Noise Management & Its Control
Prof. Nachiketa Tiwari
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 48
Measuring Sound Power Level - Fan Noise - Part III

Hello. Welcome to Noise Control and its Management. Today is the last day of the ongoing week of this course. And what we planned to do is conclude our discussion on fan noise today. And specifically what we planned to do is; we want to complete that example and the question which I had post in the last class. And very quickly I will recap that question and then I will actually solve it, so that all of us become clearer in terms of how to compute sound pressure levels which are attributable to noise sources which are at a distance.

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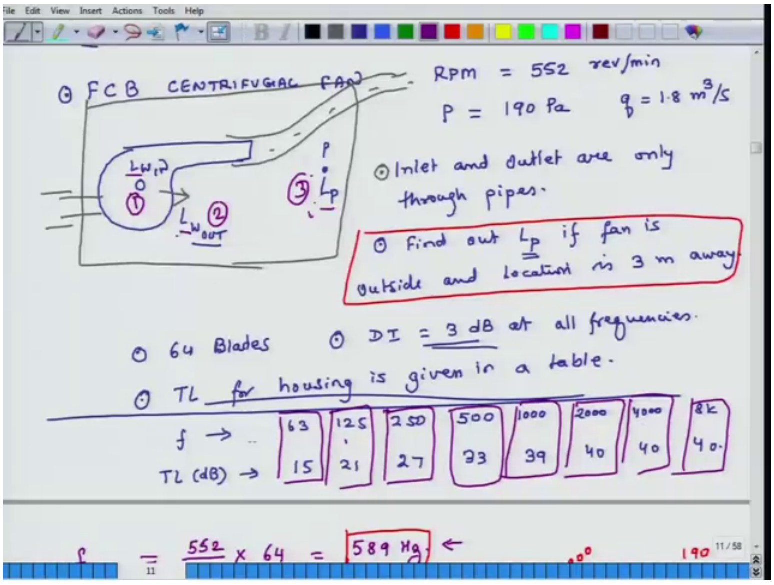

So, the question is that there is a forward curved blade centrifugal fan. It is outside the room. It is in free space. It is rotating at 552 rpm. It is generating air and the output of air is 1.8 cubic meters per second, which is 1800 litres per second. And the pressure of this out coming air is 190 Pascal's and the inlet and the outlet is not throwing out air just in the open actually it is taking air through a pipe to somewhere else it has 64 blades the directivity index with respect to the point of observation is 3 decibels the transmission lies for housing loss for housing is given in this table.

So, with this all this information what we are supposed to do is find out LP which is the pressure sound pressure level at this point P, I have to find LP. So, to compute LP I have to find LW out and to compute LW out I have to find LW in. So, first what I will. So, so here is the overall approach for different frequency bands.

So, please remember all these computation will be for different frequency bands these are different frequency bands. So, we will compute for every single frequency listed here not frequency bands LW in then we will find LW out, then from that LW out we will find LP. For every frequency band first we will find LW in, then we will find LW out then we find LP. And then for and then we will add up different values of LPs corresponding to different frequencies different frequencies. So, that is how we are going to do.

So, I had said that this fan will produce 2 different types of noises. One is tonal noise and the other is broadband noise.

