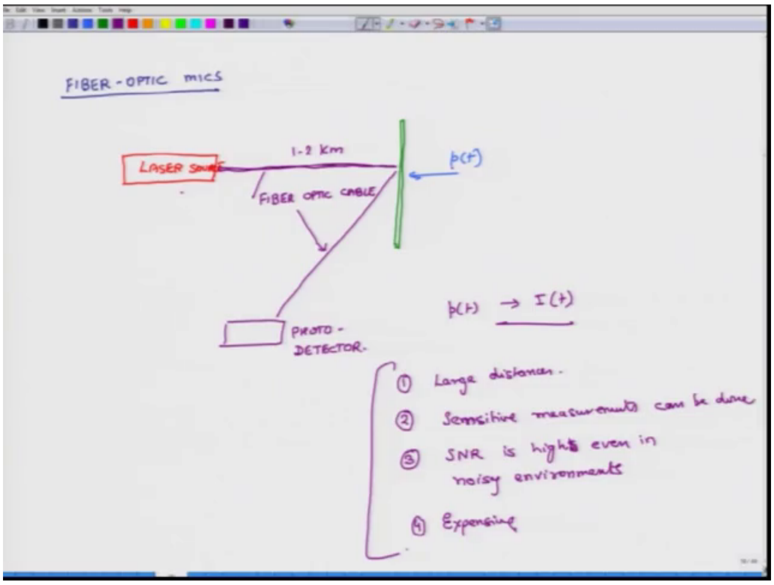

So, that is there and then the last category of microphones is fibre optic, fibre optic mics. So, a broad description, very general approximate description. So, what fibre optic microphone has is a laser source. So, what you have? Suppose this is the diaphragm and when sound is strikes it this diaphragm moves back forth it vibrates, it would back and forth now what you do is you have a laser source. So, it emits a laser ray and this laser ray is carried through fibre optic table. So, there may not be in a straight line the cable can bend and twist and it can be very far away, this distance could be 1 to 2 kilometres also.

So, if you are interested in measuring 2 kilometres away your expensive stuff laser source is very far away and suppose this there you, here suppose on the diaphragm there is a lot of explosion and things like that. So, you want to keep your laser source away, you have a cable and then this cable emits laser, it strikes and then you have a collector cable and then you have a photo detector, you have a photo detector. So, this is also fibre optic cable. So, the principle is that as pressure changes diaphragm moves back and forth and the intensity of the light received by this collector cable it changes right, it changes and. So, pressure is measured in terms of intensity of the light, couple of things you can measure sound at very large distances, large distances, the second thing is that is very sensitive measurements can be done.

Third is that suppose because this is light travelling through fibre optic cables, suppose there is a lot of electromagnetic field or electric field it does not influence light right. So, light remains. So, the signal to noise ratio is high even in noisy environments and by noisy I do not mean noisy as in because of sound, but noise because of electromagnetic fields, but it is expensive. In context of this course most of the times, I mean most of you as who are watching this if you have a need measure sound you will most likely be measuring sound either using those electret microphones or in some cases using those free polarized microphones, but I just wanted to give you an over view of how microphones can be classified on the basis of measuring measurement technology, what are the measuring principles.

So, that is one thing, the second way to classify microphones and this is also important to understand and know is based on what kinds of fields are there involved. So, what we have discussed till so far are different types of microphone based on the technology which is used or the measuring principle which is used, in the process of measuring sound pressure level. Another way to classify microphones is based on the incidence of sound wave. So, what does that mean? So, let us look at this picture.

