Noise Management & Its Control
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Lecture – 62
Large Acoustical Enclosures – II

Hello, welcome to Noise Control and its Management. Today is the second day of this, second last week of this course yesterday we had discussed how to design a large enclosure to reduce the overall sound level attributable to some noise sources. And what we plan to do today is to do an example for starters which will explain how to actually apply all that, but knowledge which we had learnt yesterday so that we can use that thing more effectively.

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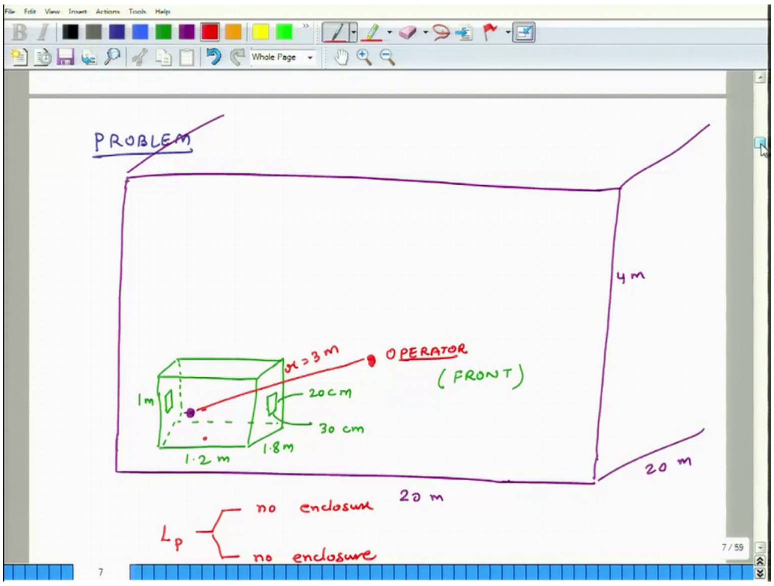

So, here is the problem. So, what we have is a machine, so its emitting some sound and it is in a large room. So, let us keep the machine here and it is in a large room something like this and the size of the room is 20 meters by 20 meters by 4 meters. So, all the dimensions are in meters.

Now there is an operator which is at a distance 3 meters away. So, this distance 3 meters away. So, here is where operator and we want to ensure that this person gets less amount of sound he hears, less amount of sound because this is a very noisy machine. So, you want to design an enclosure so that this operator can be protected from the ill effects of this excessive noise. So, what do we do is we are thinking of designing an enclosure whose dimensions are something like this. So, its dimensions are 1.2 millimeters 1.2 meters long, let us say 1.8 meters wide and the height is 1 meter, height is 1 meter and we also have in this enclosure 2 windows so that material can come into the machine and out of the machine I can put material into the machine and take out from the machine. So, the size of this thing is, this is 30 centimeters wide and 20 centimeters toll both the windows.

One thing I made a little inaccurately is, so the operator is 3 meters away, but operator is in the front of the machine the way I have drawn it here is that he is on the side and the windows are also on the side, but in reality the operator is on the front of the machine. So, operator is somewhere here, but 3 meters way from the distance ok.

We are also givens some information about the noise sound power level produced by this machine. So, it produces some you know generates noise and the sound power level of this machine I will specify here is this. So, it is different for different frequencies.

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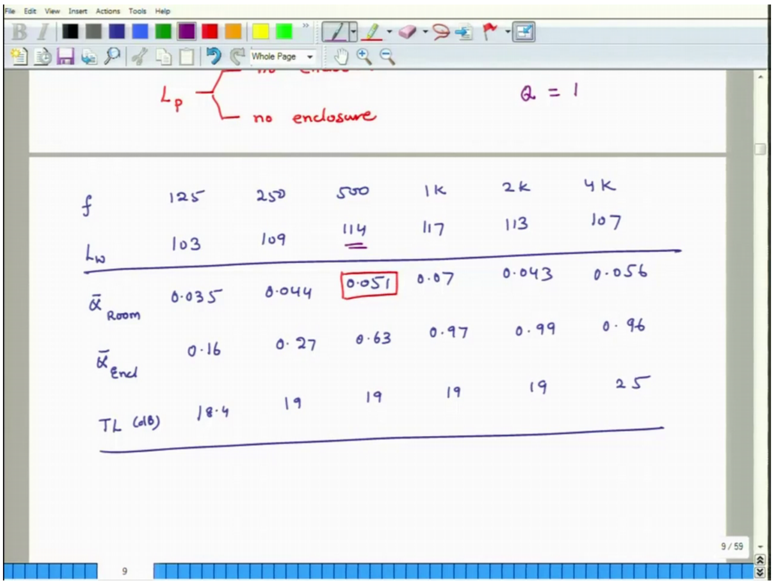

So, frequency 152, 250 Hertz, 500, 1K, 2000 and 4000 Hertz and the value of L W for these this is 103 decibels, 109 decibels, 114 decibels, 117 decibels, 113 decibels and 107 decibels.

