NOISE CONTROL IN MECHANICAL SYSTEMS

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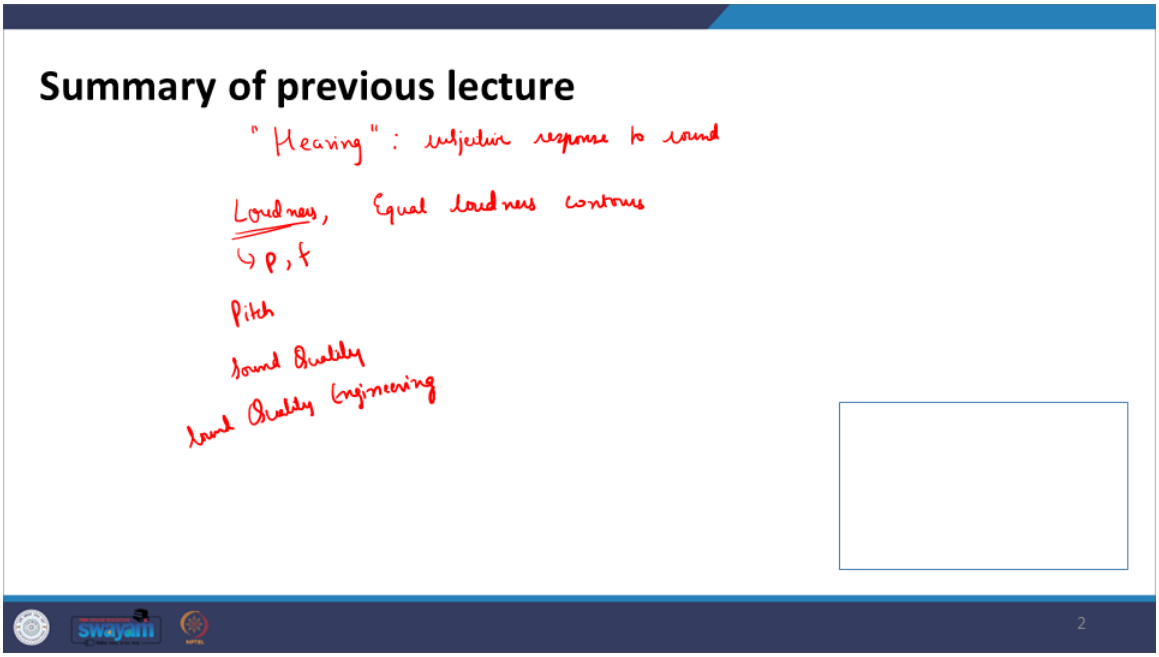
Week:4

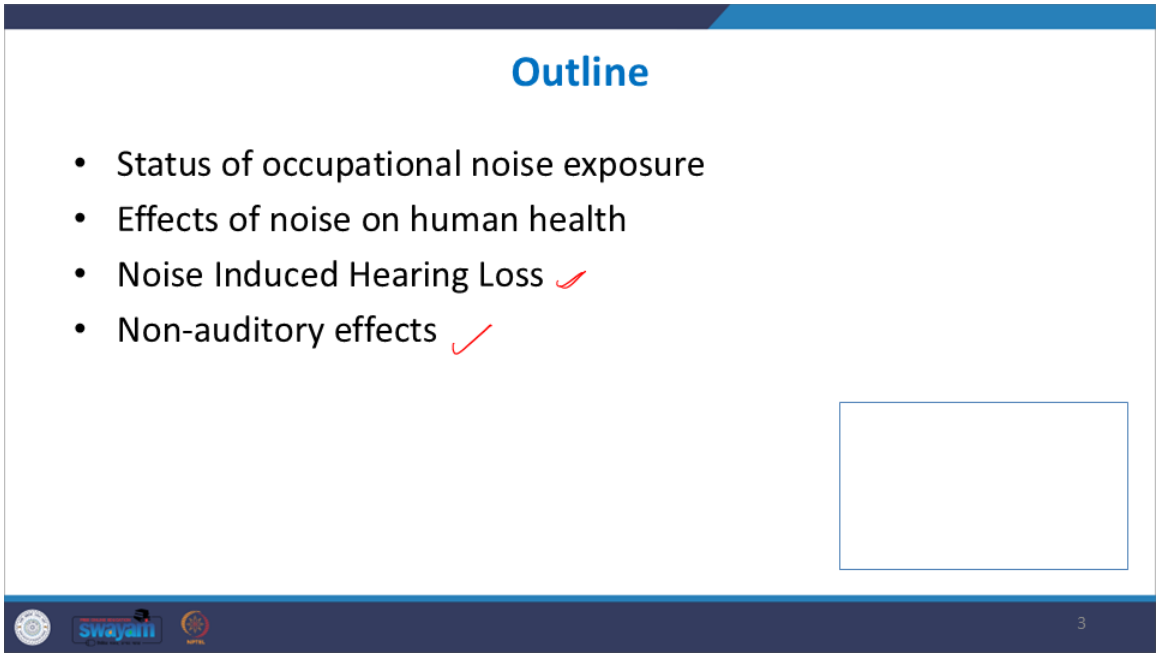
Lecture:20

Lecture 20: Noise and human health

Hello and welcome to Lecture 20 in this course on noise control in mechanical systems. I am Professor Sneha Singh from IIT Roorkee. We have begun our module on the human response to noise. This is a continuation in this module where we have Lecture 20, which is about noise and human health. Here is a quick summary of what we have studied so far in this module. We have studied about hearing, which is essentially the subjective response to sound by a human ear. Then, we have studied about some subjective measures, such as loudness and the equal loudness contours, which say that our perception of the level is not just dependent on the decibels or the sound pressure. It is also dependent upon the frequency of the sound. That is what we have come to know: loudness perception depends both on the sound intensity or the pressure and the frequency. Then, we have also studied

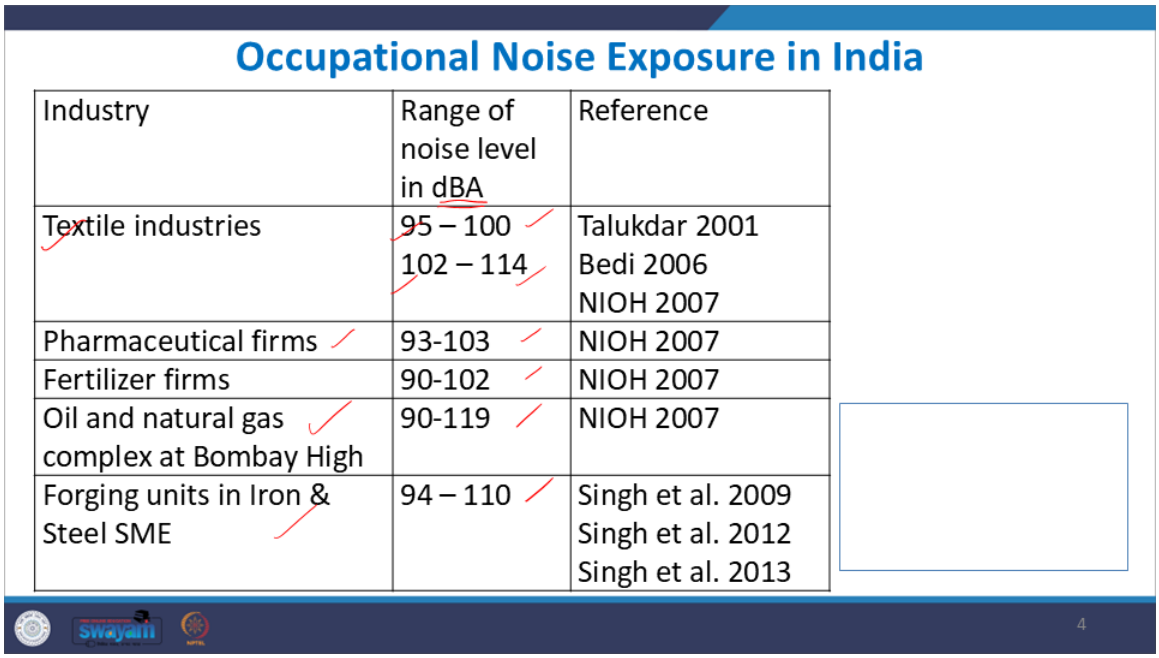


about something called pitch, which is a subjective perception of frequency, and then about sound quality and sound quality engineering.