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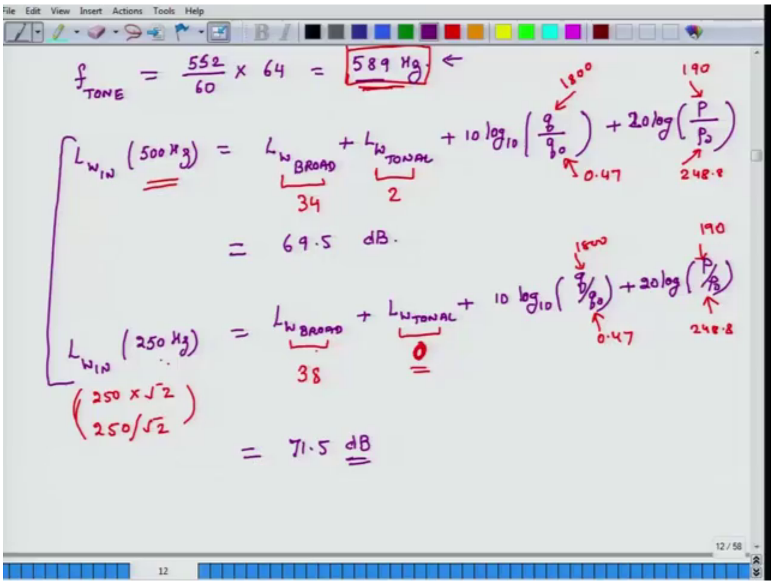

So, let us look at tonal noise. So, what is the frequency of that tonal noise? It will be the number of blades times rotations per second. So, frequency of that tone will be how much? It is rotating at 552 rpm. So, I divided by 60 to get rotations per second. And this I multiply by number of blades. So, this is 64. So, if I do the math, I get 589 hertz.

So, what this means is that my fan will produce tonal noise at 589 hertz. And also it will produce broadband noise. It will produce tonal noise at 589 hertz and it will also produce broadband noise for all these frequencies which are listed here 63 to 8000. So, next is I compute LW.

So, what again what is our methodology? First we compute LW in for different bands then we compute LW out and then we compute LP. So, this is what we will do. So, LW first we compute LW in. And for starters we will compute for the frequency band which in which 589 hertz lies. So, let us look at this table. See 589 hertz is the tonal noise. It will lie in which band will it lie in 250 hertz band or 500 or 1000 hertz band. Either you compute the bandwidth of 500 is 500 divided by 2 to the power of 1 by root 2. And upper limit is 500 into root 2. So, what is the 500 hertz band upper limit is 500 into root 2. So, that is what about 7 about 714 hertz. And then this is 500 divided by root 2. So, that is about 357 hertz.

So, which means that this 500 hertz tone it will lie in this 500 hertz band; it will not lie in any other band so we will first do computation for 500 hertz band because it is a special band for other bands also we will use, but. So, so we do it for 500 hertz band. And what is the relation for LW in LW in is LW broadband plus LW tonal LW tonal. This is the relation, which I have given in plus 10 log of 10.

What is that q over q naught q naught plus 20 log 10 P over P naught? What is q naught? Q naught is 0.4 5 to 4.47 litres per second we have given that value. And what is q? Is 1.8 cubic meters per second? So, that is 1800 litres per second. 1 cubic metre is 100 litres. So, q is this what is P naught? P naught is 248.8 Pascal’s right. And what is P 190 Pascal’s this is given.

So, in this relation for LW in we have figured all these parameters except for LW broad and LW tonal. And where do we get LW broad and LW tonal from form that table.

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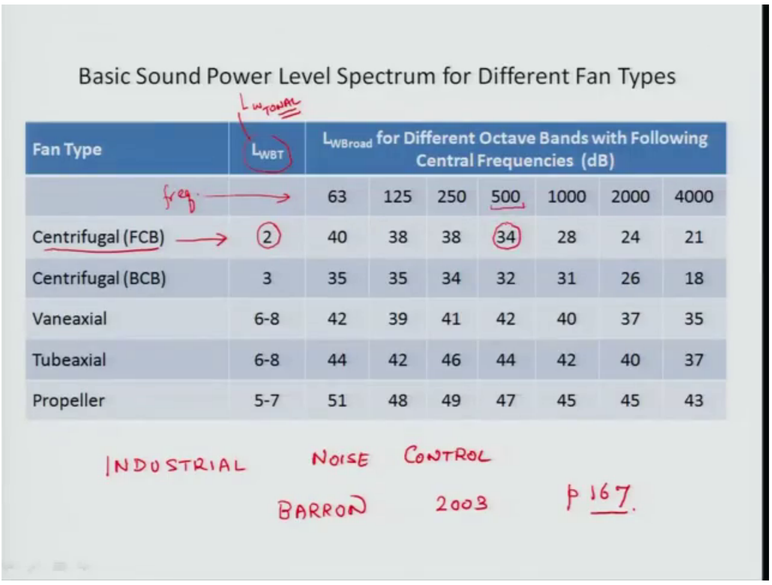
Basic Sound Power Level Spectrum for Different Fan Types

