Ergonomics Workplace Analysis
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Lecture - 14
Analysis of Auditory Environment and Noise Pollution

Welcome back to one more class. Today we will be talking about one environmental parameter that is acoustic environment. So, what is the effect of sound noise on human being at workplace and how the performance and activities are getting affected by that particular variable or parameter?

In few previous classes we talked about thermal environment which has lot of adverse effect; somewhere some motivational effects are there as per this environmental variable or factors are concerned. Today we will be talking about acoustic environment. Let us understand what these are and then how does it impact and how are we going to identify it or measure it or asses it at workplace.

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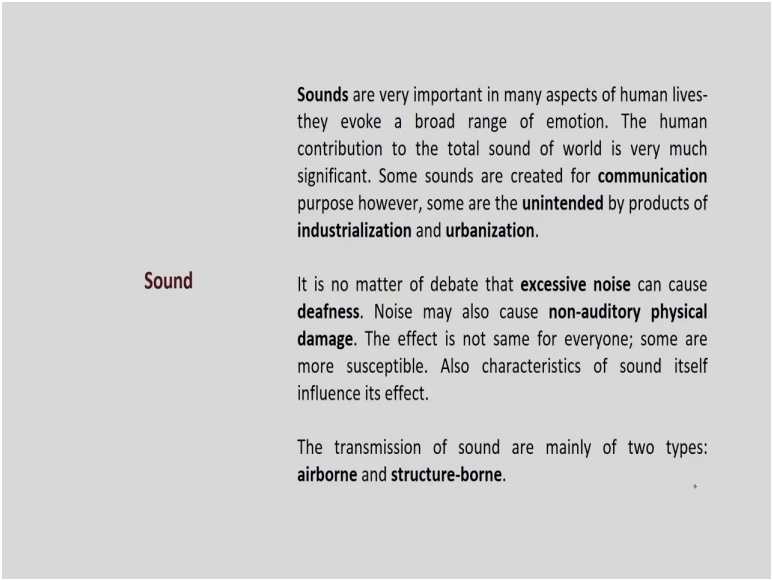

As far as sound is concerned it is very important in many aspects as far as human life or human being is concerned. Whenever we are talking about sound it is very important as we are considering communication. Now take example of this particular class: if the sound of this particular video is missing, we will not be able to communicate what I am trying to tell you for this particular class.

So, here sound is very important; its positive impact is there. But same thing when it converts to the industry like machineries and lot of instrument use, in industrialization urbanization cases, sound has some adverse effects. Based on the context, the impact of sound actually keeps on changing. So, whatever sound we are getting exposed or noise we are getting exposed, if it is excessive in nature in terms of amplitude, magnitude, duration or exposer level, it has a negative impact. If it is excessive of course, it has an impact on your ear or your auditory system and slowly it can cause deafness. So, it is very dangerous.

Of course it has positive impact as well because without sound or this particular sense of hearing we will not be able to sustain in a particular workplace. Understanding the requirement of sound or noise in a particular environment and managing that in a optimal condition is important for an ergonomist to create an optimum ergonomic workplace. If we can do that then only today's topic will be beneficial. To achieve that goal we are going to study this auditory system and how the measuring systems should be used.

We know that noise has some impact which is non auditory physical damage, a very important aspect. In many cases it happens that you have impact of the sound, as we are not in a position to concentrate or to perform a particular job. All these details will be covered today.

Now when we are talking about sound it transmits from one source to the recipient. It has two way to transmission process or types one is airborne asthrough air it goes another is structure borne.

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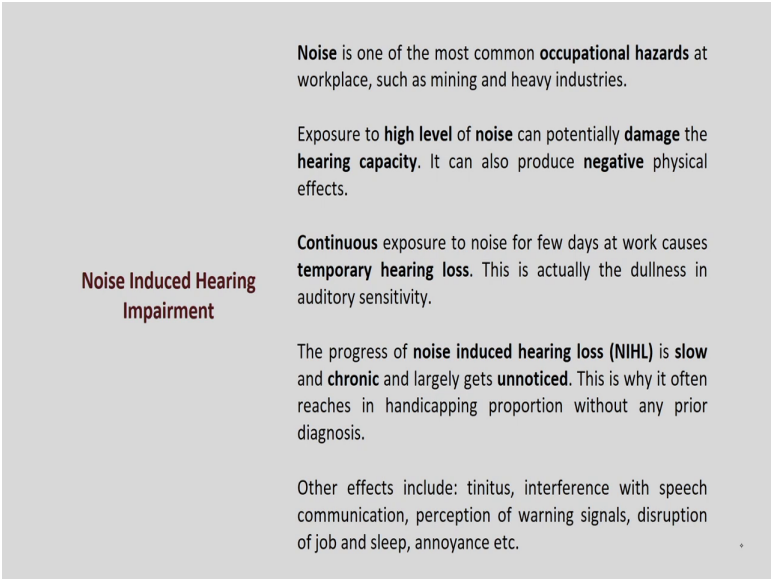

Let us understand what are the types of impairments that are possible and how it is segregated in the industry as well as in personal level. Noise is one of the most common occupational hazards. If you go for industry you will definitely get to know different kinds of occupational hazards. Noise or noise related hearing loss is one of them and it is very common. When we are talking about handling heavy machineries, mining industry these are major sources or major industries or location where you will get these type of incidences. If you have a continuous exposure for a few days or continuous work then you may get a temporary hearing loss.

Suppose you are working in a particular mine where digging is happening. There are lot of machineries which is digging that particular mine and they are getting the mineral out. Now for this whole process these machineries create or is the source of huge noise. If you are getting expose to that particular noise for a long time, and you come back from this particular area and sit in a silent place, you will experence a temporary hearing loss.

Now, this particular type of hearing loss is subject to recover if you get a proper recovery time. But when you are exposed continually to noise before it comes back to the normal, then slowly the changes happen in your physiological system.

So, what happens? We understand if it is high level of noise and the damage can be very high and it has a potential to actually affect your hearing capacity. It has lot of negative impact. Noise induced hearing loss is very common phenomena when we are talking

about noisy industry and their impact on the human health. What it actually does? It is a slow and chronic impact on the hearing facility or the whole auditory system. Because it is slow and chronic, it actually remains unnoticed; because the time it starts you may not understand.