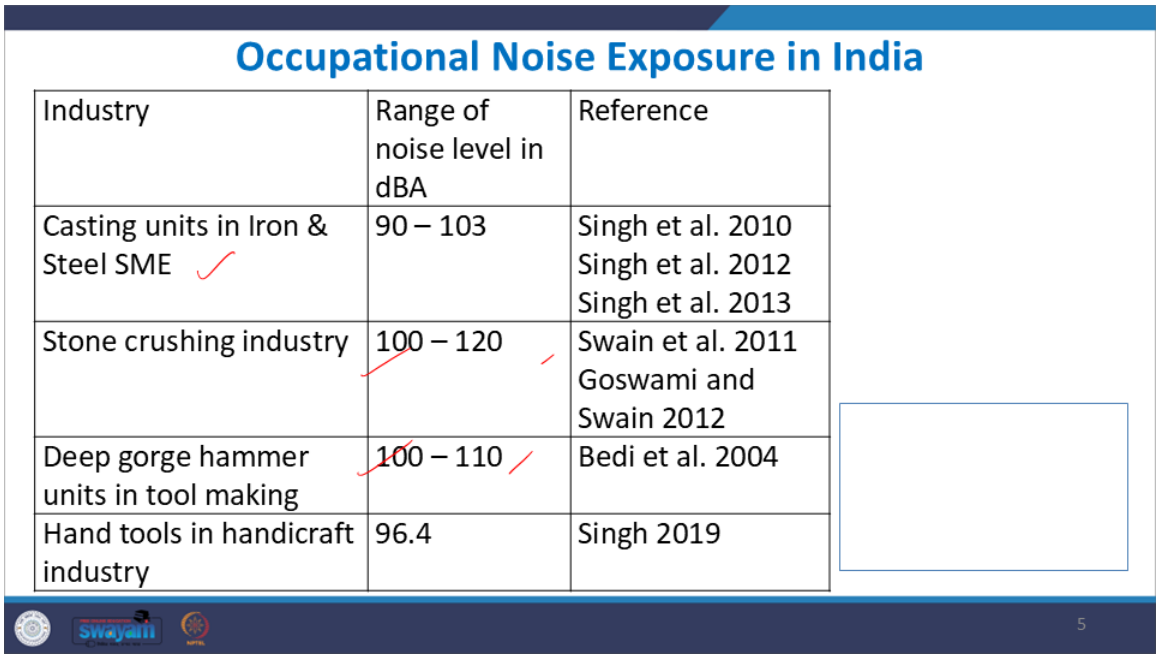


Here we'll see, because it is about noise and human health, we'll first see what the status of occupational noise exposure is across the world and then what the effects of this noise are

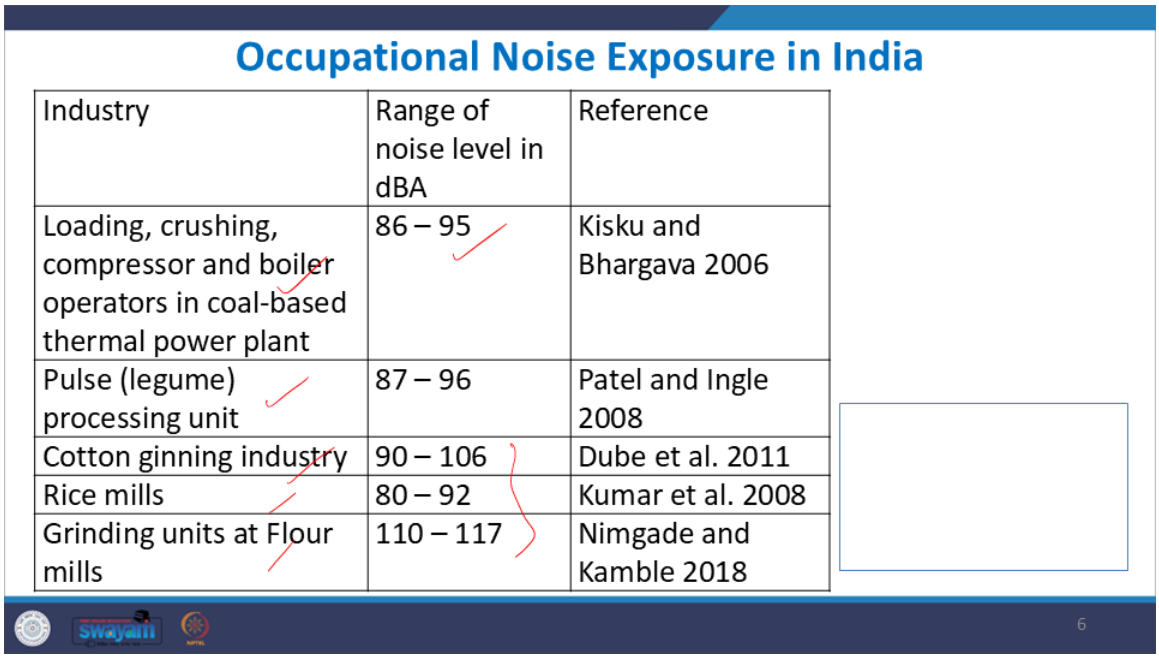
on human health. We will see both auditory and non-auditory effects, and one of the major auditory effects is noise-induced hearing loss, which we will discuss in detail.



Let us see. This is a summary of the research done on noise exposure in the occupational environment in India, with reference to various papers. what you see is that in various industries, such as textile industries, the range of noise levels in dBA is 95 to 100 and then 102 to 115. Similarly, in the pharmaceutical firms, again, it is in the range above 90. In the fertilizer firms, oil and natural gas complexes at Mumbai High, forging units in the various iron and steel SMEs. In most of these, the noise level is always above 90, sometimes closer to 110 or 114, which is extremely loud and dangerous for human hearing.



In the same way, what we have found in various critical industries such as the casting units in iron and steel SMEs, the stone crushing industries, the deep gorge hammer units, and the hand tools in the handicraft industry. This is just a summation of the research done in India. And where they have found the noise levels within the industry to be at a dangerous level, such that the workers working in this industry are exposed to such dangerous noise levels and they suffer from hearing loss because of it. in most of these cases, the noise level is touching 100 dB and it is always above 90 dB.



Occupational Noise Exposure in India

Industry	Range of noise level in dBA	Reference
Loading, crushing, compressor and boiler operators in coal-based thermal power plant	86 – 95	Kisku and Bhargava 2006
Pulse (legume) processing unit	87 – 96	Patel and Ingle 2008
Cotton ginning industry	90 – 106	Dube et al. 2011
Rice mills	80 – 92	Kumar et al. 2008
Grinding units at Flour mills	110 – 117	Nimgade and Kamble 2018

Again, in the loading, crushing, compressor, and boiler operations in various coal-based thermal power plants, the noise level is above 85. In the pulse processing units, cotton ginning industries, rice mills, and various grinding units of the flour mills in these food processing companies as well, sometimes the noise level is above 90 and, in fact, above 100 or 110 dB even during certain operations. In the same way, if you look at the research done worldwide and try to see what the typical noise levels are in the various industries.

Since India is still a developing country, in developing countries the problem of noise pollution is heightened, as you can see with these extremely high sound levels recorded in these various industries. And worldwide, even in some of the developed nations, the noise level is reaching a dangerous level, such as in the olive oil mill industry. Although in certain operations the noise can be as low as 74, in certain operations when the milling machine is going on, it can reach above 100 dBA. In the same way, in the aerospace industry, the noise

Occupational Noise Exposure Worldwide

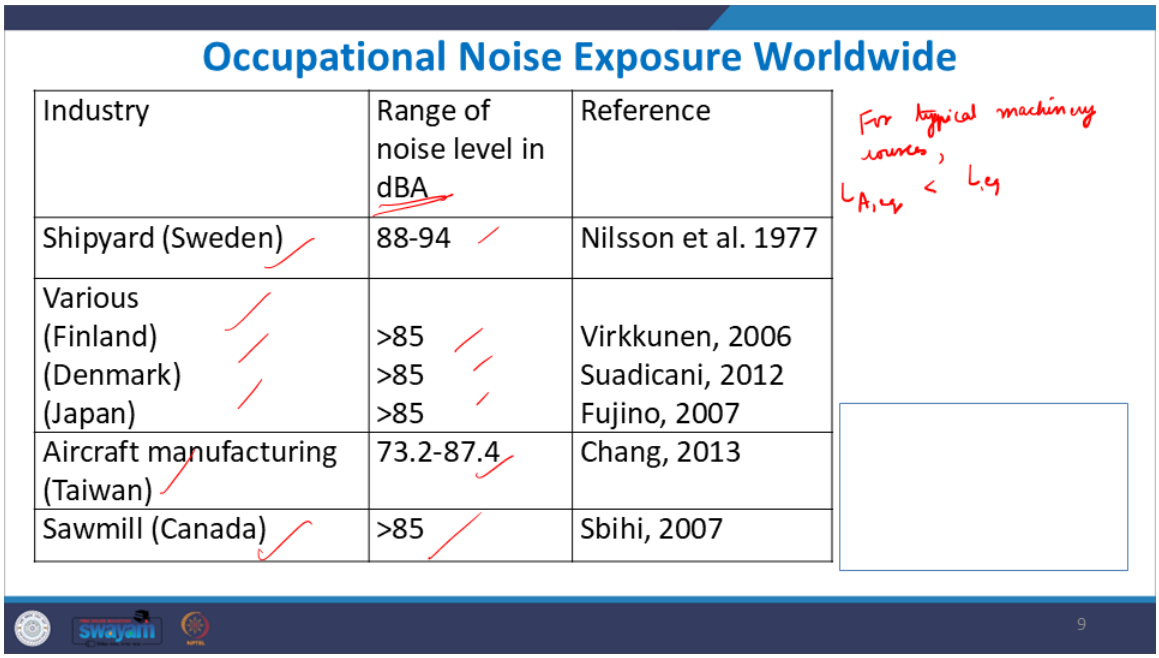
Industry	Range of noise level in dBA	Reference
Olive oil mill industry (Spain)	74.2 – 105.3	Juan et al. 2018
Aerospace Industry (Taiwan)	82-106	Yu-Ting et al. 2020
Cement Factory (Iran)	78.5-88.5	Ali et al. 2022
Construction Industry (Australia) (Malaysia) (Netherlands)	 75-100 70 – 140 87-96	 Kate et al. 2017 Ain et al. 2018 Leensen et al. 2011

can sometimes reach up to 160 dBA, and these are the various countries where this kind of research has been reported. Similarly, in the cement factory in Iran, this kind of noise level has been seen. And then in the construction industries in various countries like Australia, Malaysia, and the Netherlands, what you see is that the noise levels can sometimes start above 70 and can sometimes reach beyond 90, up to 100, and even 140, which is when deafness happens. This is a dangerous level for the ear, a very dangerous level. For the human ear. Even in these countries, it is happening.