Fan Type	L_{WBT}	L_{WBroad} for Different Octave Bands with Following Central Frequencies (dB)						
		63	125	250	500	1000	2000	4000
Centrifugal (FCB)	2	40	38	38	34	28	24	21
Centrifugal (BCB)	3	35	35	34	32	31	26	18
Vaneaxial	6-8	42	39	41	42	40	37	35
Tubeaxial	6-8	44	42	46	44	42	40	37
Propeller	5-7	51	48	49	47	45	45	43

So, we will now go to that table. So, let us look at that table. What type of a fan is this? This is a centrifugal FCB or forward curved blade. We will look at this particular row, because this is a centrifugal FCB type of fan. What is the value of LW tonal 2? So, this is the number we are going to put in that relation. LW broadband, what is the value? We have to look at the specific frequency band we are interested in right now. Right now we are computing for 500 hertz central frequency. So, the number we are going to use is 34.

So, with this understanding we go back. So, the number of LW broad is how much 2 and the number value of, oh I am sorry this is 34 and LW tonal is 2. So, you do all the now we know everything in this equation. And what we get? 69.5 decibels: if you do all the math this is the number, you will come a with 69.5 decibels. Let us do for one more frequency. LW in, so we have do it for all the frequencies right. What are frequency bands we are interested in, we have to compute it for 63 125 250 500 1000 2000 4000 8000 we have to do it for all.

In this class I am going to compute for one more thing, because then you will learn how to do it; so for 250 hertz. So, again LW broadband, plus LW tonal plus 10 log 10 q by q naught plus 20, log P by P naught. The same equation does q change q does not change it remains at 1800 ditto for t ditto for q naught ditto for P naught. These numbers do not change.

What about broadband? This we have to see the table whether it is different number or not. And what about tonal; it will be 0. Why; because this frequency lies only in the 500 hertz band. It does not lie in 250 hertz band. We saw that what is the 2 what does 250 hertz band mean? It means all the frequencies lying between 250 times root 2 and 250 divided by root 2 are 589 hertz tone does not lie in this bandwidth. So, this is going to be 0. It is important to understand this number will be non 0 only for one band in which that frequency lies for all other bands it is going to be 0. And what is LW broad we go back to the table.

So, in this case what is LW broad is our frequency central frequency 250 hertz. So, the central frequency is 250 hertz. So, LW broad is 38 decibels. So, now, I go back. So, this guy is 38 decibels. And this is 0 n. So, now, if I do all the calculations and I add up everything else what I end up with is71.5 0.5 decibels. So, this is LW in.

So, I have calculated LW in for 500 hertz. I have calculated LW in for 250 hertz. And similarly we have to calculate for 63 125 and all the frequencies. So, you understand this. So, next, what did we say we have to do LW in then we calculate LW out? Our path is from here to here to here. This is step 1, this is step 2, and this is step 3. This is our final goal because what does the question say find out LP. First we have to compute LW in then I have to compute LW out then I have to compute L LP. So, now, you know how to compute LW in.