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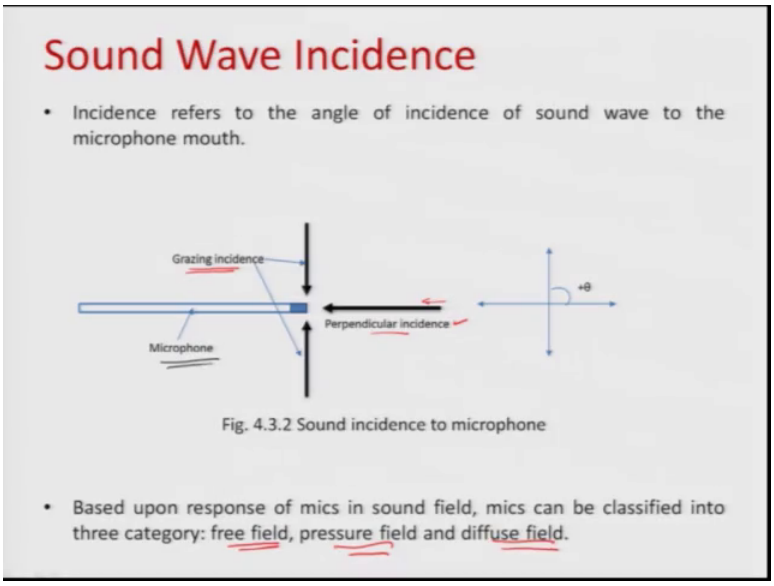

What you have here is. So, suppose this is our microphone and sound could come and hit the microphone from different directions. So, if the sound is coming from this direction we call it perpendicular incidence. So, this is the microphone diaphragm and the sound is coming and hitting it. So, the direction of the sound propagation is normal to the plain of the microphones. So, that is why it is called perpendicular incidence ok.

In another case this is our microphone and the sound is coming in direction parallel to it, in parallel to it. So, that is called grazing incidence. So, we have 2 incidences perpendicular and grazing and in reality sound would come from all directions, may be in some situations sound comes primarily from perpendicular direction in some other situations it could be coming from in the grazing angle. So, it could be all sorts of things right could be all sorts of. So, based on how sound comes and hits the microphone that could also be a way to classify microphones, how sound comes and hits it.

So, that is what it says based on the response of. So, based on how the microphone responds to different types of sound pressure level it sees, you can classify microphones as free field microphones, pressure field microphones and diffuse field microphones and we will discuss this what do these things mean. So, there could be a situation where your need is such that you have to use free field microphones. In other case it could be that the, you may have to use the pressure field microphones because it may be the best thing for your kind of situation or it could be a diffuse field microphone. So, we will talk about these, this is another category of microphone, categorization of microphones.

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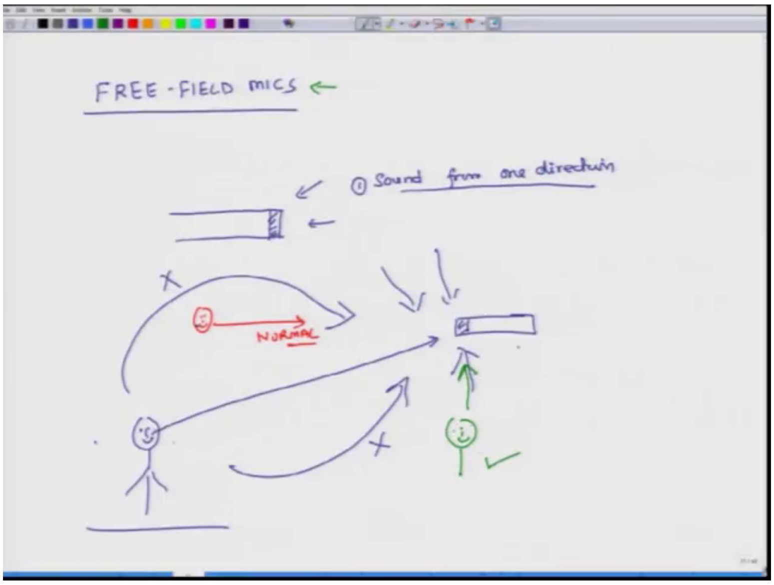

So, let us talk about free field microphones ok.

So, in this case your microphone is like this and the sound is coming from, it comes primarily from one direction, sound comes primarily from one direction. So, it could come either from here or here, but it is not coming from all over the place like this, it is coming from one direction. So, this is a free field condition, what could be an example of free field condition? Suppose you are in the outside, you are in a football field pardon me there microphone is like this, oriented like this and there is a person who is shouting. Maybe 50 metres away from here and you are in the outside, you are in the outside where does the sound come from sound comes to the microphone from this direction only it does not come from these directions right.