Actually the you are getting some hearing loss for that particular person for that particular operator. But over the period of time may be 30 years of exposure or the whole job experiences, after that you may see the impact of a particular sound. A normal person who does not have any exposure and the other one who is he already worked in that noisy industry for long years has difference. So, that the persons threshold limit has been changed and we call it noise induced hearing loss.

That is why it is very important for us to understand those impact and how we can measure them and control them. We are going to discuss it further.

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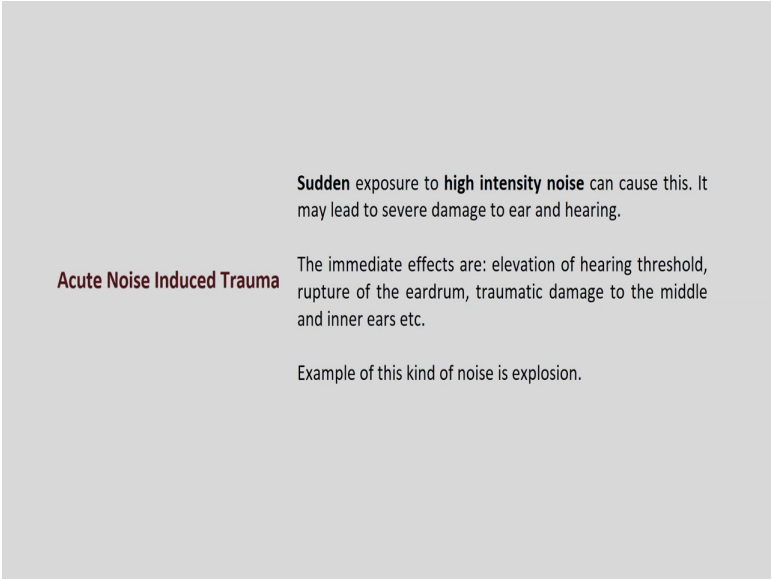

Another impact is Acute Noise Induced Trauma. The first one is very slow damage but in this case all of a sudden there is a explosion. High intensity sudden noise if you are getting exposed to, then there will be certain damage to your hearing capacity. Mainly it happens when you are going to expose yourself to an explosion or a some accident or something like that. There you may feel this type of problem. When we are talking about noise induced hearing loss, a very important concept that we are going to discuss is Temporary Threshold Shift.

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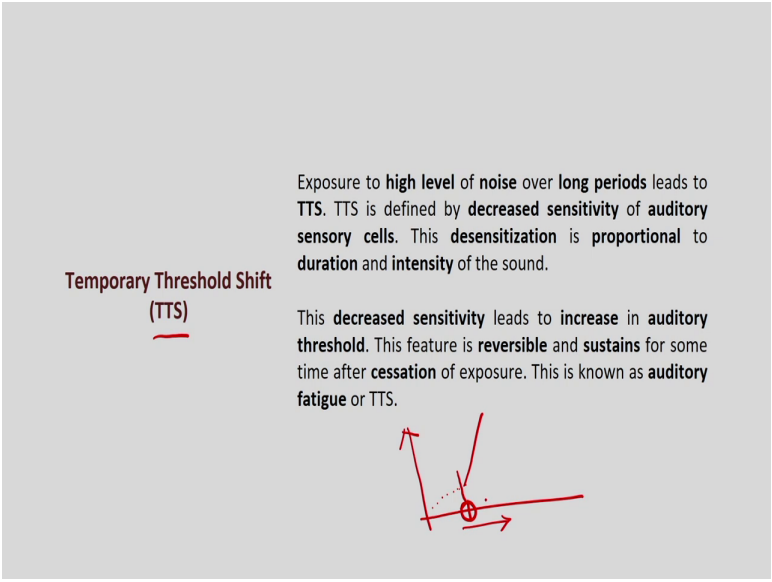

What is threshold? There is stimulus and based on that stimulus your system is going to respond. If the dose of that particular stimulus is to up to a certain limit then the responses will start. So that particular point is called threshold. Now let us see so if this is like this now if I am giving stimulus here; here; here; here; here; here like this it is increasing responses are increasing, but actually it is not giving a particular threshold. But all of a sudden maybe after this point you will see a sudden rise.

So, this particular point may be called as threshold point. Now, if this is the amount of stimulus we are considering for normal person as a variable, what happens when you are getting exposed to high amount of noise for a certain period of time? This threshold point actually shifts towards right. So, more amount of stimulus is required to get that response. That is called temporary threshold shift. So, exposure to high level of noise over a long period leads to temporary threshold shift. Why does it happen? It happens because of decreased sensitivity of the auditory sensory cell.

So, there is some amount of stimulus and then what happens continuously I am getting exposed? I become less sensitive to that particular amount. If I get more than that then only I am going to respond. If I get equal to that or less than that then I am not going to respond. That is called temporary threshold shift. So, understanding that is very important when we are talking about designing of that particular acoustic environment or that particular workplace.

If we understand the kind of noise or sounds that are available and then how that is impacting on your sensitivity of hearing, then we can design, redesign or modify the particular source or the layout or the position. That way we can actually reverse those impacts. Temporary threshold shift actuallyis reversible; if you give a proper rest it comes back to the normal.

So, if a person is getting exposed for 8 hours job and it is the person is getting sufficient rest from that particular kind of noise before he or she is coming back in the next day job and the auditory system is in the normal condition. Then that impact is less. When it is just after the shift maybe there is a hearing loss, but in the morning when he or she is back to the job it is normal again. But if this particular exposure is very high and it causes the degeneration of the hair cell. Hair cells are the receptor of sound and causes the neural transmission to understand that particular sound. If that damage happened to the hair cells then that is the permanent threshold shift.

A particular decibel is really not audible to that particular person because the hair cells or the whole auditory system became desensitized to that particular amount of sound. So, they or that worker or operator only can understand or sense the sound beyond that. That is called permanent threshold shift.