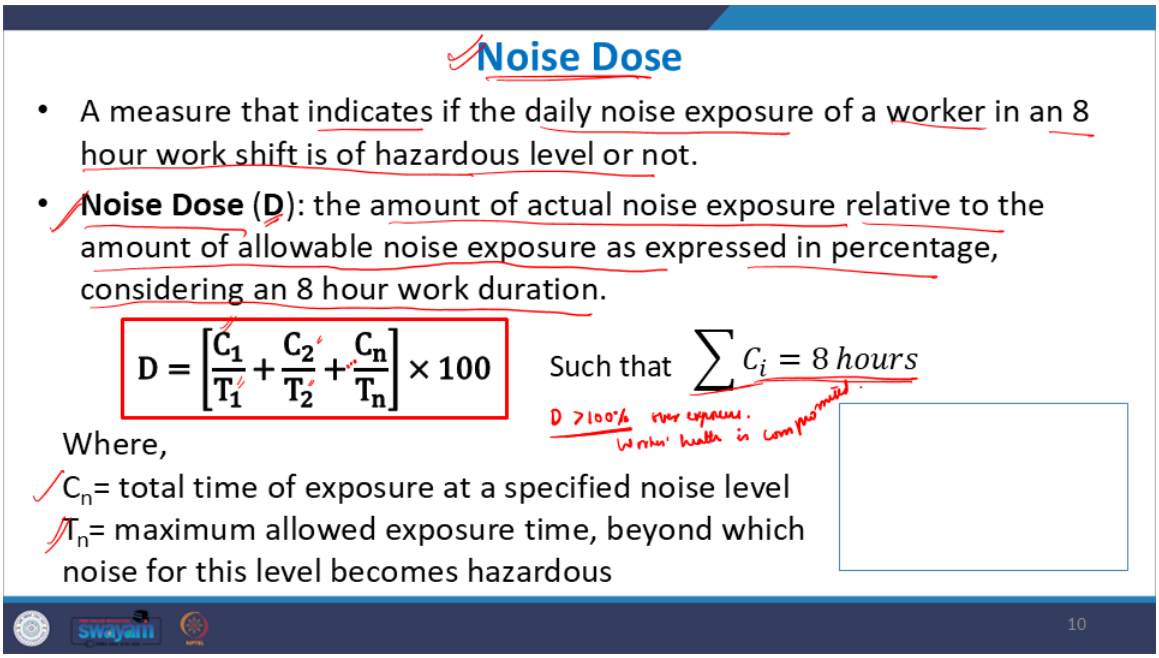
Occupational Noise Exposure Worldwide

Industry	Range of noise level in dBA	Reference
Automobile Industry (US)	85-114	Lee-Feldstein 1993
Smelter (Canada)	<90 dB	Martin et al. 1975
Metal Industry (Egypt) (S. Korea)	 112-139 >85	 Kamal et al. 1989 Lee 2009
Mining (Australia)	90 dB	Leigh et al. 1990
Auto part Factory (Thailand)	80.8 – 97	Apiradee et al. 2017

And then the automobile industry in the US is also affected. the reference of the various papers is given here, and what you see is that the range of noise level is somewhere between 85 to 114 dB. Even in the smelter plant in Canada, it has recorded the noise level is less than 90 dB, but still, it is at a higher range, and then in the metal industry in Egypt and South Korea, you see an extremely high noise level, very dangerous for human beings. In the mining industry, again, 90 dB of noise have been recorded in the auto parts factory in Thailand as well, sometimes the noise is above 80 and reaching up to 95 or 97.



What you see is that in various industries, such as the shipyard industry in Sweden, again, the same phenomenon is seen. The noise levels are usually above 85 decibels and they are reaching close to 95 to 100 decibels. And in other various industries, similar observations have been made in some of the most developed nations as well, such as the Scandinavian countries like Finland, Denmark, and Japan. Even some of the industries are recording high noise levels despite the measures being taken till date. Aircraft manufacturing is also recording in the same way in Taiwan. The sawmill industry in Canada is recording above 85 decibels of noise, and this is the dBA noise, which is the A-weighted decibels, and usually, the A-weighted decibels for machinery, for typical machinery sources. The A-weighted decibel is usually lower than the decibel level. This is not like dB would be even slightly higher compared to the A-weighted decibel levels for the machinery noises. What you see from this is that in various industries and various occupational environments, the workers and the employees are being exposed on a daily basis to such high noise.



And considering that these workers are doing an average eight-hour shift per day. Now, we need to find out how harmful this noise exposure is to these workers. A measure that has been defined for this is called the noise dose. It is similar to, for example, suppose a patient is given a medicine. And they are given the recommended dose of the medicine. You don't exceed it, otherwise, it can have side effects in the same way, the noise dose can be viewed as something similar to that, where the workers who are going into these noisy occupational environments, and considering that they are doing an average eight-hour daily shift.

The dose or the net exposure they are getting to the noise should not exceed a certain level. a measure has been defined. What it indicates is that this measure is the daily noise exposure of a worker in an 8-hour work shift and whether this daily noise exposure is exceeding a hazardous level or not. Usually, we are using the symbol capital D for this particular measure, which is the noise dose. We can also say that it is the amount of actual noise exposure that is being done on a worker relative to the amount of maximum allowed noise exposure, expressed in percentage, considering that the worker is doing an 8-hour work duration.

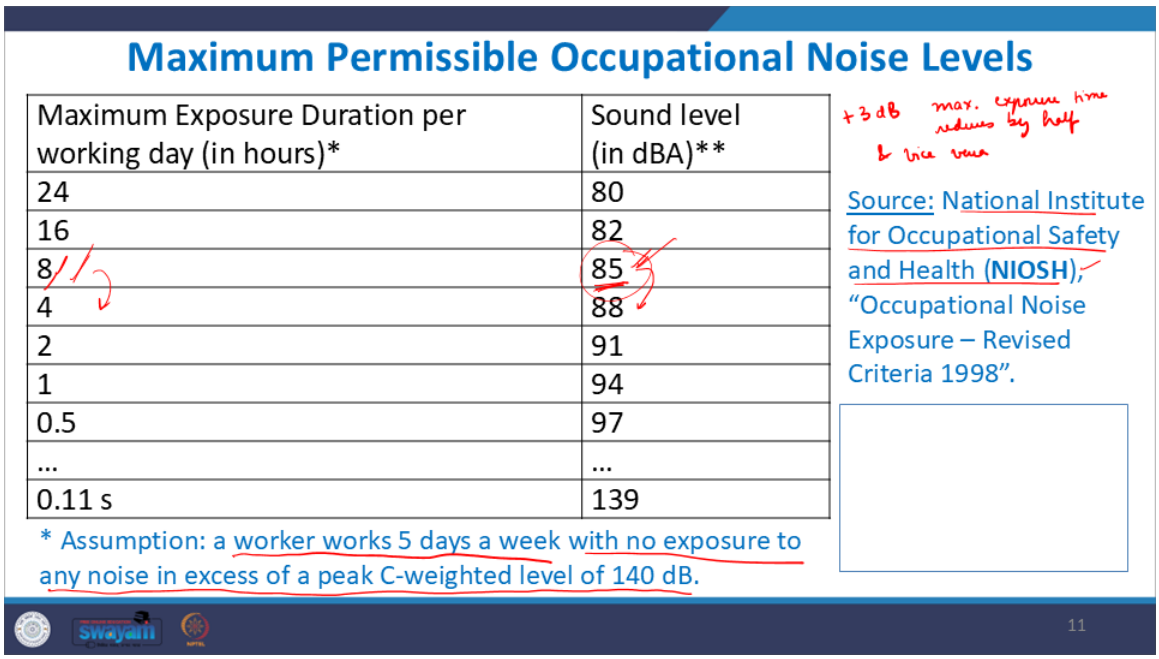
The formula for this is that,

$$D = \left[\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_n}{T_n}\right] \times 100$$

What it means here is that, all these Ci's or Cn's, what are these? This is the total time of exposure at a specified noise level, and Tn is the maximum allowed exposure time beyond which the noise for this level will become hazardous. WHO and various other institutions, such as the National Institute of Occupational Safety and Health, and others, have recommended, based on years of research with human beings, that if within an occupational environment, a worker is exposed to, let us say, some level L, then the maximum time of exposure should not go beyond a certain time t. Otherwise, it will be hazardous and dangerous for the worker's health.

