**Lecture – 39**
**Measuring impedance Using the Two Microphone Method**

Hello, welcome to Basics of Noise and its Measurements. In the last lecture, we had been discussing as to how to use an impedance tube to measure the impedance of an unknown using an impedance tube to measure a material whose impedance is unknown and specifically, we had discussed the use of two microphone method and both these microphones were actually fixed in the tube, so they were not traveling along the length of the microscope. So, we had explained the mathematics and the founding principles for this particular approach and today, we will be looking at some of the practical considerations that if we have to use a tube and design a tube to meet these needs; how do we go around doing that? So, measuring impedance using the two microphone method that is what we are continuing the discussion on.

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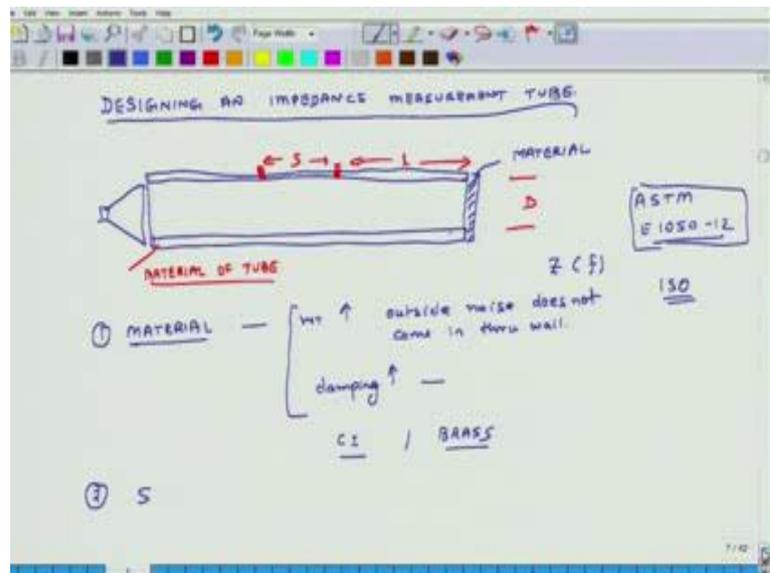


And we will look at some of the practical considerations in terms of designing this tube. So, designing an impedance measurement tube, the overall schematic we had shown in

the last class, so we have a tube, this is the cross section of the tube and here I have a loud speaker and there this is the base where I am going to place my material and what we will look at today is some of the important dimensions of this tube and how can we determine those dimensions. So, the spacing between microphones is s, this distance is l, the inside diameter is d, then we also have to figure out the material of the tube.

Now, before we start discussing all these details; wanted to make two important points that impedance is a function of frequency. It can change of a material it actually varies with frequency so whenever we want say that we are interested in measuring the impedance of a material, we should state that we are measuring impedance of this material for this range of frequencies. So, only for that range of frequencies we will be designing this tube, this tube may not necessarily work beyond the range of frequencies which we are interested in.

So, if we got to the market you will see some in impedance tubes they work at high end or at higher frequency ranges. Some impedance tubes they work at low end frequencies and so on and so forth. So, here you should be very clear what is the bandwidth in which you are trying to measure the impedance of the material and the second thing is that whatever we are going to be discussing today it is based on an international standard and this standard has been prescribed by A S T M and the number of this standard is E 1050 dash 12. So, whatever I am going to be talking about, it is based on some of the recommendations of even and some other practical considerations. So, this is an A S T M American standard, a very similar standard is also there which is an ISO standard International Standards Organization. So, they are fairly similar, there are some differences, but today we are just going to have the discussion in context of the A S T M standard.

The first thing we will look at is the material of the tube and the way we choose this material is that we have to make sure that the weight of the tube, so first is material. So one is that we want this tube to be as heavy as possible and of course, it should be practical also it should not be a ton 1000 kilo heavy because then it becomes impractical to use it and move it, but within practical considerations it should be heavy enough which means that we have to make this wall thickness high and also the density of the

material should be as high as possible, so those are the two important considerations.

So, weight should be more and then, so why do we want high weight, large weight because if you take a course in acoustics and we reach some of the details we will see that a lot of frequencies, they get attenuated by presence of large weight this is known as mass attenuation and this was especially at high frequencies. So, lot of outside noise whatever is there especially mid to high frequency noise, if the tube is heavy enough all those noises will not leak into the system through the wall.

So, the weight is there to ensure that outside noise does not come in through wall. Now of course, it can leak through the ends, so we have to make sure that the ends should be tight, but the outside wall should be heavy to the extent which is practically possible. The second thing is that the material should be such chosen that its damping should be high and why is that because when sound is been generated in this, the walls of the tube may also get excited and they may vibrate and they may generate their own noise and we want that kind of noise to damp out as fast to possible.

