Acoustics & Noise Control
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Module – 01
Lecture – 02
Introduction 2

Welcome friends. So, yesterday we had some introductory talk on the field of acoustics, we understood what causes hearing - human hearing. Today we will introduce and sort of have some motivation as to why we need to look at noise control as an important subject area.

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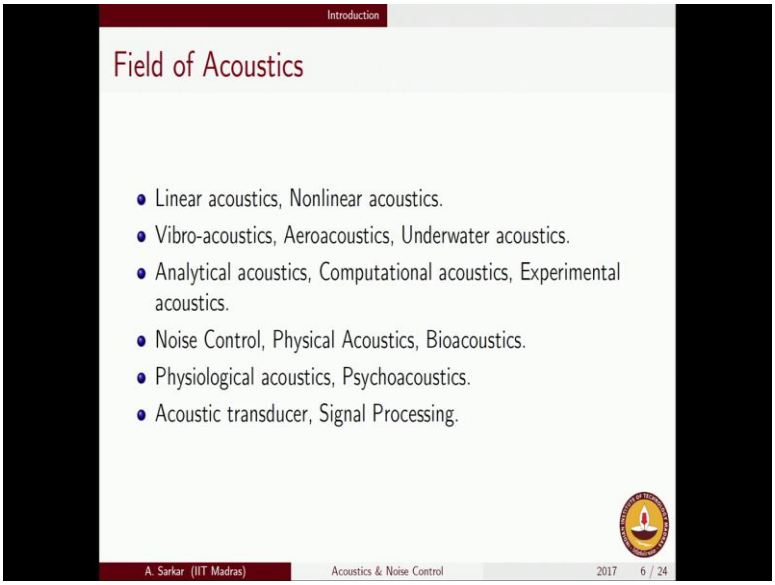

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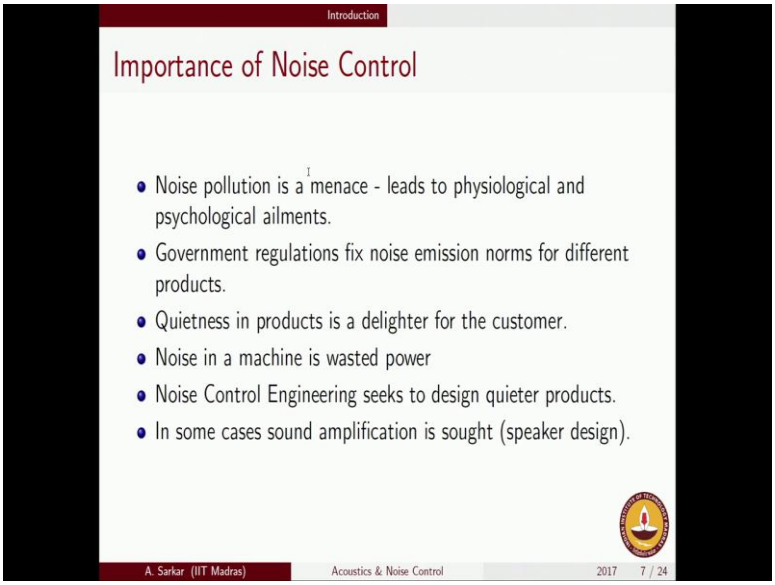

So, noise pollution is presently understood to be a menace, it leads to physiological and psychological ailments. So, too much exposure to noise in human beings can cause adverse effects and all that has been well studied and it is a well-established fact now. So, noise is a source of pollution just like emissions are a source of pollution noise is understood to be a source of pollution. So, there are different government regulations including that in India which fix the noise emission norms for different products just like the nox emissions norms for different vehicles, you have also have noise emission norms for different vehicles that are to be manufactured and sold in countries such as India and Europe and America

So, I will show you some of those norms that are represent the existing as per the Indian government rules. So, government regulations from time to time fix the noise norms for different products in different machines, automobiles being one of them, there are other noise norms as applicable for DG sets for example, so all that will be discussed. But more importantly for a manufacturer definitely the manufacturer has to sort of obey whatever the government norms are prescribed for the certain product, but more importantly from the point of view of scalability of the product, it is very important that quietness in the product be is an important attributes. So, quietness in product is a delighter for the customer.

So, usually the customer perception of the product is based on its noise attribute. So, quietness in a product is I mean quietness product is especially for automobiles, and we will have some other example also will be a very important attribute which goes behind

in the decision making for the purchase of the vehicle. So, much the drive from the point of view of the manufacturer of the product would be not only to satisfy the norms prescribed by the government, but also to go far beyond and make sure that the product is quiet and therefore, delights the customer right. Because that will be a very important attribute for the salability of the products. So, quietness in product is very important and I will give you some examples where in you will be able to appreciate in a diverse range of products quietness is an important attribute.

Another way in which we should motivate ourselves towards the study of noise control is that whatever noise is being a emanated out of a machine is basically a wasted power. It is inconsequential, and therefore, it is best sort of hardness back. If you actually make a quantitative calculation it actually does not account for much in terms of percentages, but not in the same noise is a sort of overhead to the power that is consumed by the machine and therefore, one would do well to keep this noise emanated from the machine at the bar minimum.

So, in noise control engineering what the objective of a noise control engineer would be to arrive at waves and means to seek to design a quieter product. It is the objective to design a product, which is quite by design. And the trick in this trade is this that you should not ask for too many refinements in terms of the other specifications of the product. Because usually as I discussed in the last lecture usually all other requirements as specified in terms of the performance of the product, keeping the product performance almost at where it is in terms of its benchmarks. One has the noise control engineers job is to develop waves and means in which the noise can be brought down without adversely affecting any other performance attributes for which the product is being sold so that is the job of noise control engineering or a noise control engineer rather.

And it is here that you know there are lots of tricks of the trade which is what we will learn in this course. But having said that there is there are important products where we need sound amplification. So, a very pertinent example of that is a speaker design. If you have noted that there are certain very good speakers which are actually very small, but they are very loud, there very audible, they are very sort of distinct the music quality that you hear from let say some very high end speakers will be much more clearer than you know some sort of local cheaper speakers which may look very big, but yet they do not have that much quality. So, it is not really about the size of the speaker which matters it

is about the design which goes behind that speaker box which is important. And again a good speaker design with that which preserve the fidelity of sound where in you can discriminate very nicely the different frequencies, the different tones, the different attributes of music loudness being one of them, but it is not the only to attribute.