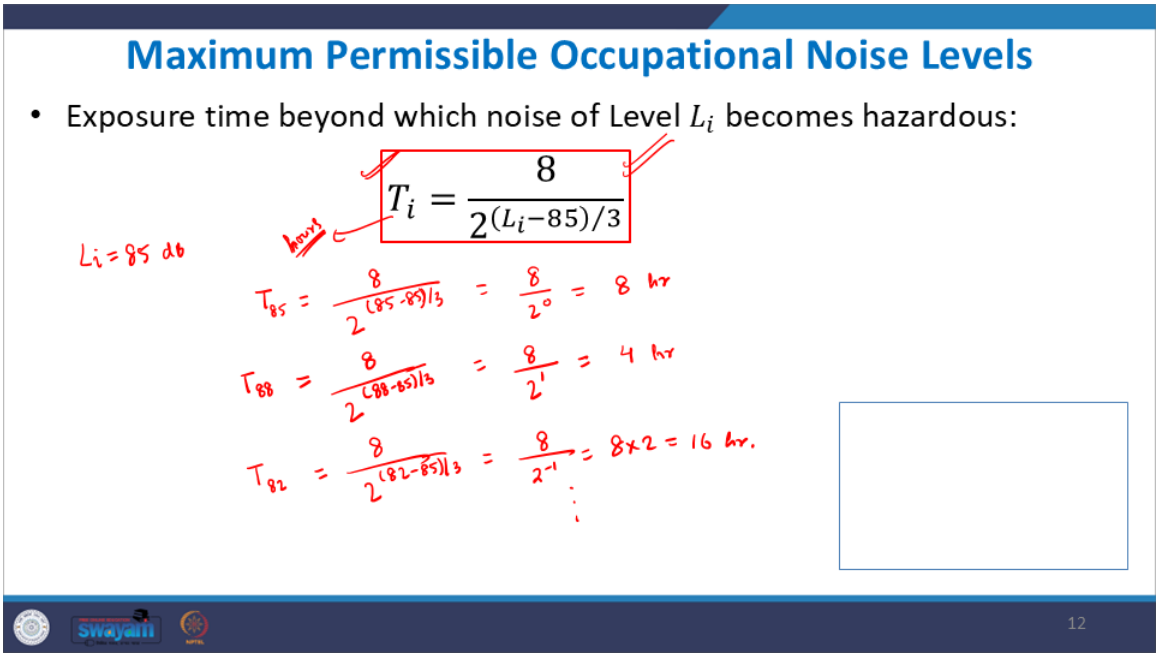
Some recommendations have been made on what the maximum allowed time is, given a certain level of noise. With common sense, you can say that the higher the noise level, the lesser the maximum time that should be allowed for the worker's exposure. This is the actual exposure, and this is the maximum allowed exposure at that level, and so on. Multiplied by 100, it gives you the percentage. which means that if D is greater than 100 percent, you have overexposure and worker's health is compromise, it is hazardous. Whenever the noise dose becomes more than 100 percent, which means more than the recommended exposure. and here it is for an eight-hour work duration. The summation of all the time has to be eight hours. We are calculating it for an eight-hour work shift.

Let us see what this T is and what the maximum allowed exposure time is for a particular occupational noise level.



Based on the National Institute for Occupational Safety and Health. Internationally, people either use the National Institute for Occupational Safety and Health guidelines or they use the OSHA guidelines, which is the OSHA guidelines, the Occupational Safety and Health Administration guidelines. But the NIOSH guideline, is stricter than the OSHA guidelines. here I have given the stricter guidelines, which are the NIOSH guidelines. Based on that, suppose, if a worker is doing an 8-hour shift, then 85 decibels is the maximum allowed exposure time, considering that the worker works 5 days a week with no exposure to any noise in excess of a C weighting of 140 dB. Because if you are giving the worker 60 decibels or 70 decibels, and suddenly there is an outburst of 140 dB or above. The ear will be damaged. There will be permanent damage to the human ear, and there is no point then.

It is going to be hazardous even for a small instant of time. Considering that the noise never exceeds 140 or above and there is an exposure, then for different levels, there are different exposure times, and vice versa. Suppose this is the exposure time; this should be the maximum level, and if this is the level, then this should be the maximum exposure time, and so on. Now, what you see here is that as you are increasing the level, the exposure time is going down, and what's the formula? If you see that every plus 3 decibels you do into the average noise level in the occupational environment, the maximum exposure time reduces by half, and vice versa. If you reduce by 3 decibels, the maximum exposure time will double.



Okay, so for any level, if you have to find out what is the maximum allowed time beyond which that level or that noise exposure is going to get hazardous for the worker, then this could be a generic formula.

$$T_i = \frac{8}{2^{(L_i-85)/3}}$$

This is the reference we take (Refer slide11). 85 decibels correspond to 8 hours. if you see here, if the level that the worker is being exposed to is 85 dB, then the time for 85 dB would come out to be, which is which is 8.

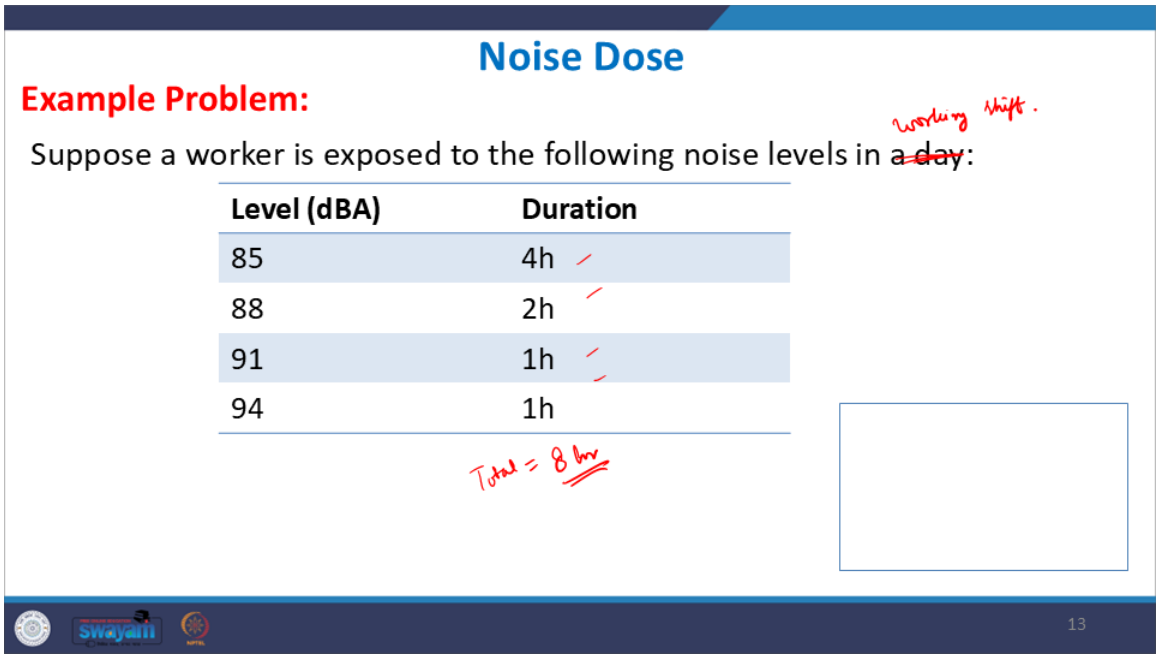
In the same way, if it is 88 dB,

$$2^{\frac{(88-85)}{3}} = 2^1$$

It becomes 8 by 2 or 4 hours. It is not the SI unit, but it is in hours. In the same way, for example, we reduce it, so let us say it is 82 dB. It becomes,