We also given the surface absorption coefficients for the room as well as for the enclosure. So, for the room surface absorption coefficients for different, so we are given average surface absorption coefficients for the room and they change with frequencies. So, this is 1.035, 0.044, 0.051, 0.07, 0.043 and 0.056 and for the enclosure the surface absorption coefficients we have been given based on the materials chosen is 0.16, 0.27, 0.63, 0.97, 0.99 and 0.96. And finally, through finite element analysis I am calculated that for the enclosure what is the transmission loss associated with the overall enclosure and of course, the transmission loss changes based on the frequency.

So, transmission loss in decibels for the enclosure is given in decibels as 18.4, 19, 19, 19, 19 and then 25 decibels. So, this is our basic data. So, what we are asked to find out is that what is the sound pressure level perceived by the operator in 2 cases when there is no enclosure and when there is enclosure when there is no enclosure and when there is enclosure.

So, we will start our exercise by figuring out what is the sound power level or sound pressure level perceived by the operator when there is no enclosure.

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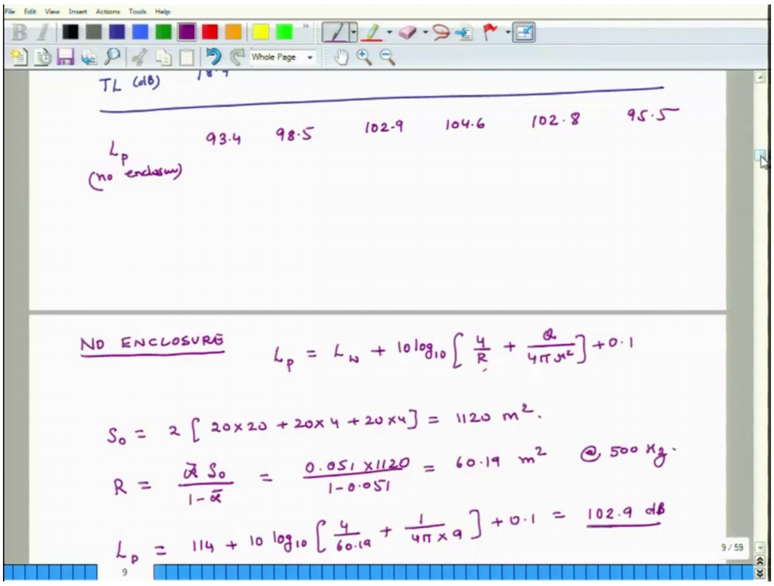

So, the first case is no enclosure. Now when there is no enclosure we know that this is a closed room and we have a relation which connects sound power level and sound pressure level in terms of the room constant ok. So, the other thing which is given is that the directivity of the sound power sound source is 1, Q equals 1. So, when there is no enclosure what is the thing sound pressure level at the point of interest equals L W plus 10 log of 10, 4 by R plus 1 over 4 pi r square plus 0.1; where capital R is the room constant of this thing and to compute room constant we have to find the internal surface area. So, what is internal surface are of the room? This is equal to 2 times 20 times 20 plus 20 times 4 plus 20 times 4 and that comes to 1120 meter square.

So, now I can compute the room constant and room constant is alpha bar S naught divided by 1 minus alpha bar, now we know that alpha bar changes with frequency. So, what I will do is I will just do the calculation for 500 Hertz, but you can use similar method to compute the entire table. So, this is equal to, let us look at the table at 500 Hertz at 500 Hertz alpha bar is 0.051. So, this is equal to 0.051 times 1120 divided by 1 minus 0.051 and that works out to be 60.19 meter square, this is at 500 Hertz.

So, I know now R, I know there is one more thing this relation is slightly inaccurate I should have written Q which is the directivity factor. So, now, I can compute L p, L p equals L W add 500 Hertz how much what is the sound power level 114, 114. So, it is 114 plus 10 log 10, 4 over 60.19 plus Q, Q is 1 divide by 4 pi into 3 square r is 3, 3 meters away 9 plus 0.1 and that works out to 102.9 decibels. So, it is very noisy. Just because of 500 Hertz band it is it the person is going to perceive 103 decibels it is very noisy he will not be happy at all and more than that he will become sick after sometime if he keeps on listening to this noise level.