So, a good speaker design would try to have a very good fidelity where in the different frequencies can be well distinguished as well as it must have a lot of power right. So, it must be able to emanate the maximum power into the audible sound output that you perceive. So, speaker design is one contrarian approach where the designer is to amplify the sound rather than to diminished it.

But in most examples that we will talk about we will have the implication that through noise control what will try to mean is that essentially a noise reduction process as opposed to a noise amplification process. Actually the word control captures the idea that if the engineer wants you can reduce it if the engineer wants he or she can increase it also. So, control preserve both the attribute where, but colloquially speaking in a community of noise control engineering control would usually refer to the idea of reduction rather than amplification. But none the same if you know one approach the other approach also probably you can guess what are the ways in which to amplify sound as opposed to what are the ways to reduce sound.

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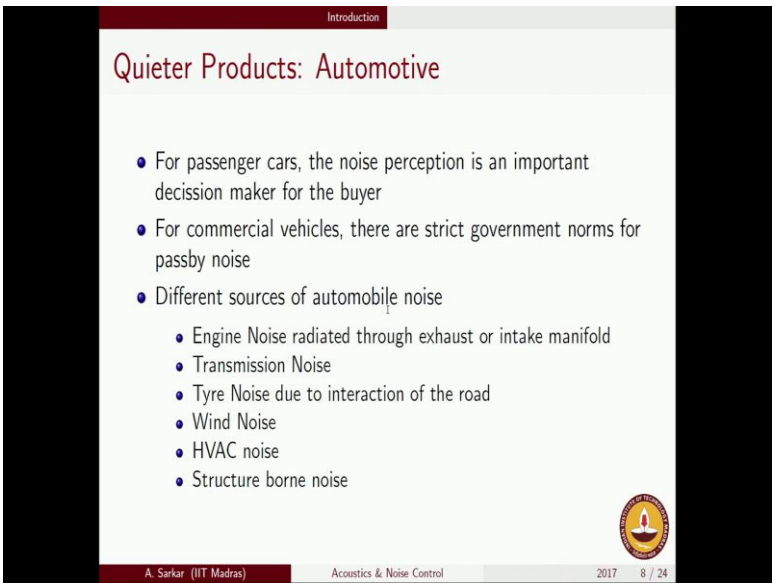

So, let us take a few examples of different products where in noise control would be very important attribute for the product. So, in automotive as I said there are plenty of example. For passenger cars the ones that probably we buy for our transportation needs. Noise perception is an important decision maker for the buyer from the time when you take the first test ride to buy the vehicle, what probably gives you feel of the vehicle quality is it noise and right comfort as we say right. So, when you take it for a test drive and if you have a very bumpy ride for example, in that car you would probably not be inclined to buy it. So, the important decision makers with goes into the place in the minds of buyers are the let see the fuel efficiency, the right comfort, the noise these are very important attributes, because usually a buyer will not get into that many technical details, but the perception of noise, the perception of ride comfort is very important.

And to the sale for passenger car noise perception is being an important quality manufacturers know this pretty well. And they are therefore, trying to push the limits and bring down the noise both interior to the car as well as in the past by to the bar minimum level and this is much more strange and this attribute will be much more stringent than the government norms. Government norms will you specify in terms of your pollution needs, but usually the vehicle manufacturers will have a more stricter norms for themselves and which they would like to meet in terms of the customer demands

Coming to commercial vehicles, commercial vehicles probably the passenger demand is not too high in terms of noise at least in India; in India, probably the drivers are still not complaining the commercial vehicle drivers I mean or not still complaining so much about the noise, but there are very strict government norms. And as we will discuss these all this is this what is called a pass by norm noise norm for which all commercial vehicles have to satisfy and that is what keeps the drive for noise control in commercial vehicles. It is not predominantly dictated by the customer needs as opposed to a passenger car.

If you look back and if you just do a very sort of simplistic analysis of what are the different sources of noise, a very dominant noise is that of an engine noise. And as I said engine noise within the internal combustion engine what happens is basically a combustion process, so that combustion essentially leads to noise and that noise is actually carried through the exhaust or the intake manifold. If there is a turbocharger in commercial vehicles for example, the turbocharger usually has a very high-speed fan like

device and that causes a lot of flow induced noise. In fact, there will be a radiator fan also in a commercial vehicle, so that the radiator fan will make large noise, the radiator fans are even in passenger car.

So, the engine compartment as lots of sources of noise and the noise that I am just talking about are mostly flow induced noises. But then the engine also vibrate the engine vibrates because predominantly it is a slider crank mechanism at its hot. The engine mechanism is a slider crank mechanism it is having a reciprocating mass it is having rotating mass. So, whatever you do in this mechanism you cannot achieve complete balance that is well known fact in mechanism. So, therefore, because of the unbalanced force that is acting on this engine, there will be a fluctuating force. If you recall your mechanism or dynamics of machinery course, we will recall that the unbalanced force that is acting on a slider crank mechanism will usually be harmonics or sinusoidal.

So, there are lots of these fluctuating forces which occur at harmonics we will come to the details probably in due course. But just as a sketchy idea the engine is subjected to lot of harmonic force of the kind that we discussed in the last lecture. And these harmonic forces will cause vibration of the engine because the engine is mounted on some rubber like mounts at three point or four point there are different mounting arrangements, like a spring mass it is going to vibrate. And through the mounts there will be a transmission of this unbalanced force onto the floor panel. And once the floor panel is subjected to the vibration or rather the harmony forcing then the floor panel will start vibrating and these vibrating the floor panel being a very large area will contribute to a large noise also which is the in cabinet noise.