So, this damping is to reduce the confusion or noise due to the sound which will get generated due to excitation of vibrations of the tube itself. So, if I have to choose, I will go for; may be a material like cast iron, but the problem with cast iron this accidentally drop it, it will crack, it is brittle. Another good material could be brass, cast iron is high damping, its density is about 7.8; brass density is some fairly close to that of cast iron. The damping is also high. If I use mild steel tube it is less expensive density high 7.8 something in that range, but damping is not that great, same thing is to for stainless steel. Aluminum density is low as well as damping is low, plastics damping is high, but density is close to 1 very low. So, if you want to make a really good impedance tube, this is one important consideration. Second, we have to figure out the value of s, what should be the spacing between the two microphones.

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So, second consideration is value of s, so one parameter which helps us determine is that s should be greater than 1 percent of lower frequency limit, what does this mean? Suppose I decide, so we will have this discussion in the context that we are going to decide that the tube has to work from 35 hertz to 2300 hertz. So, let us say that the operating bandwidth of tube is 35 to 2300 hertz. So, then one consideration we have to satisfy is that s should be more than 1 percent of lower frequency limit.

Actually, this is wrongly worded 1 percent of lambda for lower frequency limit, so at 35 hertz lambda equals 348 over 35 is approximately equal to 10 meters. So, 1 percent of it is 10 centimeters, so s should be more than 10 centimeters, this is one consideration. This another consideration for this thing and the other consideration is that spacing should be less than 0.8 times lambda for the upper frequency limit, this is the second consideration, so for calculate s we have to be in this range.

So, lambda for upper frequency limit is 348 divided by 2300, so this is about 0.151 meters. So, 0.8 lambda u equals 0.121 meters, so s should be smaller than 12 centimeters, so it has to be more than 10 centimeters, less than 10 centimeter, I will take somewhere in middle like in put it at 11 centimeters. So, just to give you a quick view, so this is one important parameter the spacing.
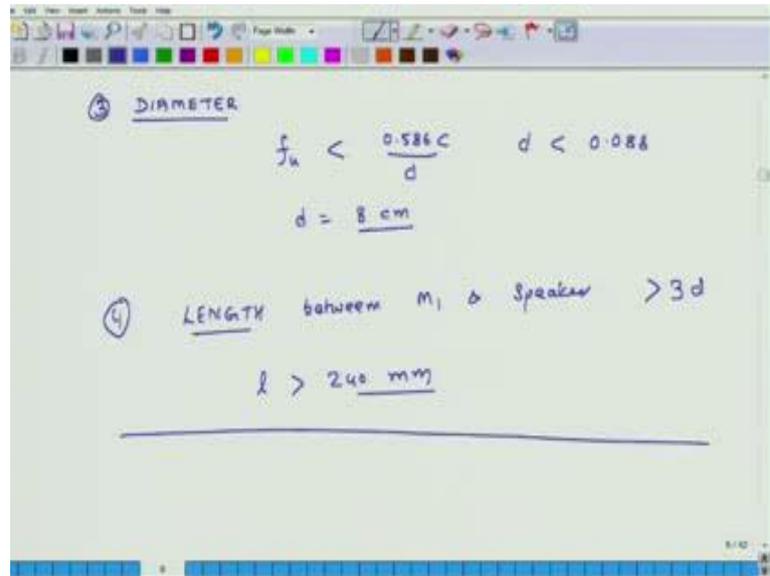
The third thing is what about the diameter, so the consideration for this is that f u which is the upper frequency limit, it should be less than 0.586 c; over d and if you do the math f u is 2300 hertz so d should be less than 0.088 centimeters. So, I take d equals 8 centimeters why is this important, well what we want is that this whole calculation is based on one dimensional wave propagation equation. Now, the diameter is very large in our original assumption we had assumed that everything is moving uniformly in the x direction, gradients in y and z directions are 0, if the diameter is very large especially when wavelengths are small then they will be all sorts of waves which will get generated in the y and z directions.

So, we do not want non planar waves to get generated and this is a guideline which based on experimentation and may be some analysis the standards people have figure out. So, if we use this then it will ensure that we continue to have planar waves in the tube, so that is there and the fourth thing is that length between M 1 and speaker. So, this should be more than 3 d, it should be more than 3 d. So, what does that mean that my length should be more than 240 millimeters, why this important again? This is to ensure that we have planar waves in the system.

So, when you have a speaker at the end, it will generate some waves and very near to the

speakers they will not necessarily be planar waves. Again, if you go and take some courses in acoustics, you will see that a lot of times waves tend to radiate and uniformly in all directions. So, it may have some kind of that, but once you had far away from the source, these waves tend to become more and more planar in nature. So, with that purpose in mind you want that the length; that is the position of the first microphone is at least sufficiently far away, so that once the sound waves reach that point they have become more and less planar in nature, so that is the other criteria.

So, with these four, five important criteria we can design an impedance tube and you can actually make these tubes, put some microphones on them and in terms of selection of microphone again you have to make sure that the size of the microphone or the diameter of the microphone should be significantly smaller than the wavelengths of the sounds which you are dealing with. So, if you use quarter inch mic or maybe one eight inch mic, the diameter will be 6 millimeters or 3 millimeters and that will take your most of your frequencies. So, that is what I wanted to cover in this discussion and I will close this discussion today and we will have a new topic starting tomorrow.

Thank you very much and have a great day.