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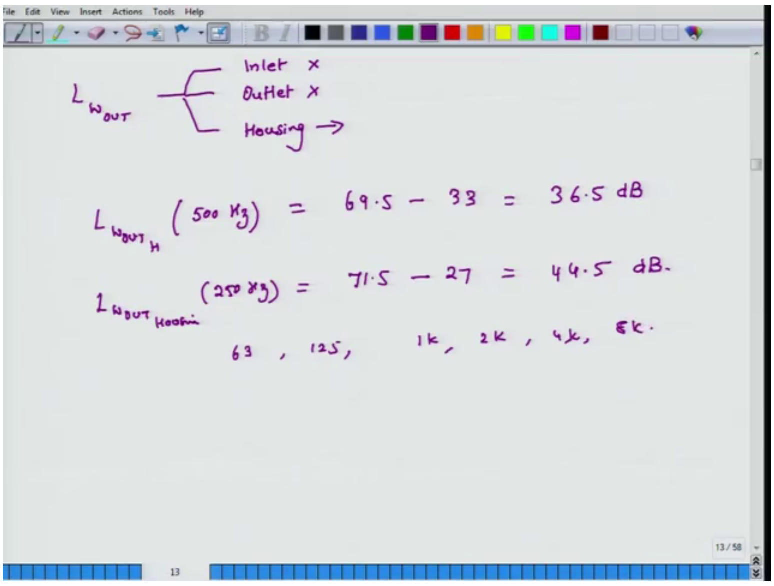

Now, we will do LW out; so LW out. Now remember we said that for a fan 3 sources. One is inlet, one is outlet, and third one is.

Student: Housing.

Housing we had ignored through the foundation. Now in our problem inlet and outlet are irrelevant. Because we said that they are connected to the pipes. So, no noise is coming from the inlet or outlet the only noise which is coming is through the housing. So, we will compute LW out for housing, I will just put h and again this is for a specific frequency bands. So, first I will calculate for 500 hertz.

So, what is that? Now we had said that the housing is such that there is a transmission loss, when the noise travels from inside to outside. It falls by 15 decibels in the 63 hertz band it falls by 21 decibels in the 125 hertz band. It falls by 27 decibels in the 20, 250 hertz band and so on and so forth. So, so this is transmission loss data is there.

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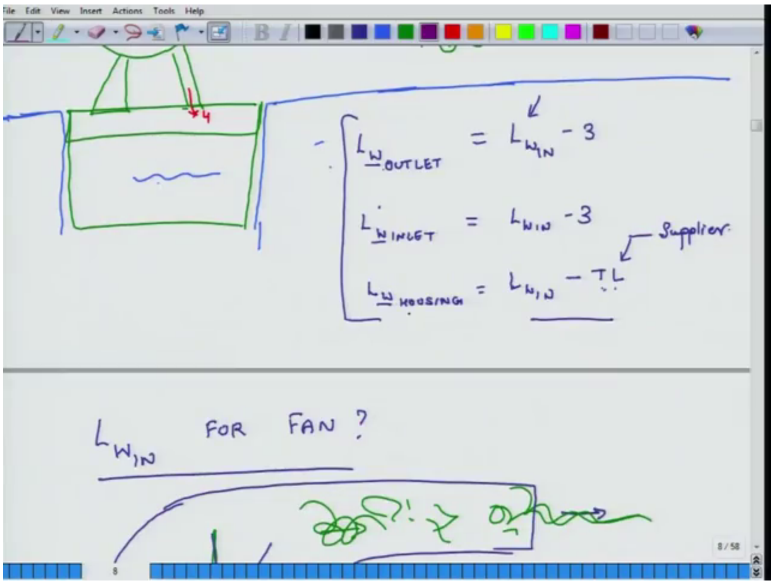

And we had also said, if you remember LW housing is LW in minus transmission loss this equation also. We have given and this is given by supplier. So, in this case the supplier or the vendor had provided us that information. So, using these terms LW out for housing for at 500 hertz is how much 69.5 minus. What is the number?

Student: 33.

33. So, 6 minus 3 3 6.5 decibels. And LW out for housing at 250 hertz is what 71.5 minus 27. And that comes to 0.5 11 minus 7 is 4 44 0.5 decibels understood. Similarly, I have to compute for all other frequencies also. So, I have to compute for 63, 125. I have already computed 250, 500 then I have compute for 1 k, 2 k, 4 k, 8 k and all this stuff good stuff.