$$2^{\frac{(82-85)}{3}} = 2^{-1}$$

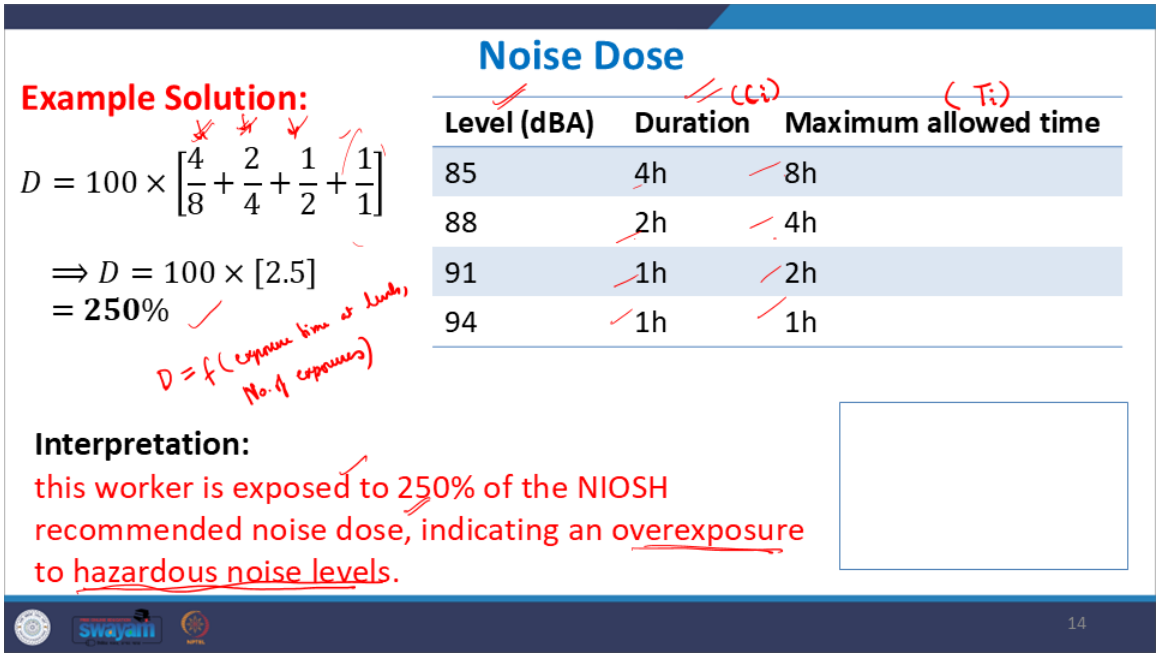
It becomes 16 hours. In this way, you can find out the various values.



let us see a sample problem on how to calculate the noise dose for a worker. let us say, suppose a worker is being exposed to the following noise levels in a working shift—rather

than a day, I should call it a working shift, because it is not a 24-hour monitoring, but an 8-hour monitoring only during that work environment.

Here these are the levels, and this is the duration. If you sum it up, the total duration comes out to be 8 hours. If it is less than 8 hours, the noise dose is for 8 hours. you just consider that the remaining time is less than 80 dB or 85 dB, and you find out. If it is more than 8 hours, then again, some readjustment needs to be made. let us calculate this problem and see what the noise dose is like. Here is the level given and the exposure duration of the worker given.



These are the various Ci's or the actual exposure times, and the maximum allowed time for a level are the Ti's, which is for 85, 8 hours; 88, 4 hours; 91, 2 hours; and 94, 1 hour. You can calculate it using this formulation. Then what you see here is that,

$$D = \left[\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_n}{T_n}\right] \times 100$$

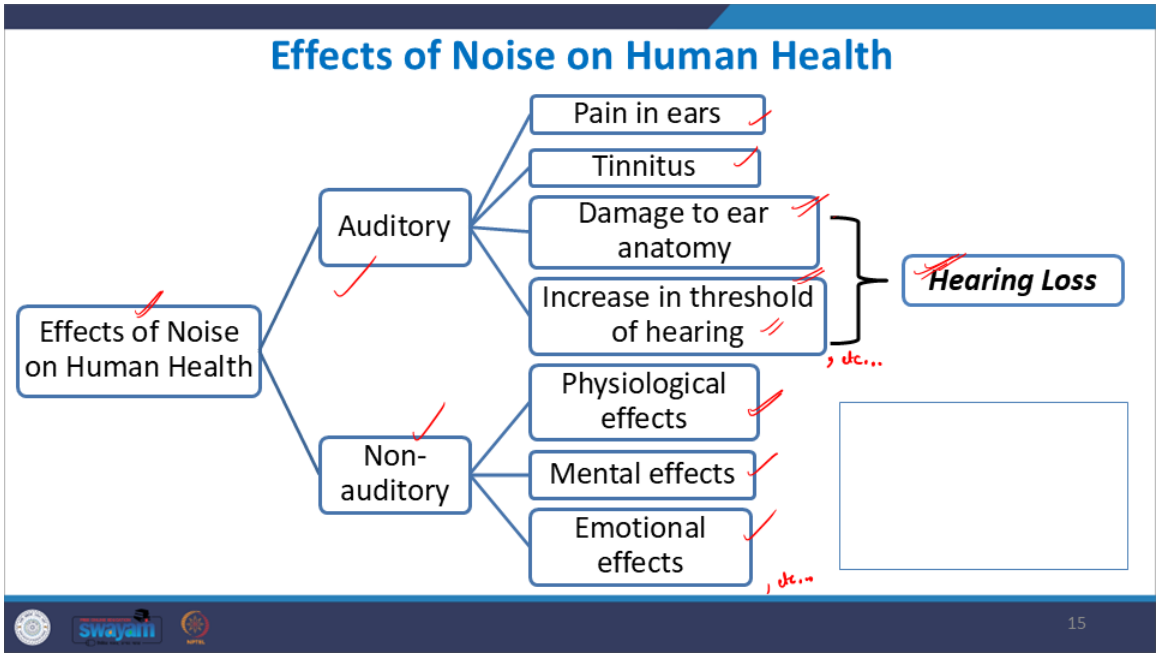
$$D = 100 \times \left[\frac{4}{8} + \frac{2}{4} + \frac{1}{2} + \frac{1}{1}\right]$$

if you do it, you come out with 250 percentage. what does this mean?

This means that the worker is being exposed to 250 percent of the NIOSH recommended noise dose, which indicates an overexposure to these hazardous noise levels. It is dangerous

for the worker. Now, if you notice here, let us say, here in the first two exposures, the worker is being underexposed to the hazardous noise level because the exposure, actual exposure time is just half of the maximum allowed. And only in the last exposure, so for the first three, it is happening like this, but only in the last exposure, it is reaching the maximum allowed time. So basically, in no exposure, the worker is being overexposed, but still, we are getting a 250 percent. What it means is that this noise dose is not just dependent on the exposure times at some levels. But it is also dependent on the number of exposures.

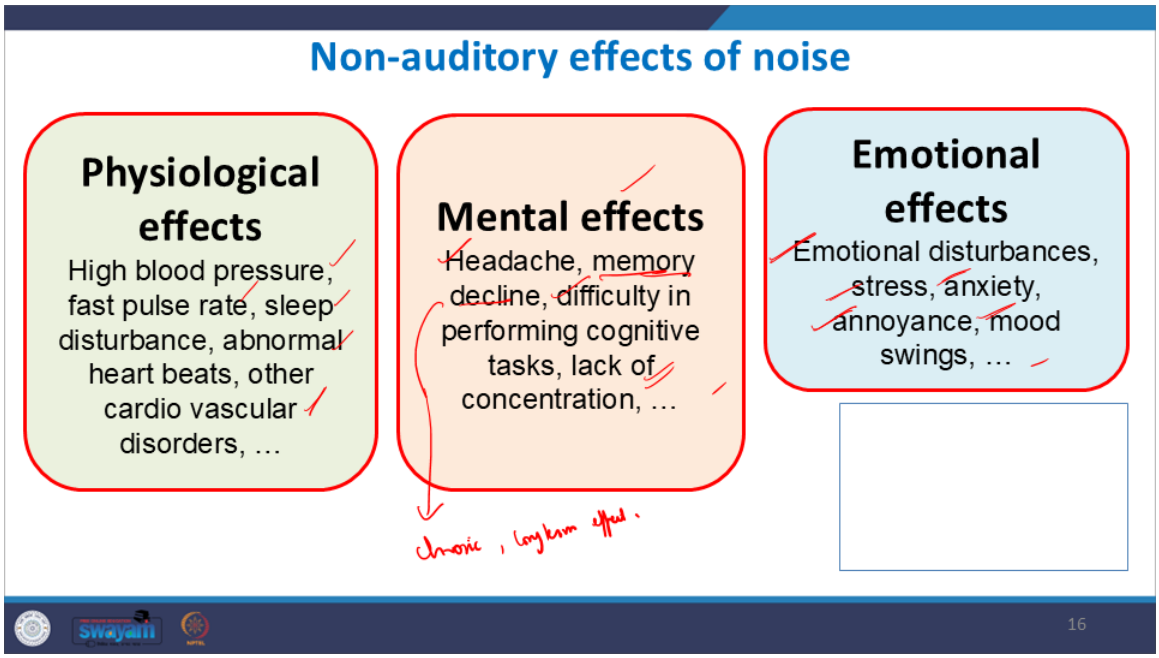
Basically, if you would have done only these first two exposures, you would have gotten 100 percent, and it would not be an overexposure, but again, if you increase one more exposure. Or you vary the different levels, it starts becoming dangerous. even exposure to these varying levels has been given a weightage, and you are getting a high exposure.



In general, what you observe is that people are being exposed to high noise, high levels of noise, sometimes reaching above the hazardous levels. For example, here for a work shift, 85 dB, if you consider, then most of the research that I had indicated, almost in all the companies, the levels were hazardous for the worker. Which means that noise is definitely an issue, and what is the effect it is actually happening on human health. What is the effect of noise on human health? We can divide the effects of noise on human health as auditory effects and non-auditory effects. In the auditory effects, you can have various things related to the sensation of hearing and the ear organ as such.