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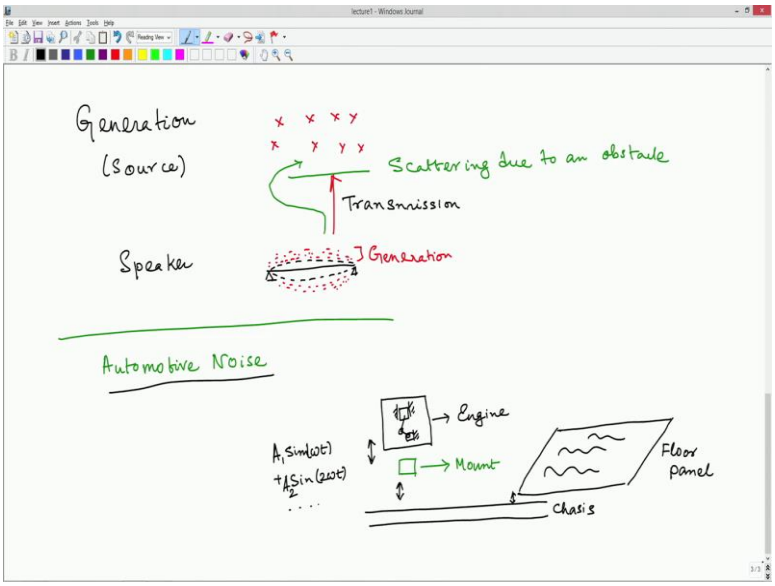

So, let me just illustrate once what I just told you. So, we were talking about automotive noise. And within that we are talking about how vibro-acoustic noise source can be generated by the engine. So, this is the engine which as I told you is basically a slider crank mechanism of the kind that is shown in this diagram. So, this means that because of its operation there is an unbalance and once the engine starts rotating then there is an unbalanced force right which is of the form of sin omega t plus sin 2 omega t and so on. So, these are what are called harmonics. So, there are harmonic forces. So, I should say a 1 sin omega t plus a 2 sin 2 omega t and so on. So, these unbalanced forces are induced because of the operation of the engine.

Now, the engine is connected to the chassis by what is called a mount. So, this is the mount whereas this block is the engine. So, through the mount again this unbalanced force will pass on to the vehicle structure of the chasse. So, this is the chassis of the vehicle. So, this entire unbalanced force through the mounts will pass on to the chassis. As a good noise control or vibration control engineer you should therefore, make sure that the mount is such that the minimal amount of force passes through right that is where you can really affect the design of your mounting system and great repercussions on the noise and vibration quality of this vehicle. But on the chassis there is a floor panel also which is mounted, so the chassis comments everything including the floor panel.

So, in some way or the other the floor panel is also can connected to the chassis. So, therefore, ones the chassis is subjected to certain forcing, these forcing will also get transmitted and the floor panel will start vibrating. And as we understood in the last lecture once you have a vibrating surface, this vibrating surface will induce oscillatory motion in the neighboring fluid particles which is air obviously. And they will induce this oscillatory motion and that will finally, get transmitted in the form of waves, reach our ears shake up our eardrums and cause the perception of audibility. So, this is how the engine operation itself can lead to noise, this is the vibro-acoustic source of it. The aero acoustic source of it is the combustion and the flow that is happening in the exhaust processes and so on. So, this is one aspect of automotive noise which is the engine noise.

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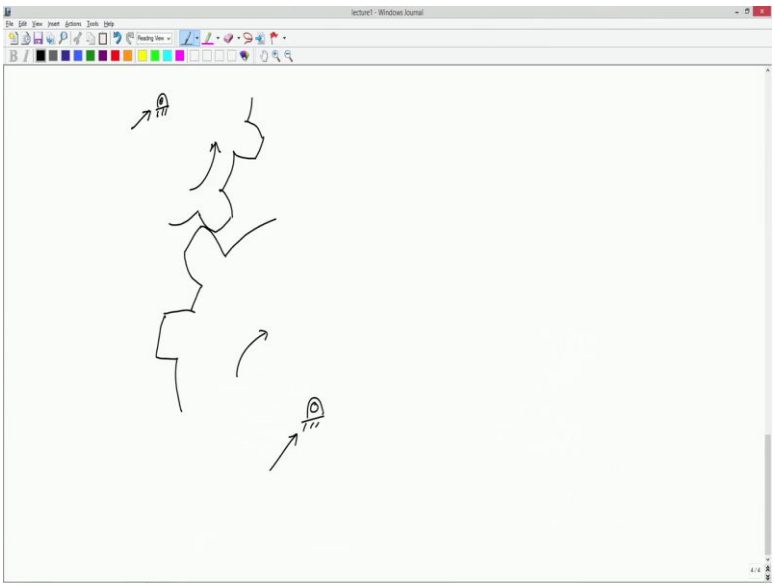

If you look at gears, so the next part of an automotive noise would be the gear noise. So, gear is, so this is typically a gear. So, let us say this is the driver gear and this is the driven gear. So, now as the contact is taking place as you know gears will have different contact ratio right so that means, let us say the contact ratio is 1.5 that means, at times there is one teeth in contact there are times there is one teeth in contact. So that means, whatever is the load that is being transmitted that will be shared at times two pairs at times by just one pair of teeth, which means that at times.

Now, if we draw the free body diagram of this gear and find out how much of the load is actually getting transmitted onto the shaft which holds the gear. So, obviously, this load

which I have just indicated in a schematic fashion through an arrow this load will change because at times there are two pairs of teeth in contact, but what has been shown in this drawing is one pair of contact because that is easy for me to draw.

So, at this instant when there is one pair of teeth in contact, the distribution of forces is going to be different than at times when there are two pair of teeth in contact. So, as a result the force which is transmitted to the shaft will be different. So, as a result the forces on the shaft are not constant, but it is dynamic or vary. And then you will get to see that once any component in your machine is subjected to the dynamic forces, then essentially those dynamic forces will get transmitted in its own path and finally, result in the vibration of a large panel such as the gear box housing and induce this noise. So, this is one way in which gear noise can be generated. There are many other ways in which gear noise does get generated, one being the transmission error, backlash and things like that some of which we do not want to get into right at this point, but I just wanted to give you a flavor as to why due to the operation of the gear, you do have noise.

So, we have transmission noise as one other very important source of noise in an automobile. Similarly the tyre once the tyre surface when it interacts with the road due to the rubbing action of the tyre. Once you have rubbing action between any two surfaces because of the contact induced forces you will get to see that there are vibrations on the tires surfaces and that is again one source of what can be called as vibroacoustic noise source. But typically it is more proper to call it as a tribological induced noise source because it is happening because of the contact between two surfaces that between tyre surface and that between road surface. A finer analysis of tyre noise would even reveal that there are some aero acoustic sources because there are some air flows which are happening with in the trade of the tyre right and a very refined analysis would reveal that those aeroacoustic sources can also be very dominate. So, there are different sources of noise in an automobile, and we will keep touching on different sources and keep looking back at this example throughout this course.