So, I have to compute LW housing for all these different frequencies, but what is our original goal I have to find LP and again the path of LP is 1 2 3. So, now, I go to compute LP. So, now, we will do LP. And again those calculations will also be frequency specific.

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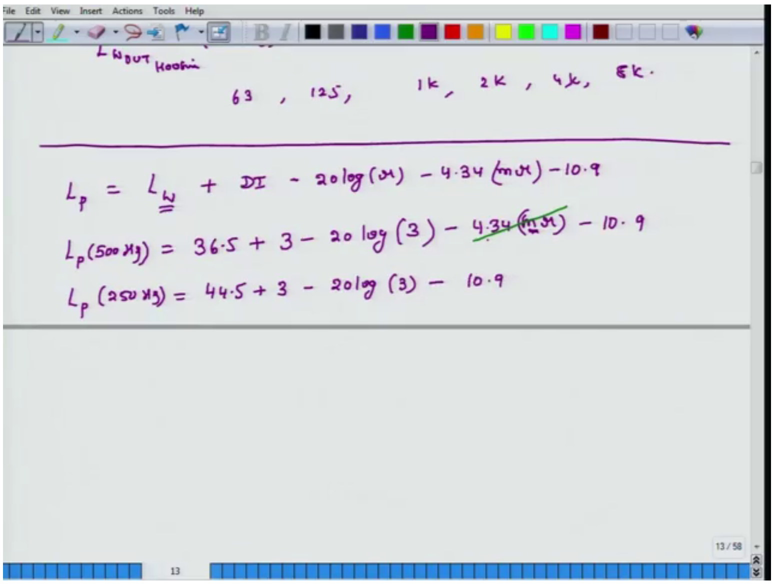

So, LP equals how much? We have developed the relation 2 weeks back, that if there is a sound source in the air and you are at a faraway distance outside. Then it is LW plus directivity index minus 20 log of r minus 4.34 m r minus 10.9. So, LP for 500 hertz is LW. And which LW are we are going to use.

Student: Sum of all these.

No you will not sum, you do not sum frequency data like that. You will again do frequency by frequency calculation. So, it is for 500 hertz, what is LW the only noise is coming through the housing it is not coming through other sources. So, it is 69 point, 36.5. And then what is the directivity index? We have given that it is 3, minus 20 log of r. What is the value of r? 3 meters, we have provided that minus 4.34 m r. And here it is 3 metres, r is 3 meters right.

And we have seen that m is such that sound decays over kilometres not over meters. The value of m becomes important specially if you are several hundred or thousand kilo metres away. Then this thing becomes important. So, because of that reason we will just ignore this in this case, but if you are may be 2 kilometres away, then you have to put the value of m and this value of m will be also specific to frequency. So, this is there and then minus 10.9.

Similarly, LP at 250 hertz is equal to what? Again I have to use LW, but LW is now a different number what is it?

Student: 44.

It is 44.5, 44.5 dB plus 3 decibels due to directive index minus 20 log 3 minus this is neglected 10.9. And similarly I have to do this computation for all the frequencies.