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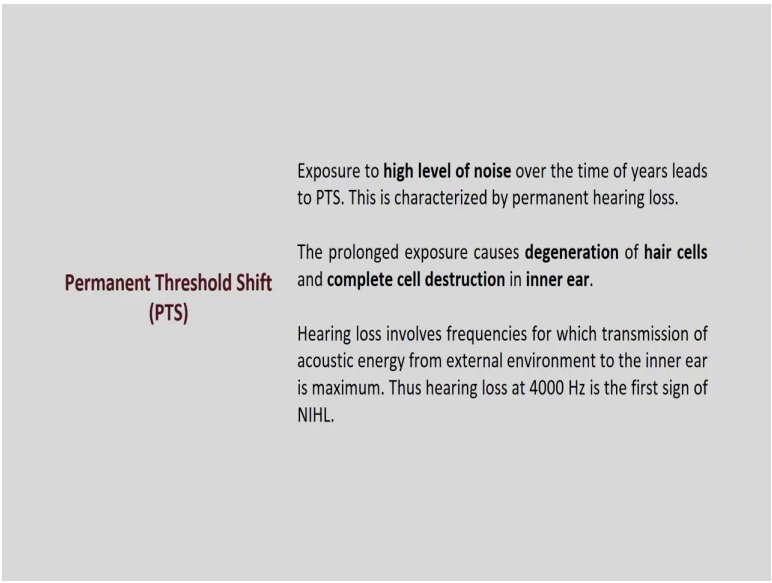

If it continues it can cause permanent damage to your hearing system and the person can become a deaf person.

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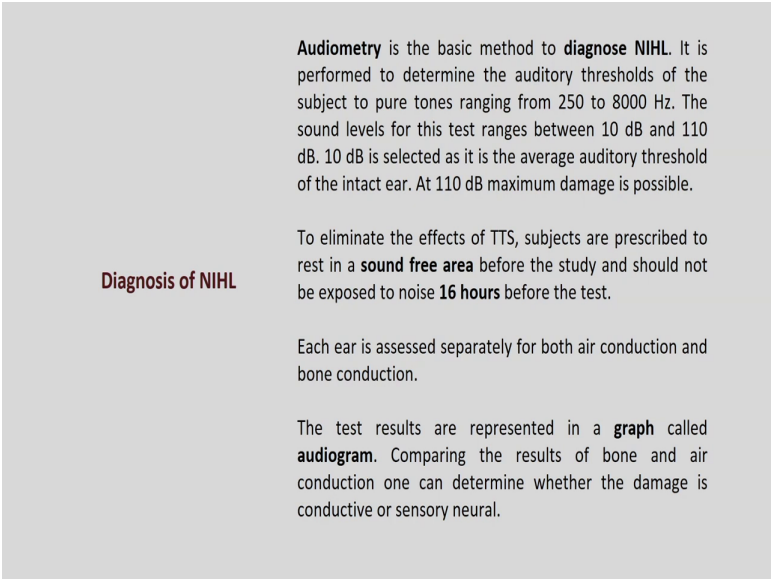

How we are going to diagnose these noise induced hearing loss is very important. Audiometry is a technique through which we are going to analyse or understand or diagnose the noise induced hearing loss. Here it is important to understand that we are going to expose the person or subject or the particular operator to a pure tone which is ranging from 250 to 800 8000 Hertz and the sound levels for these test actually ranges between 10 decibel to 110 decibel. Now why 10 and why 110? 10 decibel is selected because it is the average auditory threshold for any intact ear and 110 decibel is the maximum damage that can be possible. So, 10 decibel to 110 decibel.

How to eliminate the effects of temporary threshold shift. If the person has a temporary threshold shift then this audiometry results will be different. What we supposed to do is that we have to keep or we to have to ask the particular subject or a person to take rest within a sound free area before we start that particular testing. Also we ask or we try to maintain that 16 hours before that particular test that particular person is kept in such a way that there is no noise exposure. That is very important.

Once we do the test, what we get? We get a graph to understand that how the threshold is there and how we are listening to that, then we call that particular graph as audiogram and from there we try to interpret how the results or auditory system is functioning there. Now here the bone and air conduction both we try to compare and we try to understand if that particular hearing loss is because of conductiveness or sensory. Based on the bone

conduction and the air conduction we try to understand these two aspect. This is why and how we do audiometry.

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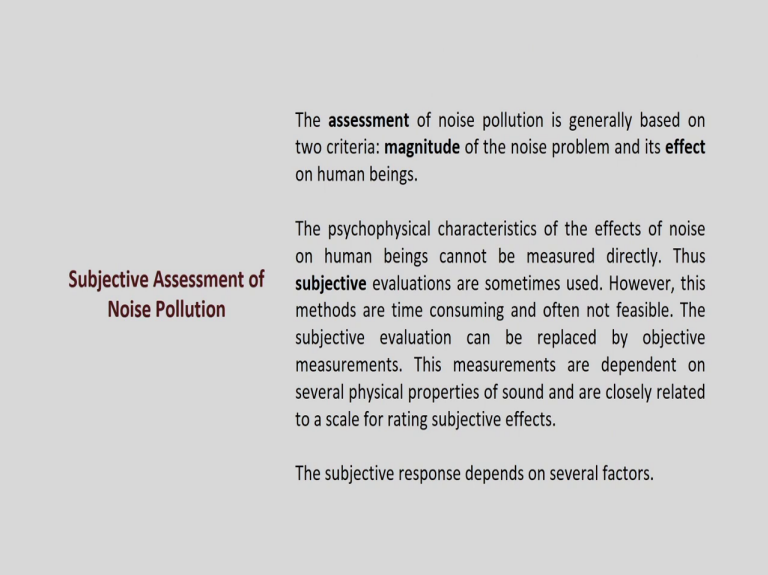

Now, apart from audiometry one important thing is that we need to understand the subjective assessment. Because a particular sound a particular noise can be perceived by a person differently the other person differently. So, subjective assessment is very very important. Magnitude of the noise problem and it is effect on the human being you can really measure using the instrument, but the subjective responses subjective understanding is very important. For that we have several small tools available which you can use and you can classify that.