It comes directly from the line which connects the microphone and the person, suppose you had a situation where this was a closed field you know closed field then what would happen. Some sound from this person will reach microphone directly, but sound will also reach the walls of the enclosure and those walls will reflect that sound and that sound will also come from other directions also, but that is not the situation where what we are talking about. We talking that sound is coming only primarily only from one direction, primarily only from one direction because there are no reflecting surfaces around. So, where ever whatever is the source, the source emits sound and then you have a microphone and the microphone whatever the line connects the microphone and source that is the direction from where the sound comes.

Now, this sound could come either as normal incidence, which we have discussed you know. So, suppose the person was here then it would have been normal incidence right, suppose the person was here then it would have been grazing incidence and this is some general direction (Refer Time: 19:11) some general direction. So, microphones which are capable of which do a good job, where in terms of measuring sound in such situations where sound is of free field type they are free field microphones. Normally what do you expect such a microphone to do that if the person is here or the person is so suppose the person is here or the person is at this location or the person is at this location the microphone should be able to measure sound coming from all the directions right.

In each case sound is only coming from one direction, but if the source moves it should be able to measure and it should be equally sensitive to all the directions. So, that is an important characteristic of free field microphone that if the sound source is changing its location changing it should be able to sense that sound equally well and should not be sensitive to a particular direction it is.

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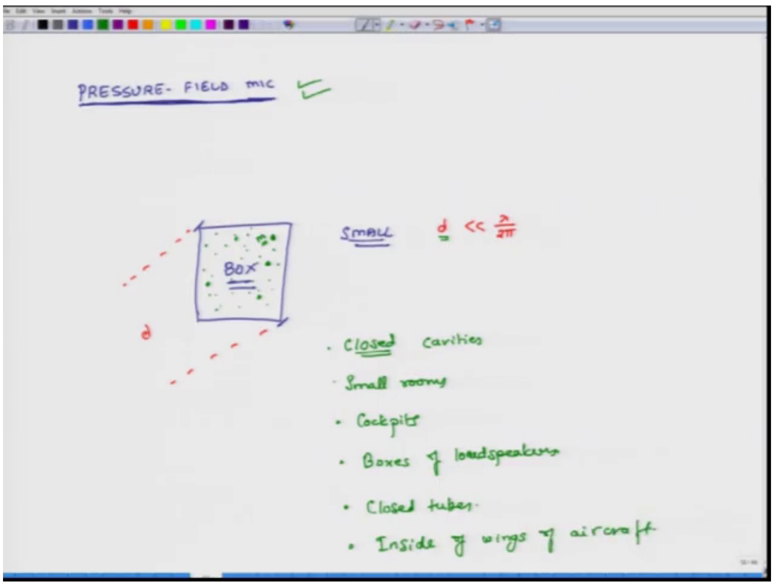

So, these are free field microphones, second type of microphone is known as pressure field microphone pressure field microphone. So, before I talk about pressure field microphone one example.

So, this type of situation for free field could be where if you were in a field right, if you were in a outside, in a field, on a big lawn or near ocean or in a big ground or even if you are in an air right you have a microphone in the air and there are some birds chirping and you want to see or some plane moving by you want to capture all that is free field condition all that is free field condition. And an another example could be and anechoic chamber, what is an anechoic chamber? It is a room it is a special room when I talk the sound does not get reflected by the walls because I make walls in such a way that they do not reflect any sound. So, in that kind of a situation also what if I have a microphone it should be of free field type because there are no reflections ok.

So, the next one is pressure field microphone, now what is so special about pressure field microphones. So, suppose you have a small closed box. So, closed box and I say that it is a small and let us say this distance this dimension the largest dimension is d. So, when I say d box is small, what I mathematically imply is that d is fairly small compared to lambda over 2 phi, where lambda is the wave length of any frequency which exits in this box. So, suppose in the box there is a noise making machine, there is a noise making machine this is there is a machine which is generating noise, but it is a closed box. Now, there is box in reality could be a room, it could be a cabin, it could be a cockpit whatever does not matter and it is generating noise, but the main thing is it will be small in the sense that d its largest dimension should be small compared to 1 6th of the wavelength of all frequencies which are present in the box.