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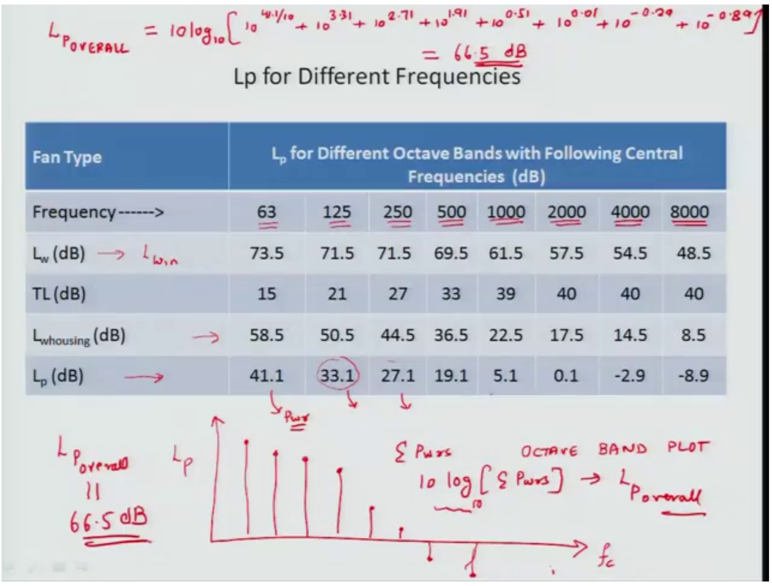
Lp for Different Frequencies

Fan Type	L_p for Different Octave Bands with Following Central Frequencies (dB)							
Frequency------>	63	125	250	500	1000	2000	4000	8000
L_w (dB)	73.5	71.5	71.5	69.5	61.5	57.5	54.5	48.5
TL (dB)	15	21	27	33	39	40	40	40
$L_{whousing}$ (dB)	58.5	50.5	44.5	36.5	22.5	17.5	14.5	8.5
L_p (dB)	41.1	33.1	27.1	19.1	5.1	0.1	-2.9	-8.9

So, now I will show the results for all the frequencies. So, this is there. So, these are the different frequencies, these are not specific frequencies. Each of these frequencies it represents a band. It is not that at 500 hertz the sound level LW is 69.5. It is that in that band the sound level is 69.5.

So, first we calculated LW, which is basically what did we call it LW in then using that LW in. I calculate I have I subtracted transmission loss. So, I calculated LW out which is LW housing. So, these are the numbers and then from these numbers I calculated LP. So, what does this mean that sound will be most intense, in which at which frequency at 125 hertz it is highest at 33.1 then it will be at 27, 250 hertz band then it will be oh I am sorry it will be most intense at 63 in the 63 hertz band and so on and so forth.

So, what I can also do I can make a plot central frequency LP and this is 41.1, then this is 33.3 then this is 27.9, 19.1 5.1, 0.1 minus 3 and minus 9. This is this type of plot. I cannot connect these plots by a smooth line. Because each point it just represents a central frequency it itself represents that entire band. So I never connect these things I just make put them as points.

So, this kind of a plot is known as octave band plot. Where on the x axis I have central frequencies of octave bands and on the y axis I have sound pressure level or sound power level or whatever. If these central frequencies belonged to one third octave bands it would have been called a one third octave band plot, but this is a term which comes verify regularly in noise related stuff. So, you should understand this.

Now, the final step which we are going to do is see these are at different bands we have different sound pressure levels, but we may be really interested in trying to figure out what is the overall sound power level or sound pressure level, because of a combination of all these things because of a combination of all these individual frequency components. So, the way we do that and this we have also discussed earlier we add them up, but it is just not adding them up by adding them up it is a little different. So, this is frequency specific sound pressure level.

Then what we do is calculate LP overall. And how do you do that you do not add 41.3 plus 33 plus 27. You do not do that that will be wrong this is because this is on logarithmic scale. So, what we do is we add up the energies or powers. We add up powers and then we take. So, what we do is for each of these frequencies, we compute the power. So, we find out what is the power corresponding to this what is the power corresponding to this what is the power corresponding to this. And then when the ear hears them it will hear the sum of all the powers. So, then we add up this power one power 2 power 3 all these things and then we sum up all the powers. And then we take 10 log of sum of powers that will give us LP overall.

So, I will show it here how do we do that we have discussed several weeks back in time how we add up powers and I am just going to directly write the numbers. So, we take 10 log 10. And then what do we inside the bracket. So, this is this part 10 log 10. In the sum of powers what do we do? First number is 41.1. So, I do 10 to the power of 41.1 divided by 10 that will be the power associated with this thing or elative power because second number is 33.1.