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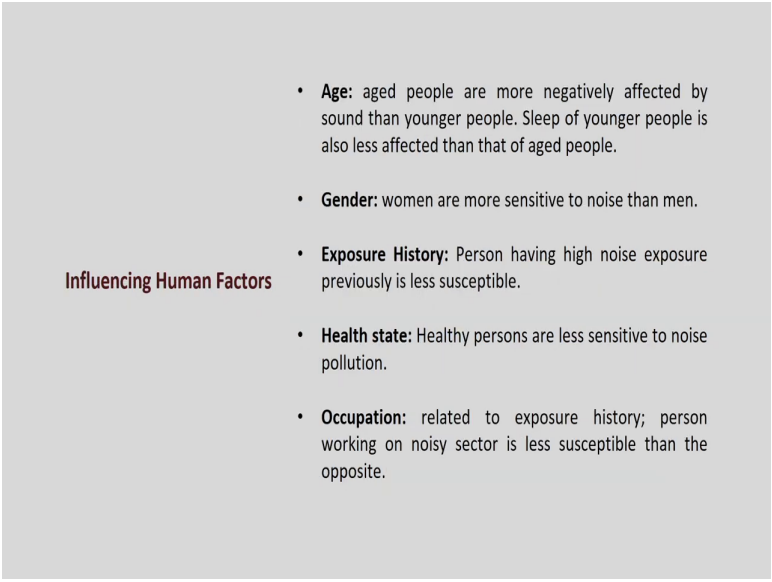

So, once we understood all these aspect we need to know is it the absolute one or is there any impact of other factors on understanding or on this particular auditory system how the impact is happening, is there any other influencing factor are present or not. Yes, there are lot of influencing factors. Few are personal, few are organisational. Age, gender if you have some a prior exposure history for a particular noise, the kind of health status like you know how physiologically you are strong right now kind of occupation you are having, so all these are the influencing factors.

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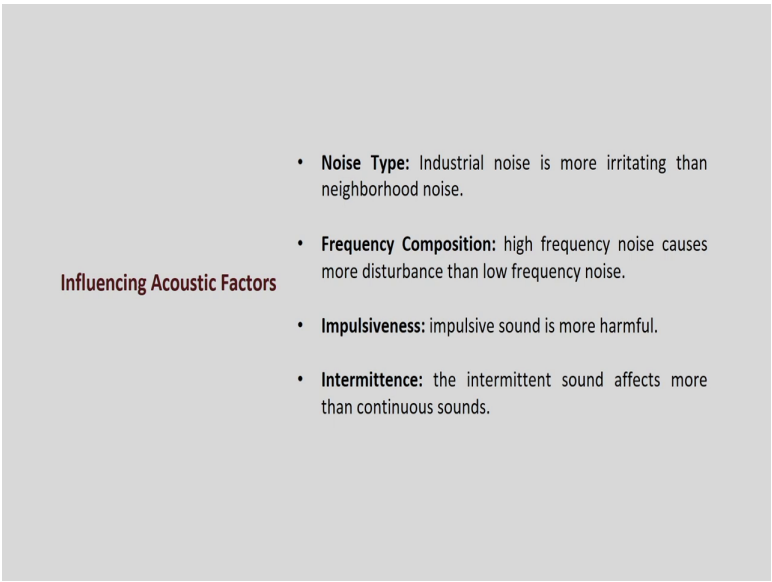

Now these all factors are related to human being. So, the particular person now there are some influencing factor which is related to acoustic environment. These are noise type frequency composition impulsiveness intermittence, fluctuation directivity, occurrence time, duration etc.

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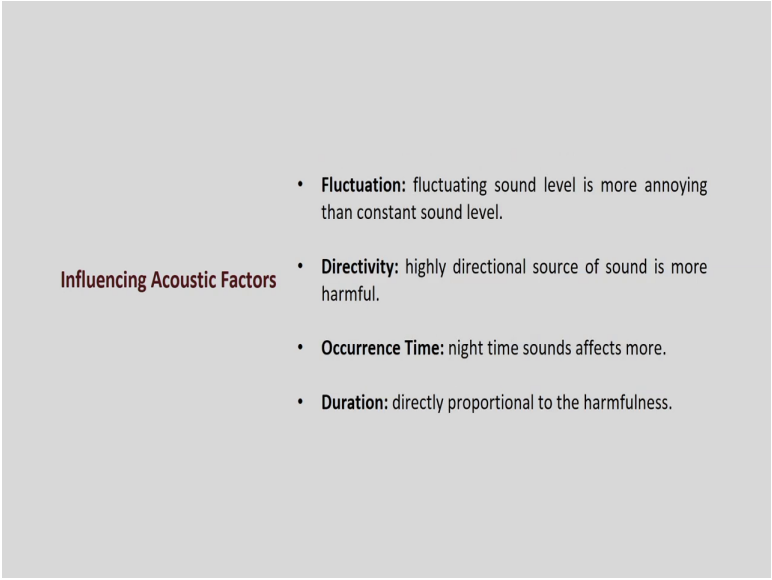

These are all acoustic environmental influencing factor. All these factor has different impact on the hearing loss as well as the whole exposure or whole experience and the impact on the productivity. It is very important to measure that.

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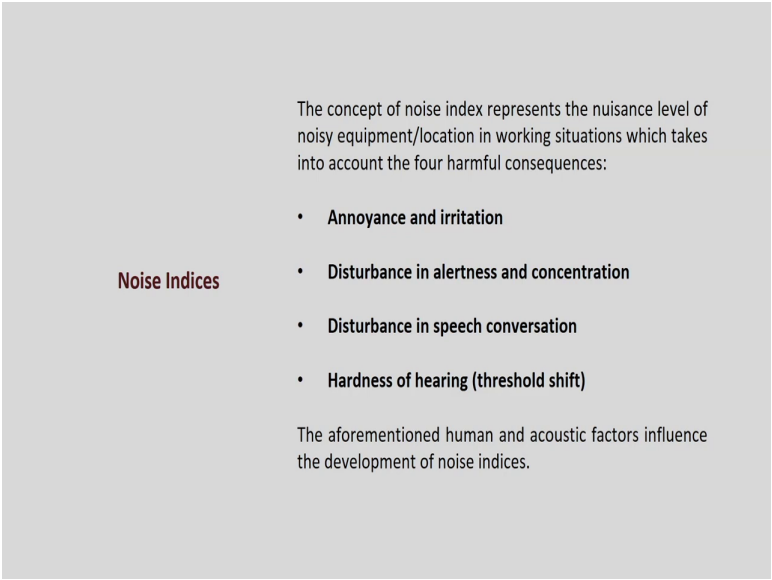

So, how you are going to measure it? There are various indices through that we actually measure it. The concept of noise index represent the nuisance level of any noisy equipment or particular location in a working situation which takes into account four harmful consequences. First one is annoyance or irritation. If there is a noise and I become so irritated, I am not in a position to concentrate and I am not going to give the kind of productivity I am supposed to deliver. Because of annoyance it is getting hampered; disturbances in alertness and concentration. I am not alert. So, I am not able to concentrate and I am not going to work properly.