So, what I shown you is how to compute L p for 500 Hertz you can use exactly the same method for computing L p at all other frequencies. So, what I will do is I will write down the value of L p, L p no enclosure. So, if I do all the computations. So, the sound pressure level works out to 93.4, 98.5, 102.9, 104.6, 102.8 and 95.5.

So, next what we do is now if I have to compute the overall decibel level well how do I do that? I have to add, add the contributions from each of these bands right and how do we do that we. So, the contribution from 93.4 decibels will be what 10 to the power of 93.4 divided by 10 and I add up all these numbers and then I again divide that by reference power level times 10 the log of that that will be give me overall decibel level. And if I have find overall sound pressure level in dBA then I have to do the a weighting and we have explained how to do a weighting in earlier classes and again I use the same approach for each band I have to first weight by certain decibels and then I do the a weighting and add up the contributions.

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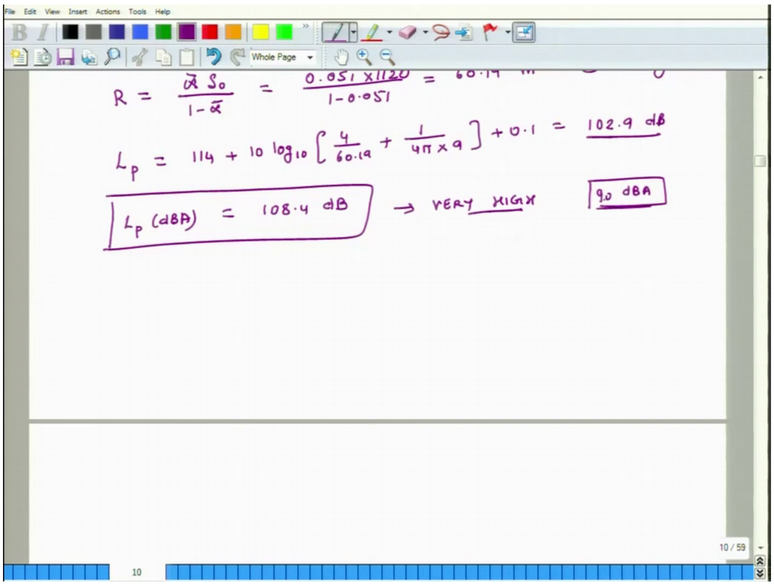

So, a weighted sound pressure level overall it comes out to be 108.4 degree and this is very high. So, clearly we want to ensure that this number in worst case scenarios there is actually a law which says that in worst case scenarios a person should not be exposed to more than 90 decibels a weighted if he is there working for one entire shift which is like 8 hours. So, add for 8 hours continuously the maximum amount of sound pressure level which you could be exposed to is ninety dBA. So, this is way more than 90 dB, 90 dBA. So, now, we want to ensure that this overall sound pressure level it comes down significantly.

So, to do that we have to consider the effect of enclosure. So, once the enclosure is there the amount of sound which will be coming out will be less and what we have to compute is W out right we have to compute W out and W out can be computed by this relation 1 plus s j divided by alpha j divided by the sum of s j times a t j.

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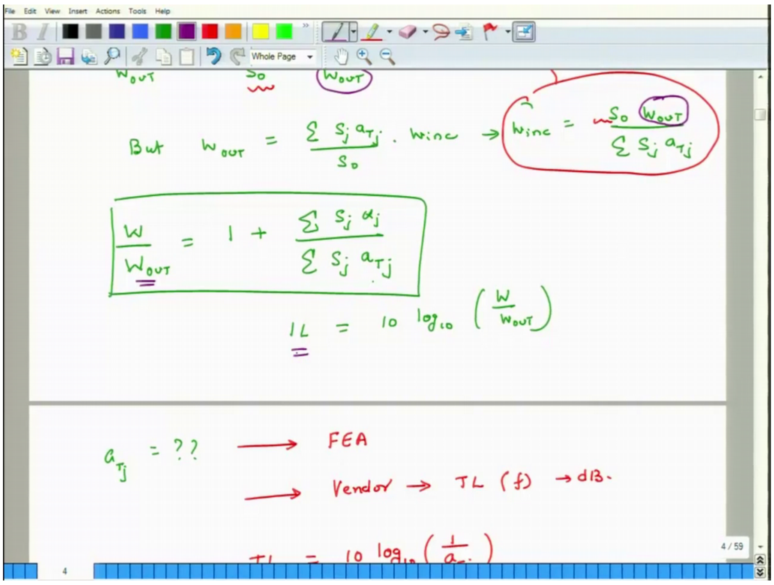

So, for all the surfaces we have to compute surface areas alpha js and once we figure out W out then I can know what is insertion loss once I know insertion loss I know what is L W out and from that L W out I can again calculate L p for each of the frequency bands. So, let us do with enclosure, with enclosure.