So, I put 10 to the power of 3.31 third number is 27.1. So, 2.7 one-third forth number is 10 to the power 19.1. So, it is 1.91 plus 10 to the power of 0.51 plus 10 to the power of 0.01 plus 10 to the power of minus how much 0.29 plus 10 to the power of 0.89; so if you add up all these numbers and take a 10 log 10 of this you end up with 66.5 decibels; so your overall LP overall equals 66.5 dB 66.5 dB.

So, this is what I wanted to explain. There is a small addition to this problem and suppose. So, in this case we have assumed that the pipes existed. So, the only sound which was coming was through the housing, but what would happen suppose we had one pipe open and also sound was coming through the housing then what we then what is it that we are going to do.

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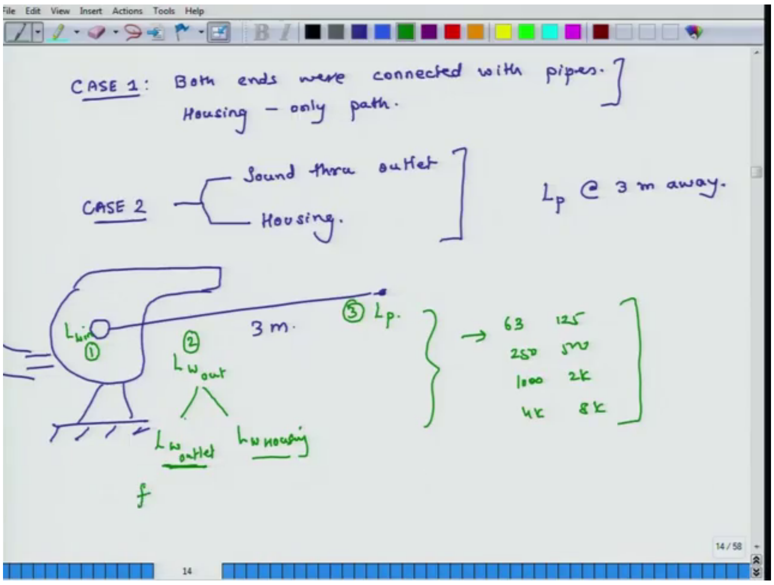

So, in the first case one, both ends were connected with pipes. So, the only source or sound outside was housing, through the housing, was the only path. And we have done the calculation for this. So, we know how to calculate in the second case we have a different situation. So, we are out and this blower is just throwing air out in the open and I am here 3 meters away. So, sound through outlet and by the way inlet is covered through a pipe. Sound is coming through the outlet and it is also coming through the housing. Sound is coming through the outlet. And also coming through the housing then what then you find out LP at 3 meters away this is what we have to find out.

The steps are still the same first we find out LW in second is we find out LW out. And third is we find out LP. So, this is step 2 the steps are still the same step 3, but for calculating LW out. Now I have to find what LW outlet and LW.

Student: Housing.

Housing I have to find out LW outlet and I have to find out LW housing. And I have to do all these calculations for what all these calculations have to be done for 63 125 250 500 1000 2 k 4 k 8 k all these frequencies. So, I have already computed LW in that does not change what is LW outlet it is LW in minus 3 decibels. So, I can calculate; so in this table in the table which I had shown for different frequencies.