You can physically feel pain in your ears sometimes when you are listening to heavy noise. What I have personally experienced is that if you have bad headphones or bad earphones and you are listening to some kind of rock music or some other type of music for a long duration, even that causes pain in my ears. Then there is an issue called tinnitus. It is a hearing disorder where what happens is that you say that, my ear is ringing. I can sense my ear ringing even though there is an absence of stimulus or an absence of sound. Even then, your ear senses some kind of ringing noise that is tinnitus. Then, damage can be caused to the ear anatomy, such as damage to the inner hair cells, swelling of the eardrum, various kinds of this. If there is damage to the physical ear and its various organs. It can lead to an increase in the threshold of hearing, which means that deafness can start. This means that a normal person might be able to hear a particular sound at a low decibel, whereas for another person, they are not able to hear it because, for them, it is too low. The threshold of hearing has risen.

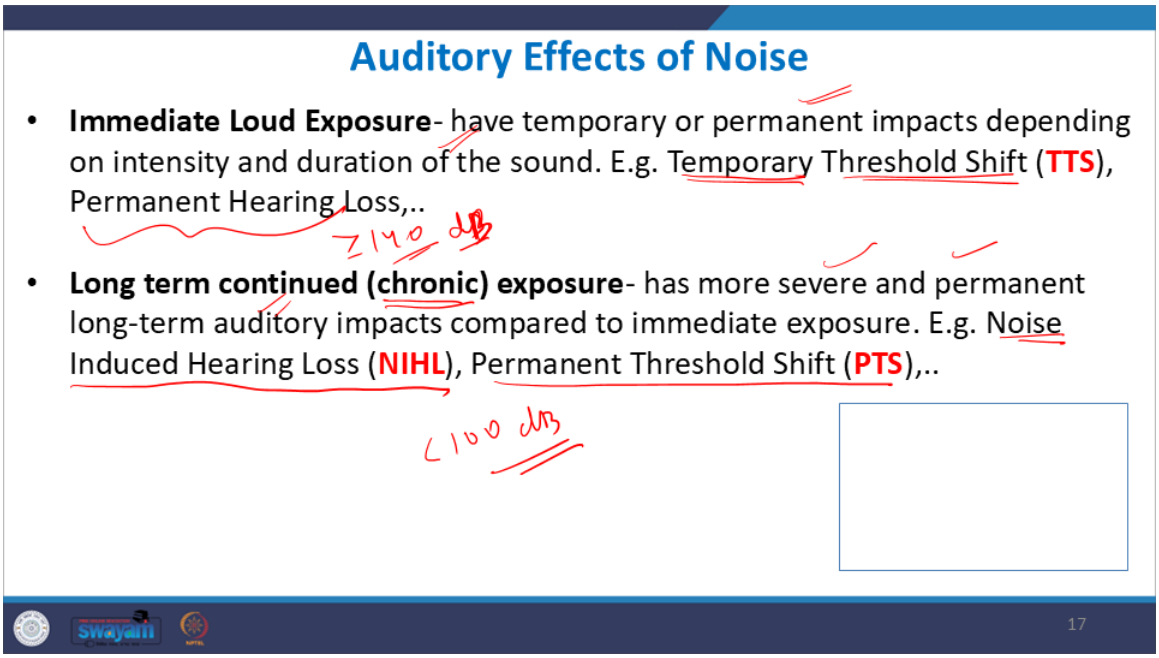
Somebody who is able to, let us say, listen to a sound as low as 0 dB or 10 dB, but for a person in whom hearing loss has started, that same person can only hear a sound beyond 40 dB or 50 dB, this thing together becomes hearing loss. There is damage that is happening to the ear anatomy, and the threshold is rising, and if it becomes permanent, it becomes permanent hearing loss. These are some of the auditory effects. I will just write etc. here, which means that obviously, there are various effects related to auditory effects, and it is not possible to cover each and everything. We are just giving some of the common effects. Auditory effects, and etc. In the same way, here al I will just add etc. Then we have the non-auditory effects. The non-auditory effects can be divided, as physiological effects, mental effects, and emotional effects.



Let us see what these non-auditory effects are. In the physiological effects, obviously, it is related to, the physical mechanism of your body and the biology itself. you can have various things like, high blood pressure, fast pulse rate, sleep disturbance, some abnormal heartbeats, and various other kinds of cardiovascular disorders, etc. All of that, palpitation, then perspiration, all of these things, come under physiological effects. Then the mental effects, it causes headaches, it can lead over time to memory decline, and all of this is due to chronic exposure. I will say it is not like you listen to loud noise suddenly your memory declines. These are chronic effects, which means very long-term continued exposure over a long number of periods or a long number of years can lead to these kinds of effects, which is the memory decline, chronic long-term effects, not immediate.

These are the immediate effects, immediately you are listening to loud noise, it can lead to headaches, in the same way, difficulty in performing cognitive tasks, as a student, as an industry professional, we are all, involved daily in cognitive tasks. We have to use our brain. We have to solve problems. We have to be involved in mathematical tasks and a lot of computational tasks and problem solving. All these cognitive tasks require a lot more focus and attention, and noise can definitely disturb the performance of these cognitive tasks and disrupt concentration. All of this is related to your brain and how it hampers brain activity. I have classified it as the mental effects. Then you have emotional effects because noise can, for example, suppose you are an avid music listener. noise, or sound, can uplift your mood or it can degrade your mood. Noise plays a significant role in how you feel throughout the day. It can listen to some music can cause anger, or listening to people abusing each other on the internet or social media can create a lot of noise. Noise and abusive language, such as people talking abusively or shouting, can create certain feelings within you, and you may not feel alright. So, noise is directly related to how you feel and the emotions you experience. Emotional disturbances can be caused, stress can be caused, anxiety can be caused, and if there is a lot of harmful noise around, you may get annoyed and experience mood swings. Listening to pleasant music or classical music can uplift your mood, while listening to people shouting at each other and abusing each other can definitely cause anger within you. these emotional effects occur.

Within the auditory effects, which is something we will discuss more in detail now, again, all of this I have added the 'etc.' as there are many other things. here in the auditory effects, you have immediate loud noise. What happens when there is an immediate exposure to loud noise? Here, what you have are either temporary or permanent impacts, depending on the intensity and duration of the sound.



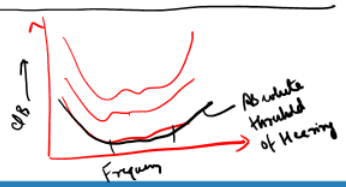
Suppose you are immediately exposed to a loud noise, which is, let us say, less than 110 dB or something. You might feel like, suddenly there is pain in your ears, a headache, ringing, or whatever. But all of that is temporary because it is just an immediate exposure. Later, it subsides. There could be a temporary threshold shift. But if it is above 140 dB, even an immediate and one-time exposure can cause damage to your hearing, which could be permanent damage.

In the same way, long-term or continued effect, which is called the chronic, either it could be an immediate exposure, or it can be a long-term continued exposure. If you are being exposed to high noise levels for a long term or chronic exposure, even lower levels, which are, let us say, even less than 100 dB, can be very harmful. It has more severe and permanent long-term auditory impacts. And it can lead to things such as noise-induced hearing loss and a permanent shift in the threshold of your hearing.

What is the threshold of hearing? The threshold of hearing we have already discussed when we started in the beginning lecture of our human response to noise, where I was showing you the equal loudness contours. Basically, what it means is that it is the minimum sound level at which it is just being heard. And usually, what you see is that in the equal loudness contours, what you saw is that most of our loudness contours are like that. And then somewhere here, which I can indicate with a different color, is your absolute threshold of hearing. You can refer back to my previous lectures where I am discussing equal loudness