Disturbances in speech conversation. Suppose two persons are interacting or somebody is delivering a lecture and there are a lot of noise coming from different sources. The person has an impact on the speech conversation how he or she is talking maybe the wordings are getting changed. The way he or she you know ready to deliver that lecture or communication will get hampered or it will has very adverse effect.

Also the kind of threshold shift that we discussed earlier may be temporary or maybe permanent depending on the type of noise and type of exposure this things will be coming.

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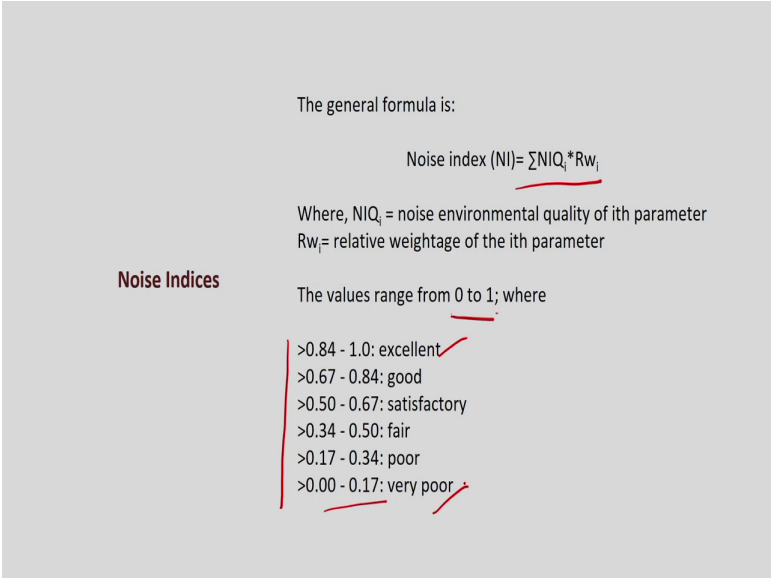

So, these are the major impacts. When we are talking about noise index this is the formula we are going to use and this is the ratings available it is from 0 to 1; whatever we are getting the value if it is 0.84 0.1 then we will say excellent whereas, 0 to 0.17 will

be calling that as a poor. If the indices are on the lower side towards 0, then that means the condition is not good.

After measuring the values let us calculate this particular thing that is the noise index and compare that with this existing values and then understand how your acoustic environment is. So, that is a very important variable that you can use along with your subjective responses to tell about the acoustic environment where you are going to work.

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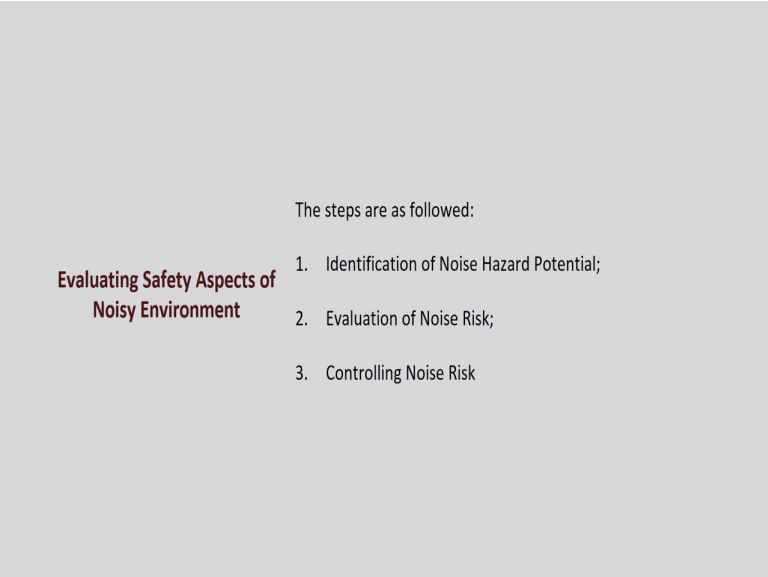

So, when we understood all this like you know indices the kind of threshold shift and all those things, let us understand the safety aspect of any noisy environment how we are going to evaluate that. There are major three steps we try to follow: first we try to identify. Identification of noise hazard potential like where the noise is how the noise is all those thing. Then try to evaluate the noise risk how risky that is and then control it. First you identify where it is, how it is then you identify what is the kind of risk we have and then you control it.

This is the way how we talk about acoustic environment impact and how that we are going to concern or consider for health and safety issues of a particular worker in a particular work place. Let us take one by one.