Another example of it is wind noise, maybe in highways when you are driving your vehicle at extremely high speed, you will be able to hear the same sort of noise as you would have heard in case of cyclone. Because it is just the same idea whether the cyclone is causing the wind flow at 100 kilometer per hour or you are driving at 100 kilometer per hour in a sense of relative motion it is just the same. So, the same flow attributes will

be produced if you happen to drive your vehicle maybe a two wheeler you can feel it even more, but my advice is do not do that. But at least in a test track if you are a riding a two wheeler at 100 kmph, you will hear the same noise as you would have heard during the cyclone Vardha the which also carried the wind at very high speed. It is just that your reference frames are getting changed. In the case of cyclone what the you are supposedly in a fixed reference frame the fluid around you was moving; in the other case the fluid is actually quite, but you are moving at 100 kmph with your vehicle, and your want to get the same flow effects which is what will cause wind noise.

So, typically if you have your even in your passenger car or a commercial vehicle if the window panes are open, and you are riding your vehicle in highways, it really high speed you will get to hear a lot of broadband wind noise and that is also one very important class of noise which happens in automobiles. Well in high-end cars and in case you have a passenger car and your window shutter is closed probably more than wind noise what you will hear is the noise from the blower of your ac, so that is what is called the HVAC noise. So, HVAC systems are very common in most cars I think this (Refer Time: 21:00) car which does not provide an HVAC back system. And what you hear inside the car is actually predominantly the HVAC noise blow and noise because you know the engine noise can be suitably isolated the gear noise can be suitably isolated, you hardly hear any exhaust noise sitting inside the car.

What enters you ear when you sit inside the car especially in sort of mid segment cars is the HVAC noise. So, HVAC noise is very important again this is a flow induced noise because it is finally, the cold air which is coming out through the different loops of your dashboard and different areas which is causing this noise. So, if you can design this loops properly such that the noise does not come in then it would be a very important from the salability purpose of this product. So, structure borne noise I have already explain how a structure borne noise can take place due to the engine vibration due to the engine operations as well as gear operations.

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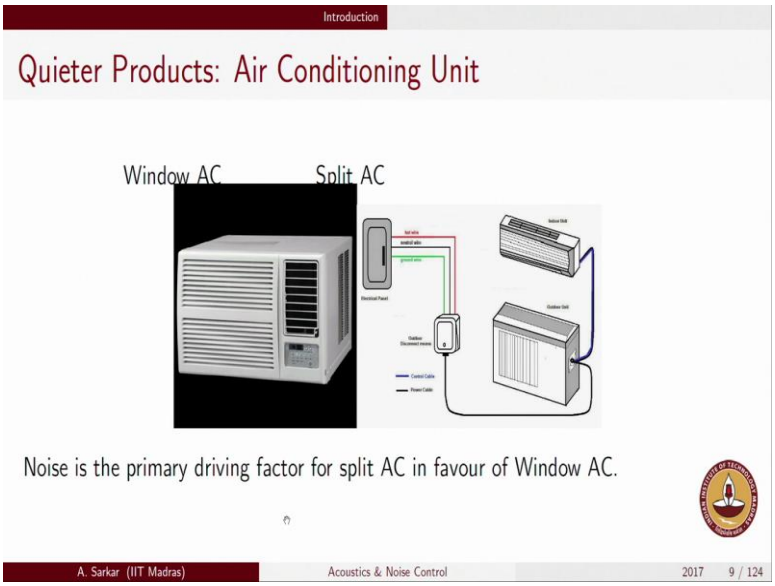

So, let us look at another product now. This is a very important example traditionally the air conditioners we would have seen at least in my generation when we were kids we would have only seen the window ac. It used to be very good, it used to be very steady in its performance everything was nice and fine for a window ac except for the fact that it was noisy. And definitely when you pay dearly out of your pocket to have a good night sleep on a summer night in Chennai, you do not like to spoil that sleep by having a noisy machine. And when they look back at this machine they found that the main source of noise is because of the compressor unit.

So, one very nice engineering solution which engineer did offer was that why do not we split this product into two parts. One part which is the noise less machine which is basically going to blow out the cold air, and the other part which is the compressor unit which we is understandably having a rotating part and reciprocating actually rotating part is that which makes noise, so which has a very high speed rotating components. And these rotating components are bound to make noise that is pretty much unavoidable.

So, what the engineering solution that they came about was this that the entire noise making part of this ac unit was split and that was put outside the bedroom. So, if it makes noise, let it make noise outside my bedroom possibly the effects of noise outside my bedroom a lesser than the effects of noise inside my bedroom. So, this is a very nice engineering solution I would say actually the noise was not killed, if you look at it

seriously there was theoretically the noise was not killed, when you go from window ac to split ac. It is just that the noise source has been kept at a distance such that the receiver is sort of oblivious to the noise. The noise has been you just relegate the problem outside your area of interest. The area of interest being the bedroom, if you can push this noise source far away and you have your doors and windows neatly short there is no way that this disc will disturb your sleep, so that was a very interesting idea.

In the initial days it turned out when the split ac technology was sort of at its initial stage it turned out that the split ac was at that time it was selling it was thermally less efficient it had other problems also right. One problem was efficiency the other problem was that the recirculation was not very good. So, it had lots of disadvantages actually if you see the birth of the split ac technology, but still it won over the window ac simply on the premise of noise. The single most important advantage of a split ac as compared to window ac was noise, and because of that driving force split ac is where actually selling and then they were able to work around the different problems associated with the initial split ac technology.

And as of today the market is overwhelmingly in favor of split ac if you go to any electronics shop most of them still split ac. Window ac is almost arcade you have to specially ordered them. Still window ac is do have advantages, but the market is just not there for window ac right. The market has turned completely in favor of split ac, but the driving factor of the split ac technology has is not a thermal efficiency or anything else, but it was noise right.

So, the initial days it was noise which was the delighted in the minds of the customer or which is why they invested in the split ac technology. Then over the years development has happened with this within the split ac technology and they took care of the efficiency issues, and they were able to have other work around for the other problems related to the lets say the recirculation. And as of today they have really refine this technology very well to the extent that window ac's are almost like a arcade museum thesis. So, that drives the point that noise was the primary driving factor for split ac in favor of the window ac units.