Auditory Effects of Noise

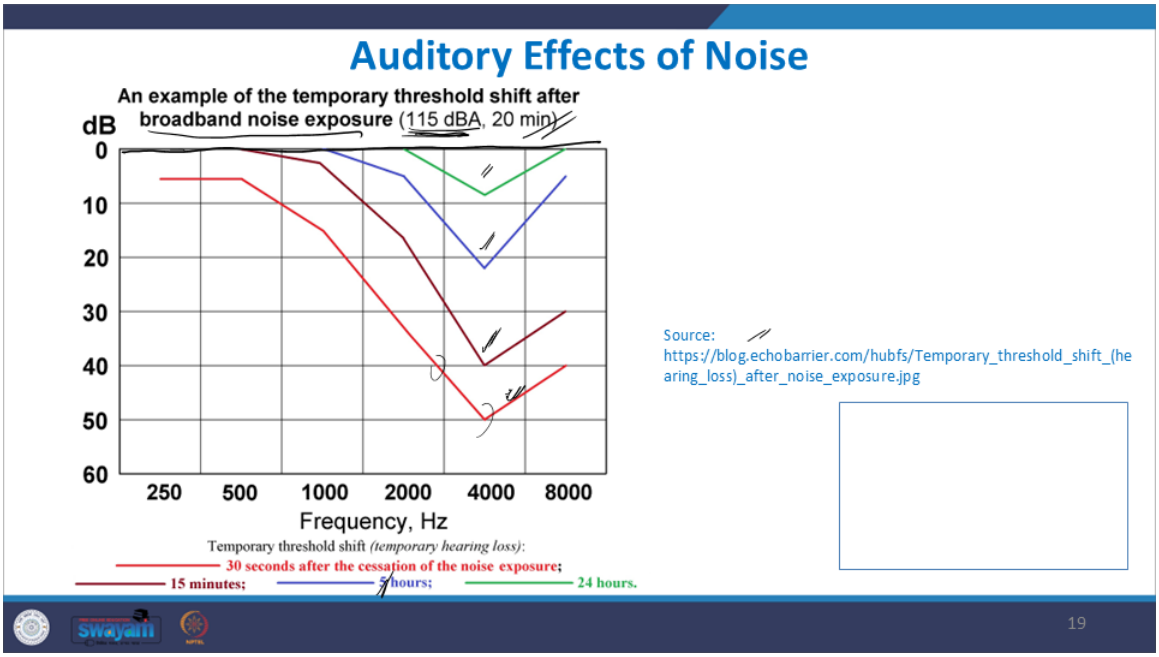
- **Threshold of hearing:** Minimum sound level at which it is just heard.
- **Temporary Threshold Shift (TTS)**-After noise exposure, the hearing threshold increases for a short period of time and then recover to its initial level.
- **Permanent Threshold Shift (PTS)**-After noise exposure, the ear does not fully recover and the threshold increases permanently and never returns to its initial level.



contours, where we have discussed about it. The absolute threshold of hearing means that it is the minimum level for a healthy human ear. What is the minimum level at which the absolute threshold means that it is for a healthy ear, which is not suffering from any clinical problem? What is the minimum level at which the sound is being heard? This obviously is dependent on the frequency.

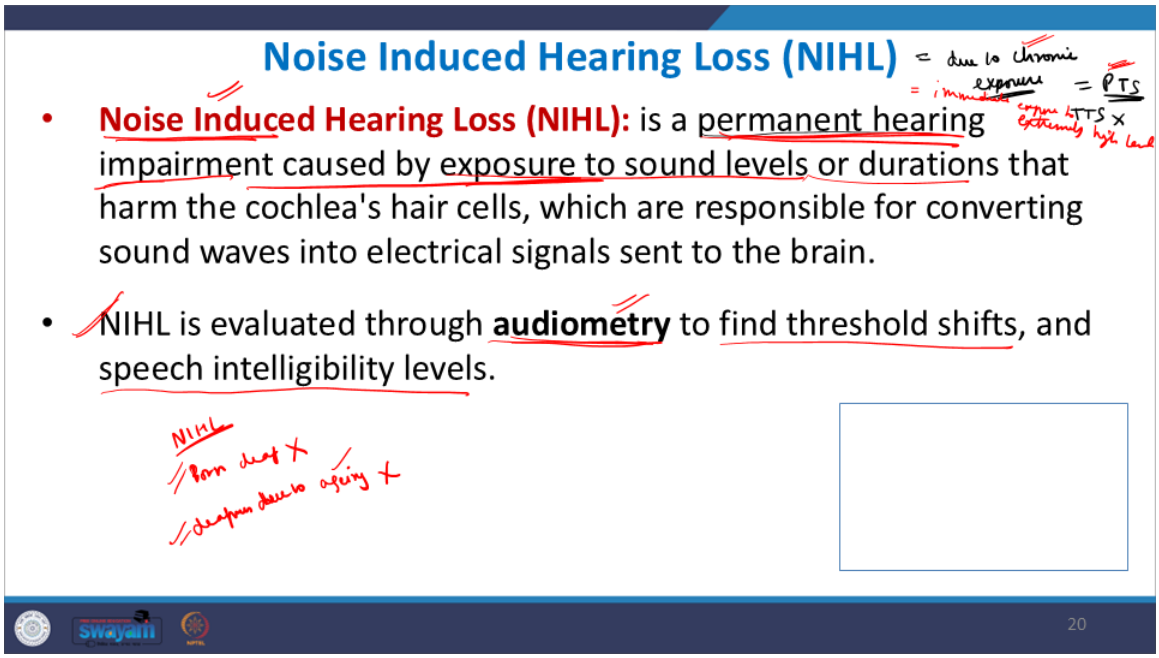
In these mid regions, it is more sensitive, so you are able to hear even lower decibel sounds. And in the higher frequency, this sort of increases up. The threshold of hearing becomes at the minimum sound level. The main auditory effect which happens due to these exposures, whether immediate or long term, is that our threshold shifts. This means that after noise exposure, the hearing threshold increases for a short period of time. Then it is a temporary threshold shift, and then it will recover back to its initial level. Then the other kind of threshold shift would be the permanent threshold shift, which means that after noise exposure, the ear does not fully recover, and the threshold here increases permanently. There is no recovering back or returning to its initial level.

Let us see what a temporary threshold shift is. Let us say, for example, you had your first experience in a flight. And after coming from the flight, you feel weird, because your ear is feeling weird. You are not able to sense all kinds of sounds. But it does not mean that you have become deaf or your hearing pattern has suddenly changed.



It is just an effect of your first flight that you had. And once you came back within a day, you recover and you retain your original hearing. In the same way, let us say you went to a concert, and in the concert, we enjoy loud music. A lot of amplifiers are there, and you are sitting in the first row. Suddenly, after the concert, you might feel that after this loud, 2–3-hour sessions of this loud noise, when you come back, the low volume sounds you are not able to hear immediately. That does not mean you have become deaf. That just means there is just a temporary shift in your threshold. Temporarily, your threshold has risen to a higher decibel level, so that lower levels you are not able to hear. But slowly, it is going to regain and return to its initial level. So here, you can see this is a temporary threshold shift which happens, let us say, somebody is exposed to A broad wind noise of 150 decibels for 20 minutes, after which they are just left. What happens after immediate exposure? This red curve shows that 30 seconds after the cessation of the noise exposure. Just 30 seconds after this exposure to the loud 115 decibel noise at 20 minutes. This is your absolute threshold that has been recorded, which means that the minimum level and at the various frequencies, what is the minimum level that you can just hear. And as you can see, your threshold has sort of, increased in value. The absolute threshold should be 0 decibels throughout. This could have been the absolute threshold, but it has gone down. Basically, it has increased in value, not able to hear the sound below 50 dB in this case and below 40 dB in this case. But after 15 minutes, the new threshold that is recorded is this.

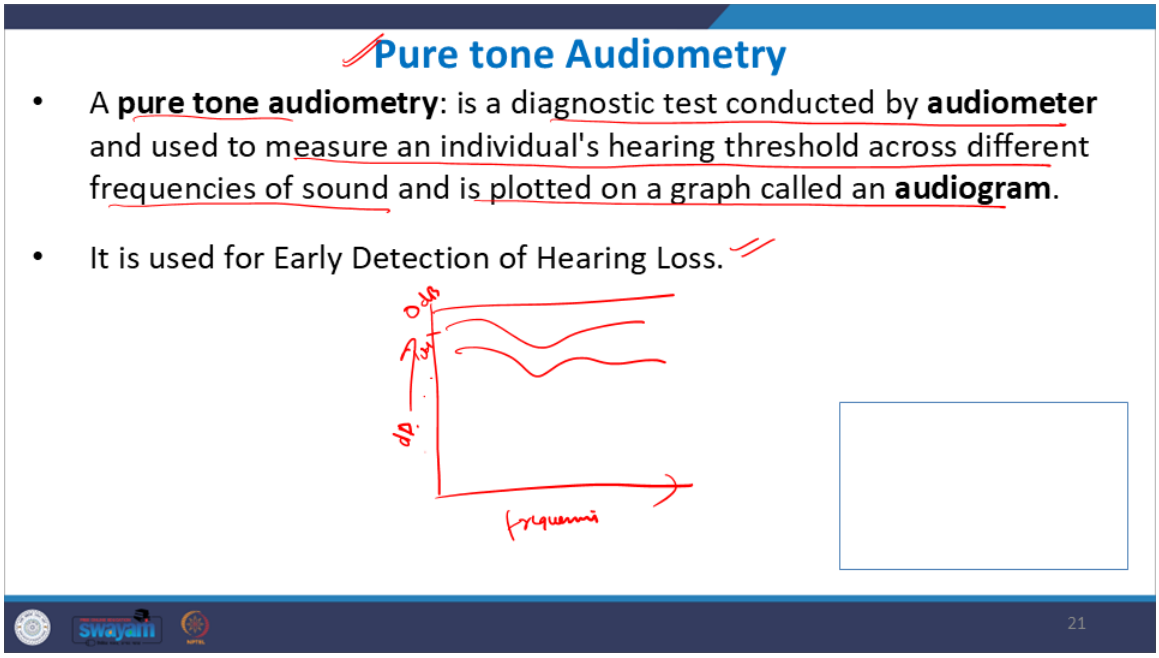
We are doing a hearing test. This is research from this website, and they did a hearing test after different time periods post the noise exposure. After 15 minutes of noise exposure, you see that this is a threshold. suddenly, the threshold is going back to the normal state, and then after 5 hours, it is further shifted to the normal state, and after 24 hours, it has almost regained the actual hearing status.