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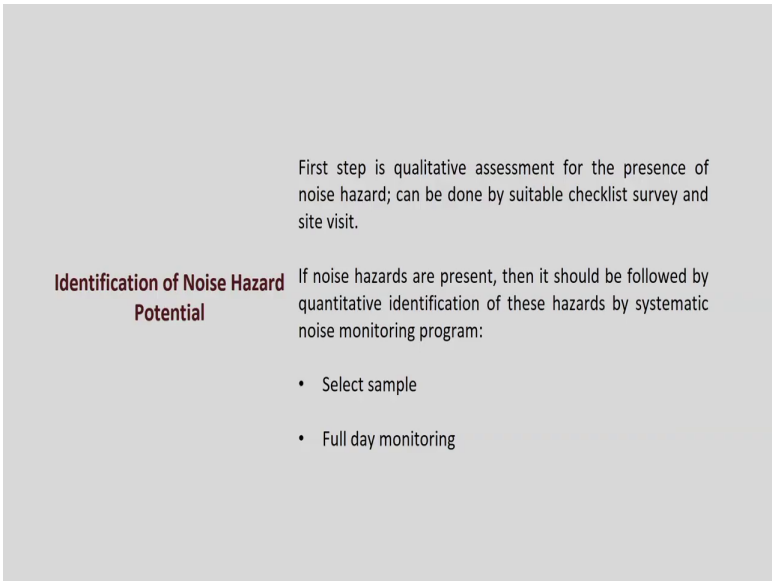

So, identification of noise hazard potential. So, what we supposed to do is a qualitative assessment for the presence of noise hazard and it can be done by suitable checklist survey and definitely direct visit. So, you select a particular sample that where you are going to what is your area of monitoring or what is the location. Select that particular sample and you do a full day monitoring of the different parameters. So, how we are going to monitor the noise?

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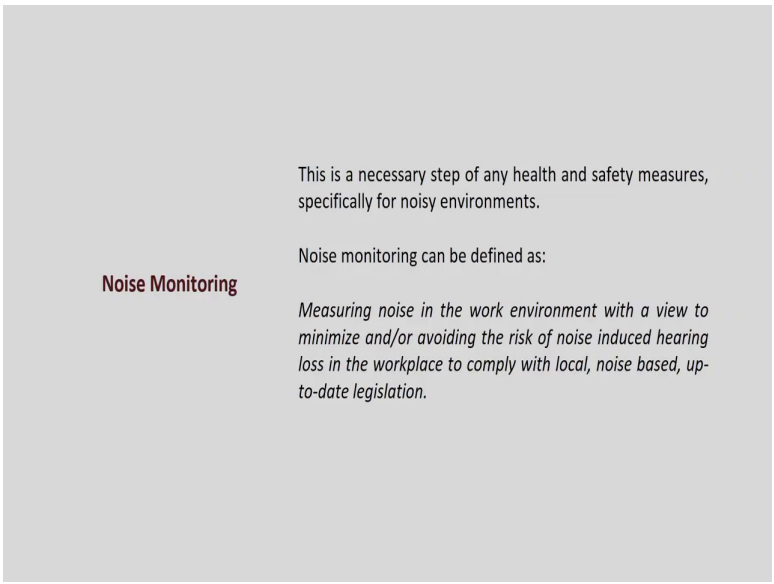

This is a necessary step of any health and safety measure especially for noisy environment. Measuring noise in a work environment with a view to minimise or avoiding the risk of noise induced hearing loss in the workplace to comply with local noise based up to date legislation. So that is why we actually do noise monitoring and this is the definition that we are going to follow whenever we do noise monitoring.

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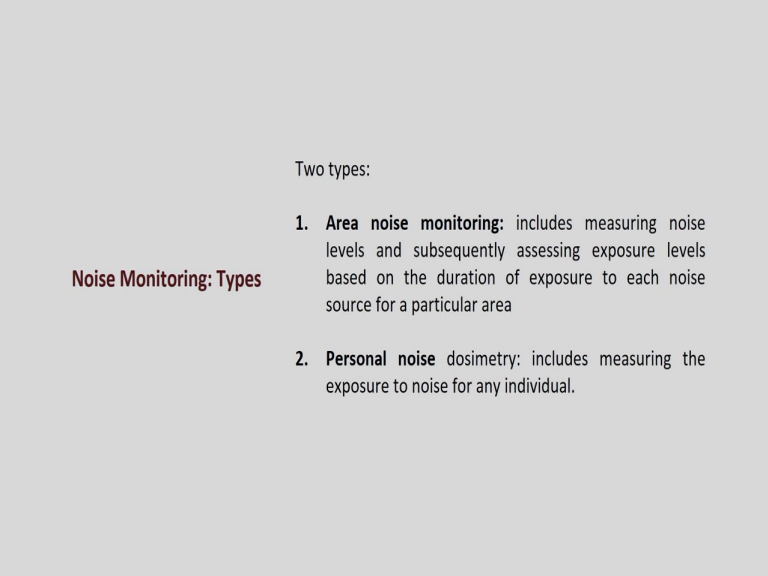

So, there are two types of noise monitoring one is area noise monitoring and other is personal noise. So, by nomenclature itself you do understand area noise monitoring means you are trying to understand in the whole area of the work.

If this is the classroom, in the whole classroom how the noise level is what are the sources are how it is getting propagated and all those things. That we are calling as area noise monitoring. Whereas, personal noise is mainly personal noise dosimetry and it includes the measuring the exposure to noise for only an individual. One by one we are going to do it. Each operator has noise dosimetry and were going to measure the exposure level of only that particular person that is why we call it as personal noise.

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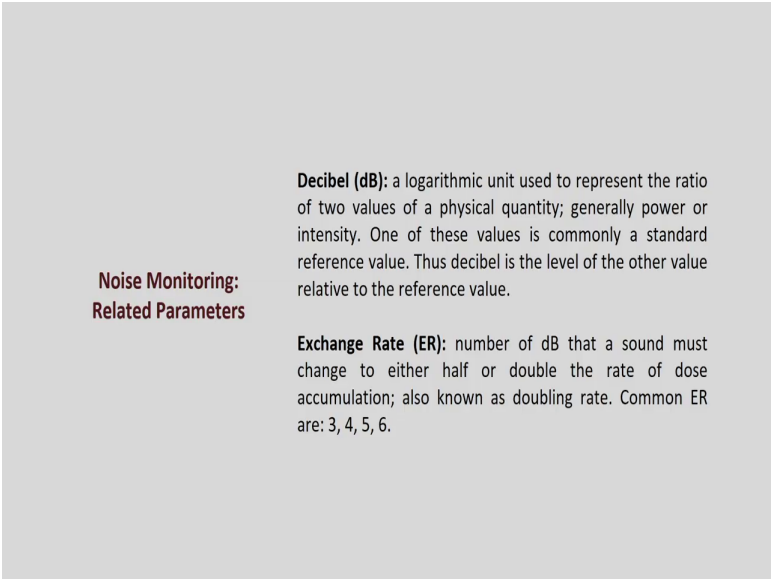

Now let us understand the related variables or parameter when we are going to measure them. A very important or known variable is decibel, other one is exchange rate. So, what is decibel? It has a particular definition we follow. It says that it is a logarithmic unit used to represent the ratio of two values of physical quantity generally power or intensity.