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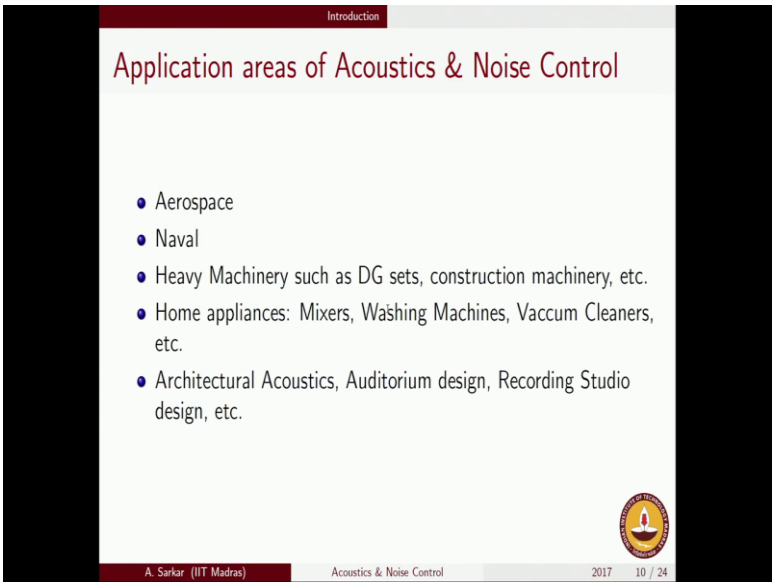

Some other application area of acoustics and noise control aerospace is a very important application. Actually there were different kinds of you know aero planes which did come out concord being one of them which had very good performance, but actually the main problem of concord was that it was extremely noisy to the extent that it had to be taken out. So, noise in aero planes is a very important factor and not only in terms of you know this customer satisfaction point of view, but the intense noise that is created in an aero plane engine can actually need to failure. It can also happen that these just like vibration causes noise, the reciprocal of that is also true noise causes vibration. And the intense noise of an aero plane can cause vibration of different components of the engine and can even lead to fled it which is exactly what happened for concord.

An event to this day you know when you talk about supersonic military aircrafts these are having very, very crucial noise issues. So, noise issues are very important for aerospace application both civil as well as military. And it is good that we get our initial training in noise properly done, so that we will be able to address these issues when we enter the industry on our professional career. So, aerospace is one of them. Naval sciences and naval technology definitely acoustics is very important because everything works in terms of acoustics. When you talking about the submarine usually the submarine must have a very good stealth attribute which essentially means that no noise should be radiated from the submarine, because if it radiates sound then it will actually be caught by this sonar of the enemy war ship and it will be torpedo. So, a very

important attribute of both the war ship as well as a submarine is stealth. And stealth in the naval context usually means acoustic stealth.

In the aircraft context they stealth from the electromagnetic perspective the electromagnetic wave should not be able to catch the aero plane, but in terms of the naval context it is stealth from the perspective of acoustics. Usually there will be some machines which will be running in the submarine and the submarine if it radiates that noise from due to the running of some machines when it is sort of supposed to be silent then that noise will be picked up by the enemy ship and it will just be bombarded. So, stealth in naval applications is a very vital importance, and you know there is lots of sensitive work it is being done around these areas.

Heavy machinery such as diesel generator sets, if you have observed most diesel generator sets whether we see them in the hotel or whether we see them in you know different function, they will actually be contained in a large enclosure. So, again the objective for that large enclosure is noise right there is no other reason why you see the diesel generator set in this large enclosure other than noise right because of that included is removed the diesel generator makes huge noise. And in a community setting, you do not want that that much noise to happen.

So, therefore, again typical engineering solution for the noise control of these DG sets is just to put a very efficient enclosure made of you know appropriate acoustic absorbing materials. Such that whatever noise is been generated by the DG sets remains within that enclosure nothing escapes out of a very minimal noise would escape out of the DG sets actually the most important noise that you probably hear from a DG set is the one which comes out from the exhaust. There is no way that you can make the exhaust happen inside the enclosure because the enclosure will that get polluted. You have to make sure that the exhaust goes out of the enclosure, so that exhaust which comes out of the enclosure taking the combustion gases out that is one source of noise in a DG set with still remains. But most other sources of noise remain contained within that enclosure you never see the DG set actually only see the enclosure, so that is how they have actually made contained the noise coming out of a DG set.

Similarly, there are different construction machinery the mixes that you see for the concrete you know once you start operating they create huge noise. Then there are

pneumatic hammer they are all very noisy machine, and there are lots of work that are going on in order to reduce the noise of this machine. For DG sets by the way we have lost in India as I will show you with strictly prohibits the DG sets cannot be solved if the noise from such diesel generator sets exceeds some prescribed noise as I will show you. But for construction machinery to my knowledge there is no such norms still date, but probably it can be coming in due course because we are all aware that that noise from such construction machinery is very annoying and it is very important source of noise pollution.

Again remaining at our homes if you look at a different appliances mixer, you know in this morning when all of us you know we live in an apartment and at 8 o clock roughly all of us are making breakfast. And everyone of us are like putting on the mixy at its highest setting and it is very, very intense sound. And my kids actually wakes up using mixy's noise. So, it is very disturbing this mixer noise. So, it is not that the manufacturers are not aware of it, some of our faculty colleagues are actually working mixers noise. So, mixer noise is a very important source and you do well to contain it right. So, we are actively working on such issues.

Similarly washing machine I mean I have been involved and one of my colleagues have been involved in designing washing machines which are quieter. Because again being a home appliance and usually in some household like mine, we will run the washing machine at the night because you know the water comes in certain time of the day and we want that is a reserved water to be used for washing and so on. So, then its best that is washing machine runs in the night time, but then while spinning and while driving if it makes that intense sounds, it is actually very disturbing not only to me the sound actually gets transmitted to download floor. So, it is that very intense. So, we need to design washing machines which are quieter.

Unfortunately, these days the washing machines actually come up with the quiet mode of operation. If you are observed some of the washing machines not actually very high end washing machines even the mid segment washing machines will come up with a quiet mode which means that they are working to try to contain this noise which is being emanated by washing machine.

Vacuum cleaner are another new sense again they are basically have whether they work in the suction mode or in the blowing mode it is the airflow the intense airflow which comes out of that duct whether it is inward or whether it is outward that intense airflow causes the noise. And you need to have a very good control of this airflow such as that you can contain this noise. So, vacuum cleaners are another applications where we need to look at how to contain this machine.

Another interesting application for military is silencer design for guns, for stealth application we need to have silencers which you know does not make any noise when the gun fire a short because that is very important for the military applications. So, there are lots of applications, if you look at it. Another applications which is coming in rapidly in India is the architectural acoustics as we are investing in you know good architectural concepts and good buildings and good living conditions, the acoustics of our buildings are becoming increasingly important. If you look at the studio carefully, you will see a lot of panel switch perforated. So, this perforated panels are the reason why that there is because of the acoustics. In the studio as we are recording this show, we want to make sure that you know if someone is gossiping, just on the outside of the video that of the studio this that gossip does not interfere with our speech.