Now, if that is the case and if you mathematical analysis you will find that the pressure field in this box at different points it does not change. If I put a microphone here or here or here or here it does not change, does not change if box is small, if the box is long then you will have standing waves and pressure will be somewhere higher somewhere lower and so on and so forth. So, for these kind of applications, for these kind of applications we use pressure field microphones. So, pressure field microphones are good in these type of.

So, where do we use them in closed cavities so important thing is closed, if it is open then at the open end pressure will be very closed to atmospheric pressure. So, we do not have to. So, it has to be closed from all these things, closed cavities small rooms, cockpits, boxes of loudspeakers you know some times lots of loudspeakers are have a transducer or a speaker mounted in a closed box. So, boxes in loudspeakers, tubes closed tubes, inside of the wings of air craft, wings of air craft are hollow and they are also sealed. So, if you want to know what kind of noise is there inside you may want to use a pressure field microphone. So, that is there.

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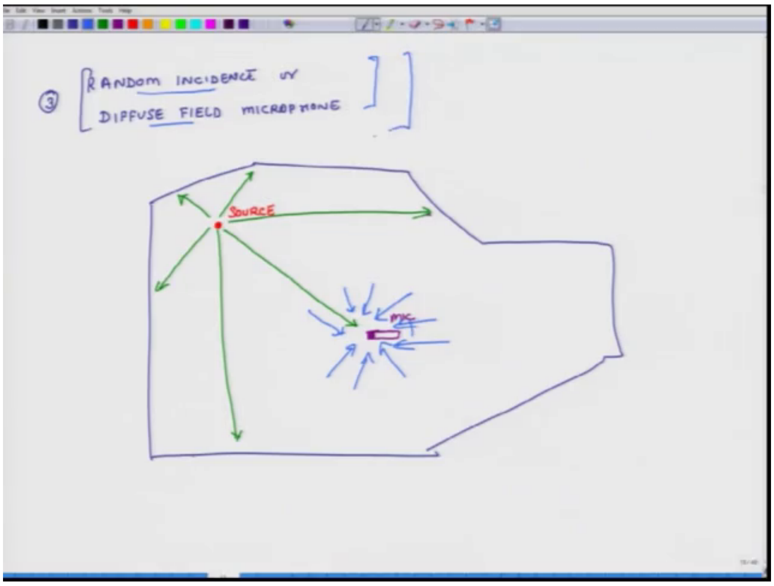

And then the third type is random incidence or defuse field microphone, I will call it defuse field microphone. So, it has 2 names one is random incidence or defuse field microphone. So, this is the third category, now what does it mean? What could be a situation? So, suppose you have a room like this and it has it is not nice rectangular room, but it has some complicated reflecting surfaces and suppose there is a noise making machine here. So, this is the source and I have a microphone placed here.

So, end takes. So, this is my mic, what happens when the source emits noise some noise reaches the microphone directly, if there were no reflecting walls this would be the case of what a free field situation. If there were no reflecting wheels walls, but this source is not only emitting noise in the direction of mic, but it is emitting noise in all directions, it emits noise in all directions right and what happens when these sound waves hit the walls they reflect and ultimately you have not only direct sound, but the microphone receives sounds from, reflected sound from all directions ok.

And it is not that because of just one reflection, sound comes reflects again goes to another wall again hits. So, at the end of the day it is all homogeneous mixture of sound coming from all directions. So, from all directions same amount of sound is kind of coming that is why it is called random it is coming in randomly from all directions and it is diffused, it is diffused. So, in this kind of a situation we use random incidence because the microphone the incidence of waves is random, earlier we have talked about grazing incidence, normal incidence, this is random incidence sound is coming from all directions and the sound field in the room is defused it is smeared it is has been homogenised ok.

So, this is random or defused field microphone. So, from the application stand point we can think about 3 types of microphones, one is free field, second one is pressure field, third one is random incidence and again you have to look at you specific situation and figure out which type of microphone is most appropriate for your particular application and that will help you make a good selection of microphone, from the stand point of application. So, that closes our discussion for today, tomorrow we will continue our discussion on microphones further and till then have a great day bye.