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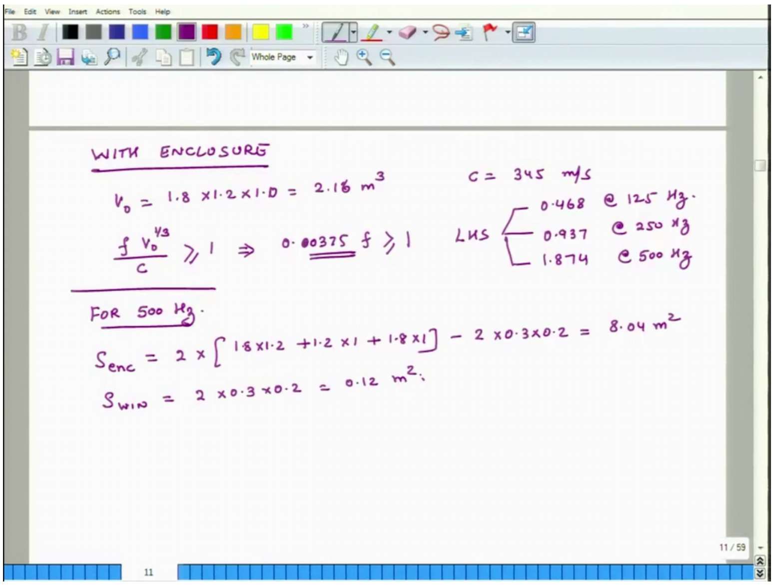

Now remember the relation we are planning to use is for which type of enclosures it is for large enclosures. So, we have to make sure that our assumption about large enclosures is correct. If it is does not, if it is not correct then we cannot use this relation.

So, what is the internal volume of the enclosure? The internal volume is 1.8 times 1.2 times 1.1 oh I am sorry 1.0. So, that equals 2.16 cubic meters.

So, let us check whether it works or not. So, the condition is f times v not the cube root of v not divided by c should less be less than or equal to 1, which implies, so v naught we have already done and c we are taking as 3 45 meters per second. So, if I put in v naught and see in this I get 0.00375 f, this should be less than or equal to 1. Now let us compute the value of LHS which is this guy 0.00375. So, LHS is equal to 0.468 at 125 Hertz. How do I get it? I just multiply this 0.00375 times 125, I get 0.468.

So, at 125 Hertz the low frequency assumption this large enclosure assumption is not valid. Let us check for at 250 Hertz this number comes to be 0.937. So, at 250 Hertz it is almost there. So, we can try our luck at 250 Hertz because it is pretty close to 1, 5 6 percent off. And at 500 Hertz what is the number it is 1.874, 1.874. So, anything above 250Hertz we are fine, at 250 Hertz we will just barely make it, at 125 Hertz our relation will not be our calculations will not be naturally accurate. So, that is the thing.

So, now, again for purposes of this class we will consider we will do calculations only for 500 Hertz and you can do the same calculations for other frequencies which one, oh I am sorry yes it should be greater or equal to 1 same thing here, greater or equal to 1. So, what is the total internal surface of enclosure, total internal surface of the enclosure, if I take on out windows is 2 times 1.8 into 1.2 plus 1.2 into 1 plus 1.8 into 1.

So, this is total surface, but then I have to subtract the windows 2 into 0.3 times 0.2 and that is equal to 8.04 meters square and S window is 2 times 0.3 times 0.2 is equal to 0.12 square meters. Next we find out the transmission coefficient for the enclosure. Now, the transmission coefficient we know for different frequency bands. So, at 500 frequency Hertz it is 19 decibels, so a T at 500 Hertz is what - 10 to the power minus transmission loss divided by 10 and that is equal to 10 to the power of minus 1.9 is equal to 0.01259.