So, therefore, it is very important that we have good acoustic absorbing materials for this room. And this is architectural acoustics, this is the reason why architectural acoustics is very important. Recording studios by the way are very common in India we have very big film industry in all the states and definitely in Mumbai. But recording studios is one very important areas where the architectural acoustics is becoming very prevalent and very important. Auditorium design even if you look at this in Chennai, we have the TTK what is it called TTK Ramaswamy music hall.

Student: Music academy.

Music academy in that TTK hall right, so that is there are some acoustics aspects in that auditorium. But yes even if you look at our multiplexes, these days multiplexes as opposed to the conventional theatres, they take a lot of care about the acoustics because if you have a Dolby studio and you know if you have a Dolby hall, but your acoustics is poor then it does not make sense right. I was fortunate to visit the Sydney opera hall also, so they are they have really invested a lot in terms of the hall acoustics. So, the

performance in a good auditorium will only be able to have a classy feel only if there is adequate investments in terms of its acoustics. It is not just the aesthetics which is important, but the acoustics of it is important as well.

So, architectural acoustics is a very upcoming and updates live area at least in India because we were sort of we did not invest too much. I think last 10 years no one was talking about architectural acoustics, but now we are seeing that is a very upcoming area. Again the basic principles of architectural acoustics will start from fundamental principles of acoustics how waves propagate what is the basis of acoustics absorber design and so on and so forth. The specializations of architectural acoustics would do a little more than what we will do in this course, but the foundations of this architectural acoustics would be coming through this course. So, in case you are interested to do any of more specialized topics in architectural acoustics, the prerequisite to that would be this course.

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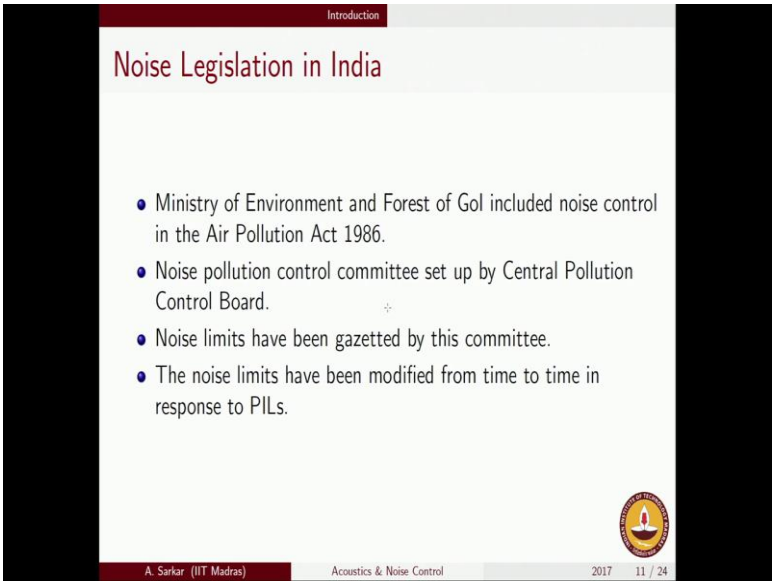

So, let us quickly look at what are the noise legislations available in India. We understand that you noise is very important. So, what has the government of India done about it? So, way back in 1987 actually noise control was included under the air pollution act. So, the identification that noise is a source of pollution is not like happened yesterday, but it happened way back in 1986. It is under the ministry of environment and forests of government of India, and they included noise control as one of the sources of

air pollution that was the act itself came into existence in 1986. There has been lots of upgrade though from 1986, we will talk about a few of them. Then within the organization responsible for maintaining the pollution levels within the country is what is called the central pollution control board abbreviated as CPCB.

So, I invite you to look at the CPCB website, I have done that myself just a few days back. So, it has got a lot of information not only on noise pollution, but also other aspects of pollution such as air pollution, water pollution and so on and so forth. So, within the central pollution control board, there is a separate noise pollution control committee which basically makes rules and norms for different noise pollution aspects for the country.

So, noise limits will come out and they will be gazetted by this committee. So, as you know gazette are like publications where in they will tell the public that these are the noise limits of different product. So, such noise limit have come from time to time and more importantly it is dynamic. It is being modified from time to time the bar is being raised or in other words the limits of noise is coming is dropping lower such that there is a drive to the vehicle manufacturers at least the commercial vehicle manufacturers to bring the noise attribute for their products.

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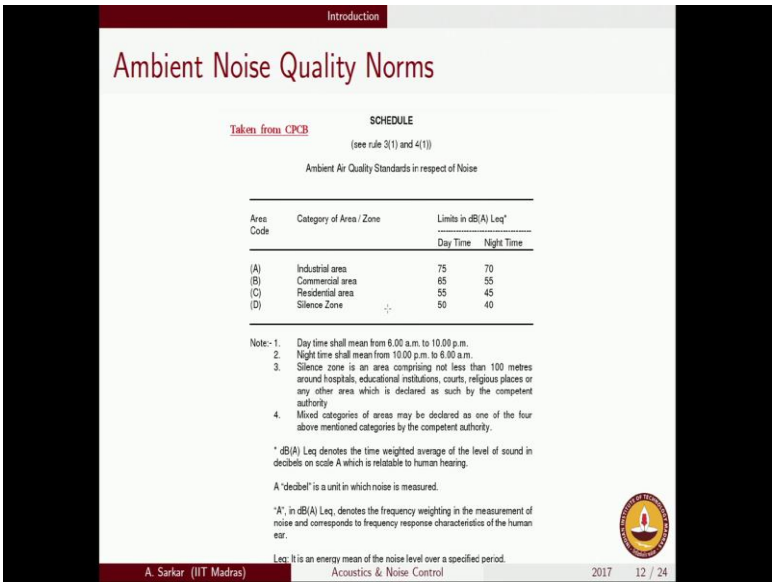

So, here is a document which I have just taken from CPCB as it is. So, if you could read this it actually says that you know what are the noise levels that are expected in different

areas where we live. So, for example, in residential area in daytime, we will expect noise limit of 55 decibels will come to what is decibel, but at present it just if I just to say the unit of measurement of noise. So, noise in residential area should not exceed 55 dB in the day and in the night it is 45 dB.