So, one of these value is commonly a standard reference value. thus decibel is the level of other value relative to the reference value. So, that is the definition we follow. Same we have for the exchange rate. What does it say? Number of decibel that a sound must exchange to either half or double the rate of those accumulation. Also we call it as doubling rate and these are the common ER available and we try to we normally use it.

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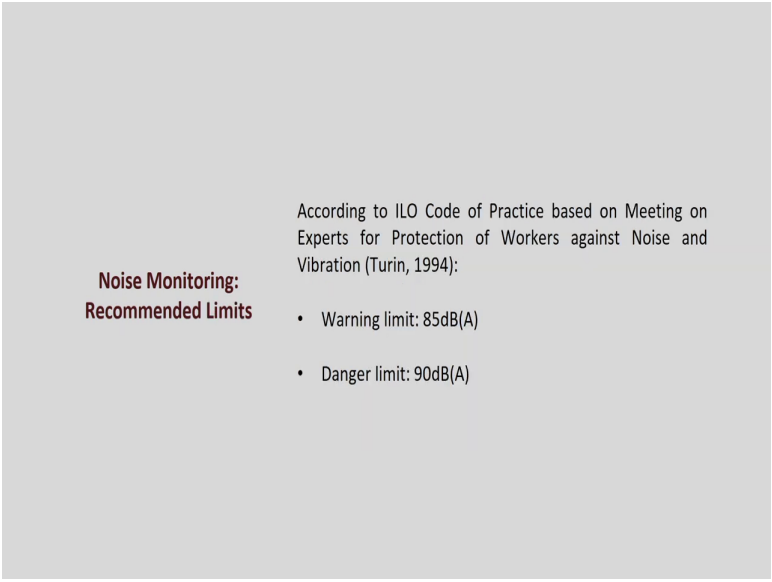

So, when we are talking about noise monitoring we know this particular value very nicely right. Almost of a I think everybody knows 85 decibel. Also this thing a weighted and this is defined like it is recommended by the ILO and it says this is 85 decibel is warning limit. Whereas, 90 decibel is the danger limit, but it is A weighted so you have to remember this.

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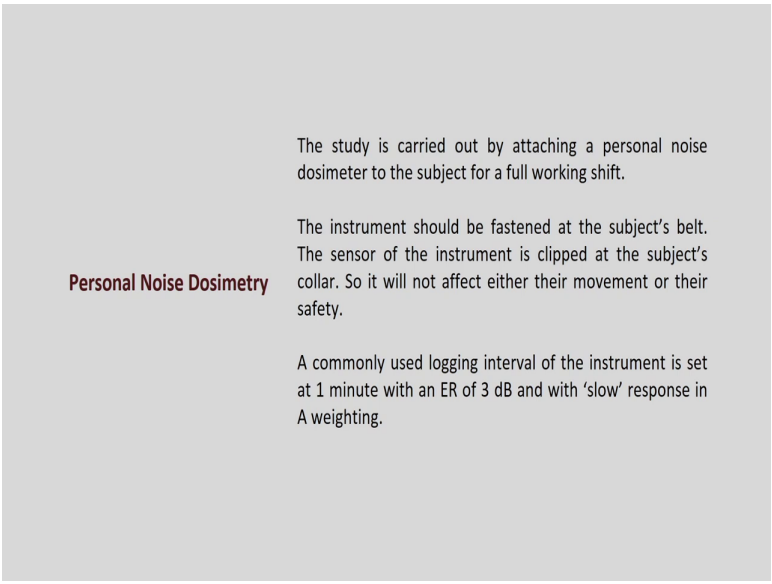

Now, let us understand what this personal noise dosimetry is. So, when we are talking about a personal noise dosimetry what we try to do is that we have a small dosimeter. It

is a sensor. What we try to do is we put that sensor or we clip that in the collar of any particular worker, because then we understand what kind of noise level we have at the ear level. We put it here on the collar whereas the whole system we plug it with the belt.

Whenever they are working we try to capture the data. It is mainly battery operated. So, it keeps on working or login those data according to the requirement and we keep that particular worker free to do the job. Whenever they are going to the near to the machine or going coming back or working in the whole 8 hours shift or maybe whole day job we get those value how much is the exposure level. That is the way we do the personal noise dosimetry.

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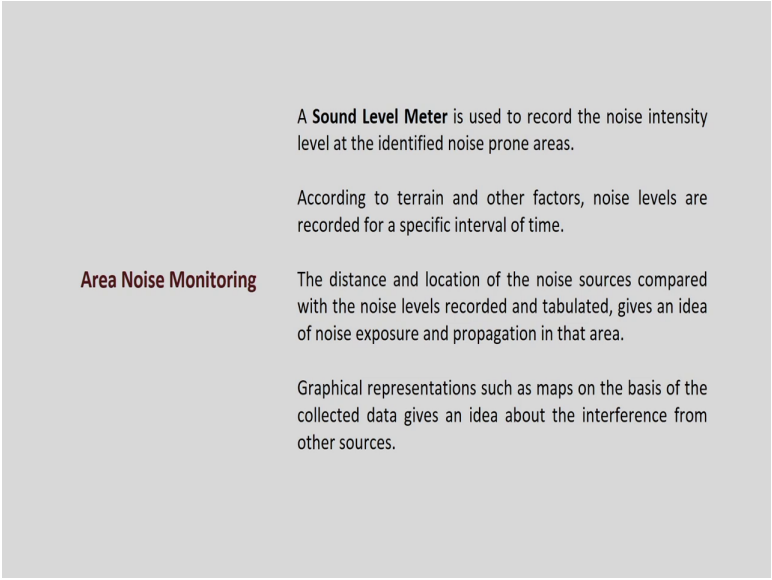

That is very easy and important measurement whenever we are talking about acoustic environment and impact of it on the performance. The second one is the area noise monitoring the same way like as I explained by nomenclature it talks about the whole area. Here the name of the instrument is sound level metre and what we try to understand the source of noise and how the whole area is noisy.