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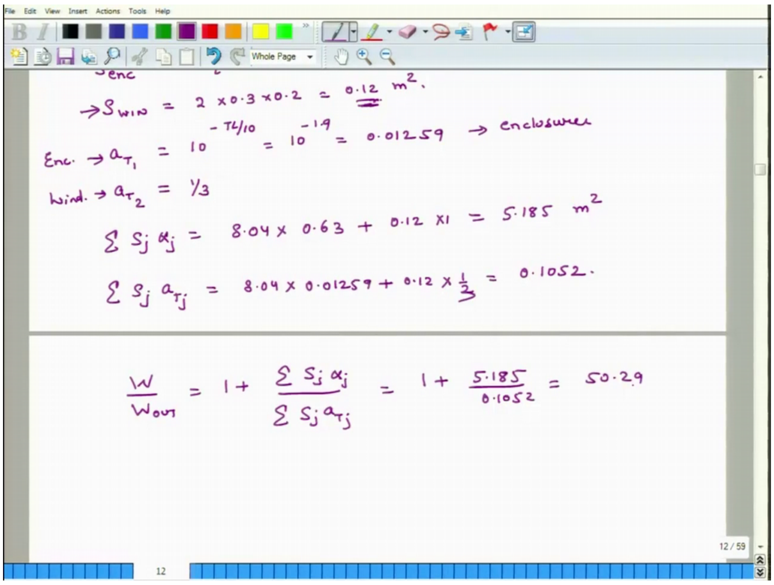

This is for the enclosure and a T. So, this is the first thing, but there is also a window we have to compute it transmission loss also and we have said that the operator is in the front and window is on the side. So, which number do we choose and there are no reflections. So, we choose this 1 by 3. So, a T is equal to 1 by 3 this is, the first this is for the enclosure and this is for the window. So, sum of S j alpha j is equal to how much the first surface area is 8.04 times its absorption coefficient again for the enclosure what is the absorption coefficient 0.63 from the table. So, 0.63 plus area of the window 0.12 and what is the absorption coefficient of window open window 1, so that works out to be 5.185 meters square and sum of S j transmission coefficient this is equal to area first area times its transmission coefficient 0.01259 plus 0.12 times 1 by 3 and this is equal to 0.1052.

Remembered this area as when includes both the windows. So, that is why 0.12 includes both the windows. So, W over W out equals 1 plus sum of s j alpha j divided by sum of s j a t j and this is equal to 1 plus 5.185 divided by 0.1052 which works out to be 50.29.

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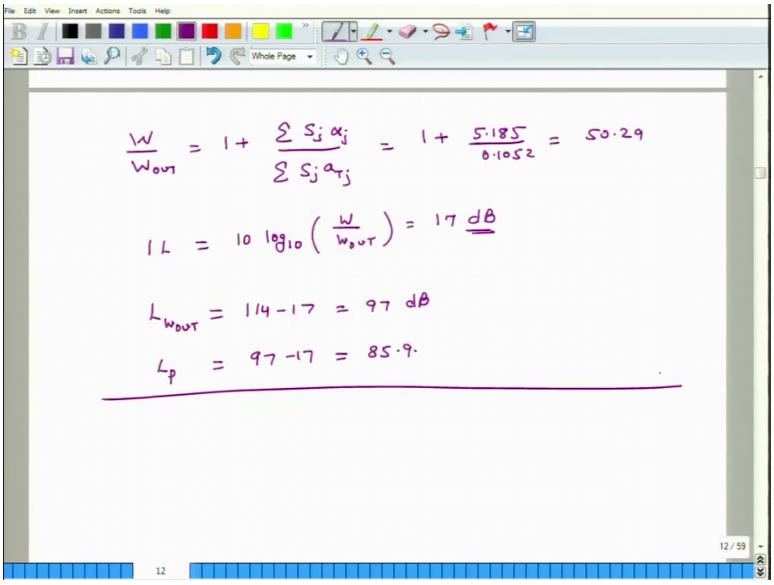

So, insertion loss is 10 log 10 W by W out and that equals 17 dB and L W out equals. So, insertion loss is seventeen decibels without the window the sound pressure level be calculated was 102 decibels. So, I just subtract 17 from there. So, this is equal to 114 minus 17 is equal to 97 dB and L p equals 97 minus 17 that is equal to 95.9.

So, in this way we can compute all for different frequency bands and then again why can once again compute the overall sound power level and all that good stuff. So, I think this gives us an overall idea how to generally go around doing the design of a enclosure which is quote unquote large in nature and I hope this will be useful to you in your workplaces or if you think you will be interested in learning about enclosure designs to control noise. We will once again meet tomorrow and starting tomorrow we will start discussing about barriers. So, with that I conclude the discussion for today and I look forward to see all of you tomorrow, bye.