So, night also is well defined, night means 10 pm to 6 am; and day means 6 am to 10 p m, so that is the rule. So, there is a residential area rules there is a commercial area rule and there is a industrial area rule, but you say that the limits are pretty stringent I mean how very rigorously this limits are actually followed that is different question. But at least I wish you appreciate the fact that the Indian government is taking has taken adequate care over the years to sort of have a very had sort of adequately emphasized the importance of noise in different areas of our living. So, I will leave some of these things for you to read, it is just a very nice reading.

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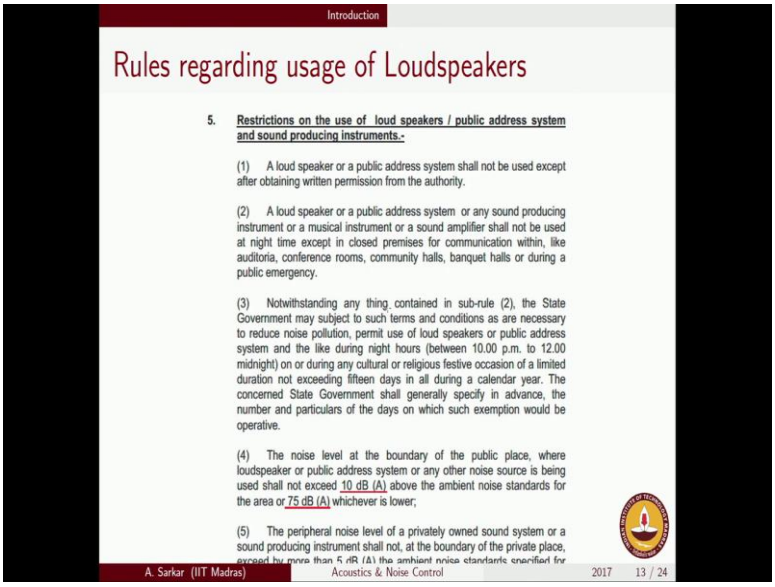

So, similarly for loudspeakers you know you just cannot have a loudspeaker playing at least by technically by the rule of the law. You just cannot play loudspeakers just because you are marrying a girl today it is not possible. The law states that if the one that I have underlined that the loudspeaker that you are playing should not exceed 10 dB of the ambient noise. Whatever is the noise without the loudspeaker, you cannot cross 10 dB from that or above the ambient noise standards or it should not cost 75 dB that does not mean. So, this rule could have been misused, if you find an area where already there

is an 80 dB noise and then you play louder and you say that I am doing fine, but then the loss is no, no you cannot have more than 75 dB noise anyway, so that is law. But I agree that probably this is not very rigorous enforced.

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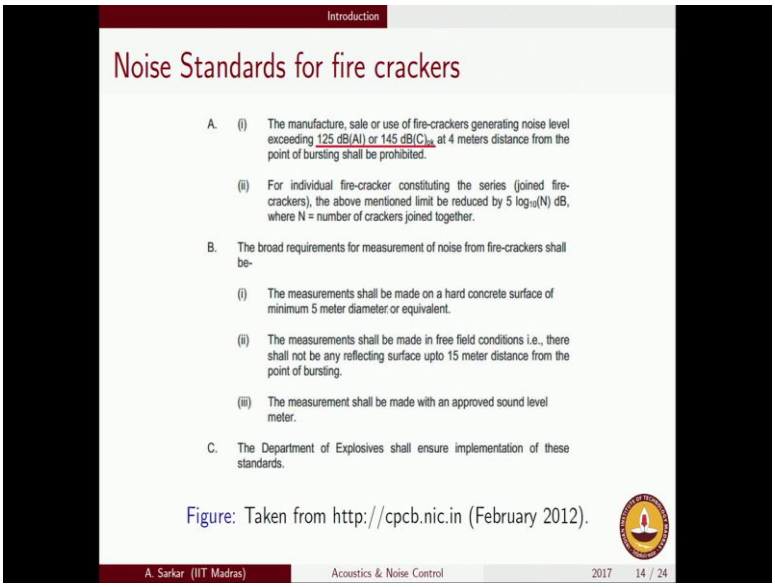

Another interesting application areas is firecrackers believe it or not we have a rule for firecrackers. We just cannot buy a firecracker and you know play it at our whims and fancies. So, the firecracker rules says that it cannot be more than 125 dB, the bracket a and the bracket c I will tell you in due course, but these are basically units of measurement of noise. 4 meter for the point of bursting the noise limits are supposed to be such and such. So, there are lots of other interesting rules which are there for the different applications.

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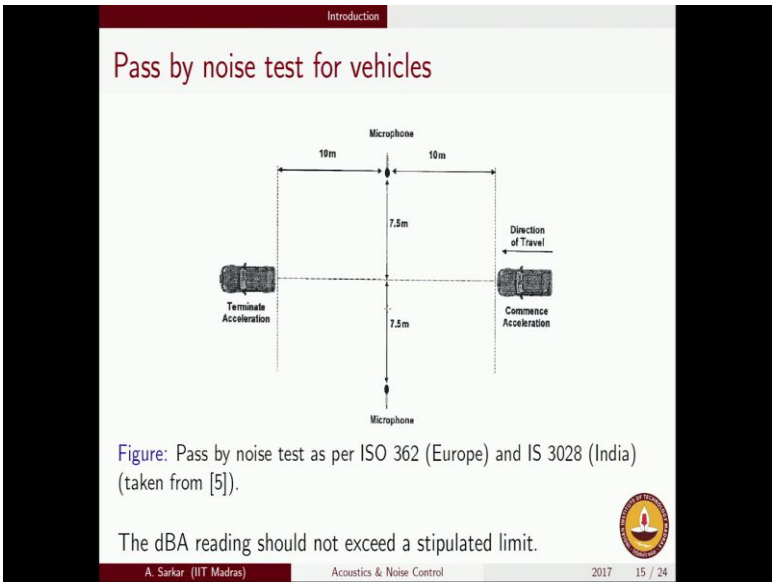

I will give you one more example that of a vehicle. So, this is what is called a pass by noise of a vehicle. So, the strict testing procedures are documented in the standards it is called as IS3028 in India; and in Europe it is as per ISO 362. There are minor differences between these test procedures, but essentially it is this that a vehicle is supposed to travel within this 20 meter distance and micro phone are placed 7.5meter on either side of the vehicle and exact conditions of the driving of the vehicle is also very well documented. But during this time of travel of these 20 meter, the microphone records the noise emanated by the vehicle, and the law is that the microphone noise that you record should not exceed a particular specified value.