What is noise-induced hearing loss? This term was introduced while discussing the auditory effect. This happens due to chronic exposure. This is not an exposure to immediate levels, and this is the permanent shift in the threshold. This is also not related to temporary threshold shift. noise-induced hearing loss, as the term suggests, is pretty straightforward; it is a permanent hearing impairment. The word 'permanent'—it is not temporary. All the examples I gave just now, like being at a concert or taking a first flight, do not qualify as noise-induced hearing loss because this is a permanent shift in the threshold that happens due to long-term chronic exposure or immediate exposure to extremely high levels. In any case, there could be a permanent loss in hearing. This permanent hearing impairment is caused by exposure to sound levels at certain durations that harm your ear anatomy.

They harm the cochlea's hair cells, which are responsible for converting the sound waves into electrical signals sent to the brain. there is permanent damage to your ear mechanism. And how do you evaluate noise-induced hearing loss? You evaluate it through audiometry, which is a standard clinical procedure for testing the threshold of hearing. It finds the

threshold shifts and also the speech intelligibility levels. We are going to discuss this in this lecture. This is noise-induced hearing loss. let us start with audiometry, which is the standard test for measuring the hearing capacity of an individual.

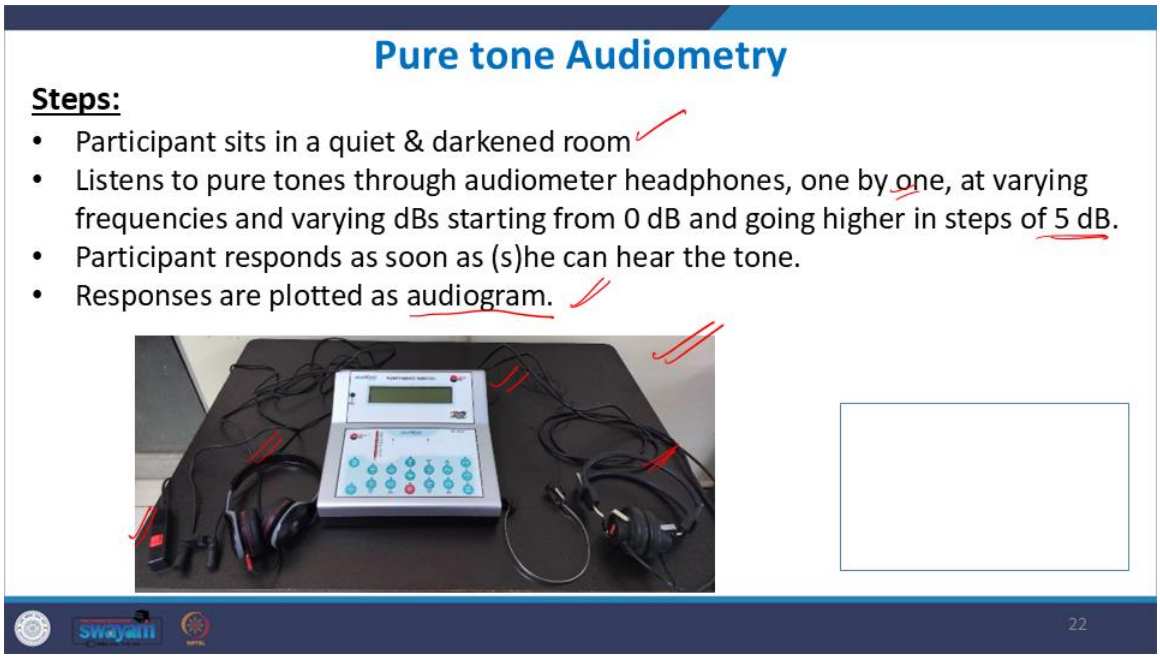


The first type of audiometry that is done is pure tone audiometry, in order to find out whether an individual has suffered hearing loss due to noise. Again here, I would like to say that NIHL, as the name says, is induced by noise.

The permanent hearing loss that is happening is caused by the exposure, okay. suppose if someone is born deaf. If someone is born deaf, that is not NIHL. Deafness due to aging, with aging, all parts of your body slowly start to stop functioning properly. There could be, in the same way, you lose your digestion, you lose your bladder control, you lose. basically, various parts of the body stop functioning, and deafness that is caused due to just aging also does not qualify as noise-induced hearing loss because this is not because of the noise. This is because of aging, and this is because of by birth itself, you had a defect, and you were not able to hear the sound. All of this does not qualify as noise-induced hearing loss.

Noise-induced hearing loss is what? It is somebody who was healthy in hearing and should have been healthy in hearing, given that age and that, health status, and still, because of being exposed to noise, they lost the hearing. Pure tone audiometry is done, which is a

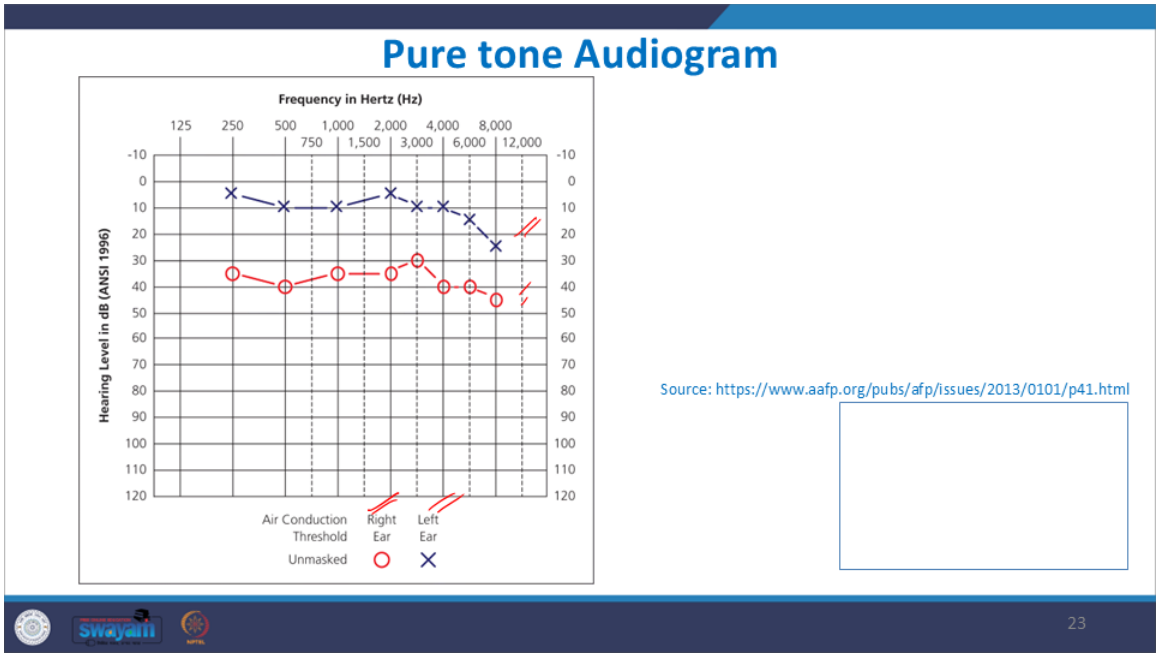
diagnostic test conducted by an audiometer, and it is used to measure an individual's hearing threshold across different frequencies, and you get a graph which is an audiogram. What would this graph look like? It would be you are measuring the hearing threshold across different frequencies. It should be a frequency versus decibel graph, suppose you start from 0 dB. 10 dB and so on, so these kinds of graphs you will get, what is the threshold across the different frequencies, and this is used for early detection of hearing loss.



This is a typical audiometer in our lab in the noise control and mechanics vibration laboratory. In this lab, we have this audiometer. What you have is this device through which pure tone signals are generated at various dB levels, and the person whose hearing has to be tested can wear the headphones, and this is a response button where they can press the button as soon as they hear the sound.

What happens is the participant is made to sit in a quiet and darkened room, which means that the participant is devoid of other stimuli and there is nothing distracting them from the hearing task. Then they listen to pure tones through the audiometer setup and the headphones. One by one, a pure tone at various frequencies and various decibel levels is given, starting from 0 decibels at each frequency and going higher in steps of 5 decibels. And as soon as the participant is given that sound stimulus and as soon as you hear it, you have to Press your response button.

Let us say we started from the frequency 500 hertz. We start by giving 0 decibels at 500 hertz, then 5 decibels, then 10 decibels, 15 decibels, and so on, until the participant presses the button to indicate they have heard the sound. The minimum level at which they heard it would be recorded, and the responses would then be plotted as an audiogram. This is what it would look like.



Both ears are tested separately, the right ear and the left ear, and their responses are recorded in this particular fashion.

I think with this, I would like to close this lecture, and we will continue our audiometry discussion in the next class. Thank you.