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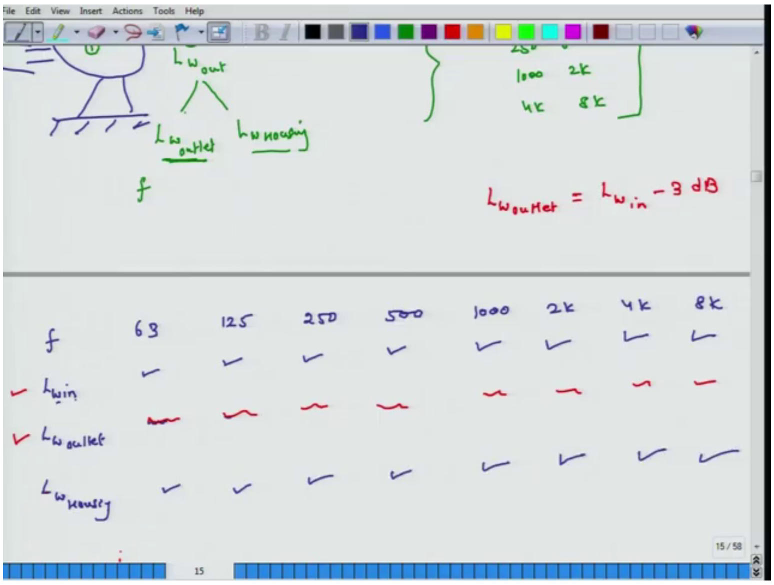

So, this is frequency 63, 125, 250, 500 1000, 2 k, 4 k, 8 k. LW in we have already done this. And this calculation does not change, this is already completed we have already completed this. LW outlet is what it is this thing minus 3 dB, we have given this relation. So, is equal to this. So, this we can calculate. So, we all these things we have to calculate for every frequency and we can calculate. Why because LW outlet is equal to LW in minus 3 dB. So, I know how to calculate. I have done this and I also know how to calculate LW outlet. LW housing this also I have calculated, I have shown the calculation for 2 frequencies and we use exactly the same method.

So, I know also how to calculate I have done I can calculate this also. Now the question is how do I calculate LP? Should I use this number or should I use this number? To calculate LP, I need LW if in the formula for LP I need this LW right.

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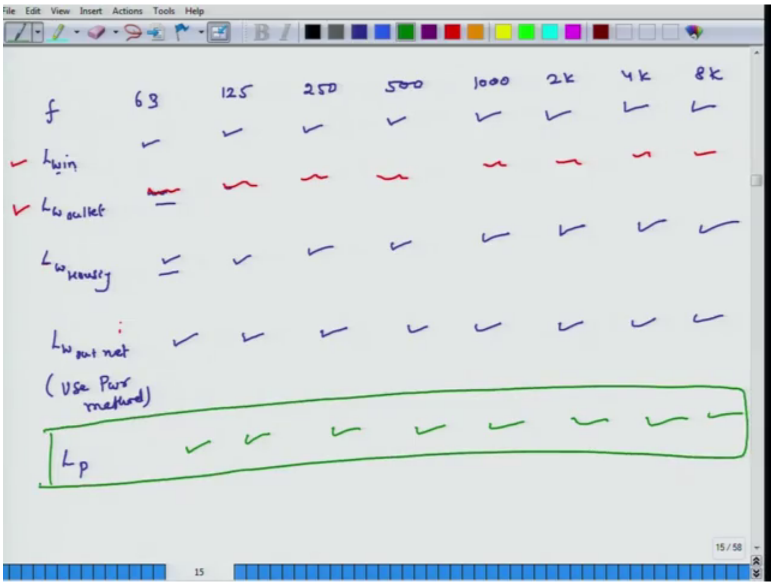

Earlier only one path was available so, I used those numbers for L housing, now what do I do? So, LW out net and I add it using the power method use power method.

But then I use power method for specific frequencies. So, I have to calculate this guy I have to calculate this guy, I have to calculate all these guys. I have to add powers for specific frequencies you know I do not calculate; I add them like this in the horizontal direction. I add specific frequencies everyone understand this and then I find LP for specific frequencies like that. And then I can, plot I can have my one third or octave band plot and from this LP data, I can also calculate the overall sound pressure level.

So, this is the overall approach and a very simple approach is there also for other noise making sources. So, this concludes our discussion on noise coming out of fans. And we will also cover couple of other devices which generate noise in the next week.

Thank you and have a great weekend. Bye.