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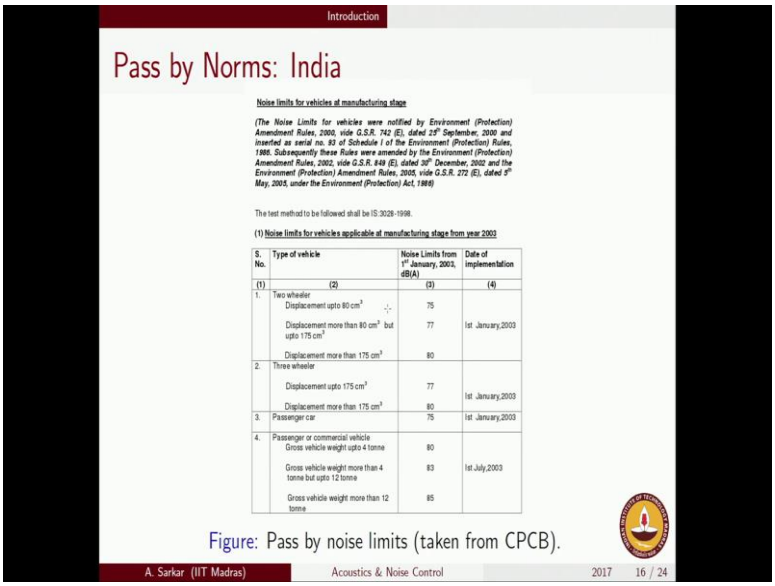

Figure: Pass by noise limits (taken from CPCB).

What is that particular specified value? These are the particular specified value. For a two wheeler with displacement of the engine up to 80 centimeter cube, the noise limit is just 75 dB; for three wheelers, it should be 77 dB. For passenger car, it should be 75 dB; for passenger commercial vehicle with gross vehicle up to four tons, it should be 80 dB and so on. And you can see the date of implementation of these rules.

So, there are lots of rules that are applicable for the pass by noise and by the way these limits are actually imposed for all the vehicles that are manufactured. Typically a vehicle manufacturer has to take his vehicle to a certifying authority such as ARI in Pune, automotive research association is one certifying authority to my knowledge which actually does the pass by noise test and certify that the past by limits are well within these specified limits of the CPCB. So, these are at just a snippets of different norms that are applicable in India.

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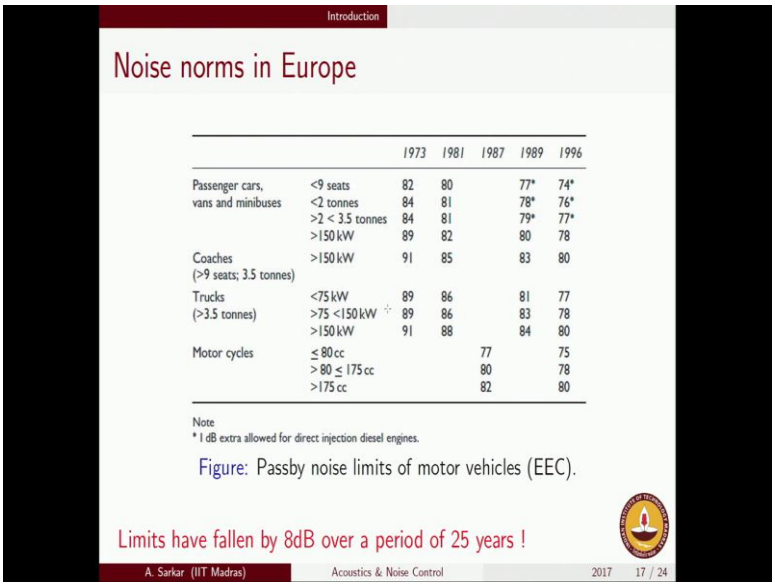

The norms in Europe have been taken from here. So, they are typically more stringent, but I am not sure I mean this has been taken from a book looks like it has data up to 1996, but I am pretty sure that you know it has been upgraded to even more stringent levels. But you could come possibly compare the different norms across different countries in different geographical location. So, moral of the story is at least in Europe, it seems that limits have fallen by 8 dB over a period of 25 years, 8 the arithmetically will sound pretty small number, but as we go along we will tell you that. 8 dB is not a small number, it is a pretty large number, so that is one thing.

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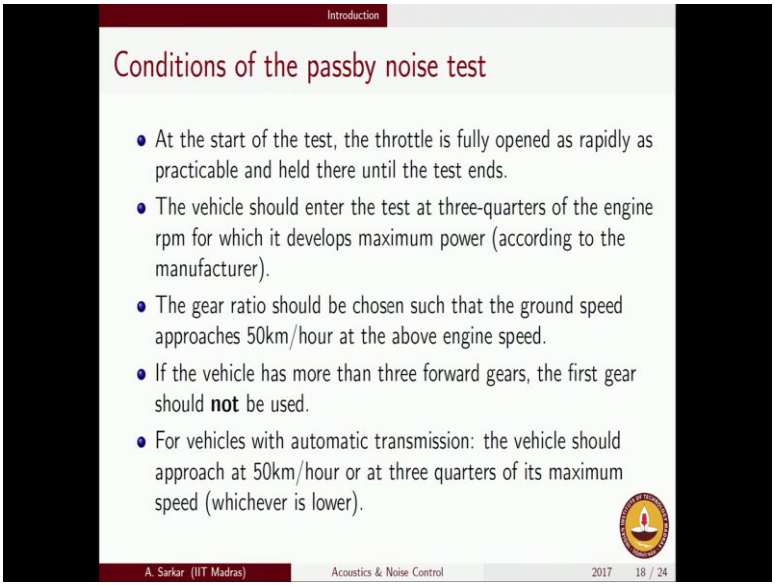

So, conditions of the pass by noise test as specified by the test procedures has been documented in this slide. I think you can go through it yourself, this nothing much I wish to talk about this at this point.

So, with that we will end this introductory part of acoustics and noise control. So, from the next class onward, we will take a deeper drive into the formal course, we will start talking about what are the equations of the acoustic wave propagation. And from there on with this motivation, I hope you will feel that the subject matter that we are going to study is of very practical interest and you should find yourself adequately motivated to carry on for the remainder of the course.

Thank you for today, meet you for the next class.