So, we try to understand different location different position and how that is impacting on the human being. What we finally, do is a graphical representation of that particular map like source how it is going. So, that we do it and then finally, based on our understanding how the propagation is and all those thing we try to give the interpretation of it.

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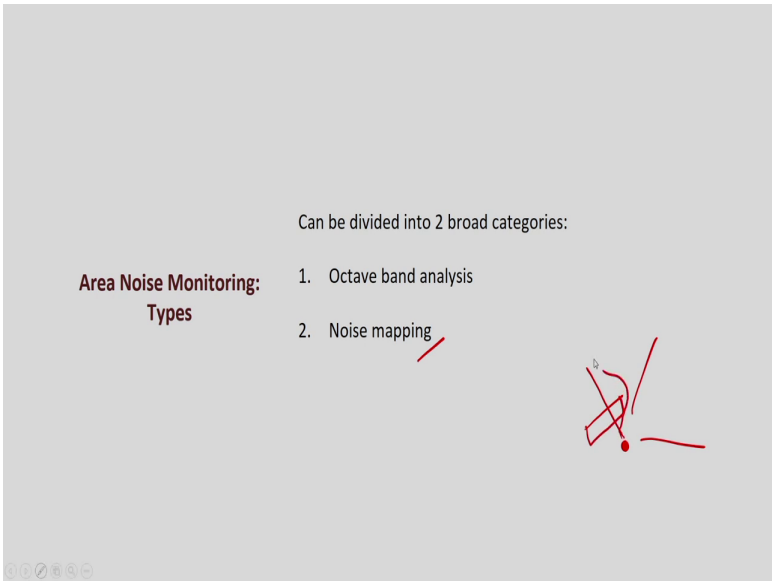

When we are talking about area noise monitoring there are two major categories: one is octave band analysis another is noise mapping. As far as this noise mapping is concerned it is a very recent technique and we have lot of new software's available through which we actually can perform.

See how the noise map looks like no if this is the source and how suppose this is the source of noise and how these noise is propagating. Those things if there is a barrier maybe big barrier. How noise is actually travelling all these detail we will be getting when we are talking about noise mapping. So, let us understand what is octave band analysis and what is noise mapping?

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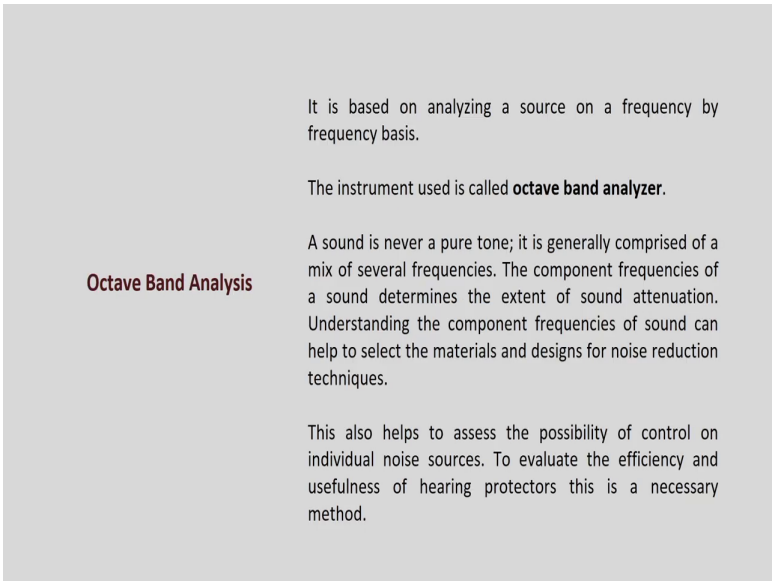

In octave band analysis it is basically is analysing a source on a frequency by frequency basis. So, the instrument used for this particular method or process we call it as octave band analyser.

Of course, a sound is never a pure tone. It is generally comprised of several frequencies. What it tries to do is that the component of those frequencies of sound determine the kind of extend. So, understanding the those component frequencies of sound which can help to select the materials and design for the noise reduction technique. We understand those frequencies and which frequency is causing problem and finally, we do the changes.

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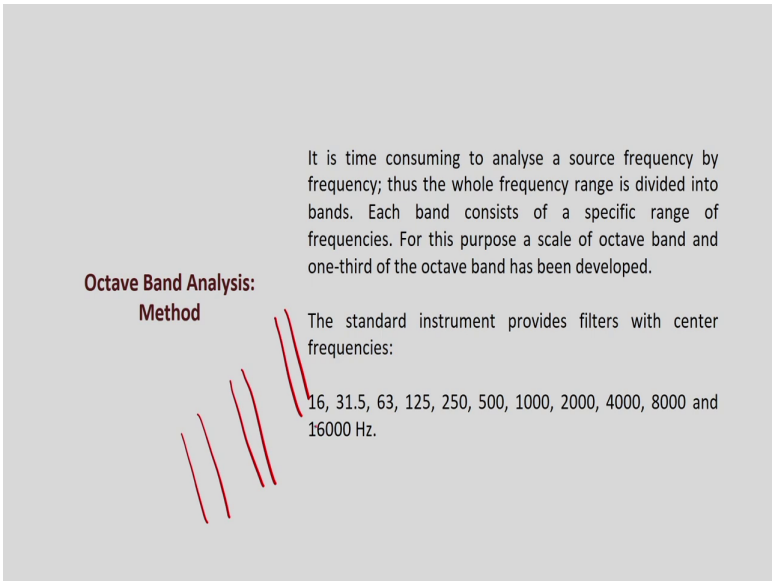

What is the method of it? It is very time consuming method and what it does is that the whole frequency range is divided into bands like you know small bands we divide it.

So, like that we divide it and for this particular purpose a scale of octave band and one third of the octave band normally we try to use and that as I mentioned that octave band analyser they normally follow these Hertz. So, these are the bands they are actually following. Based on these bands they try to measure where how the noise is spread over in a particular location.

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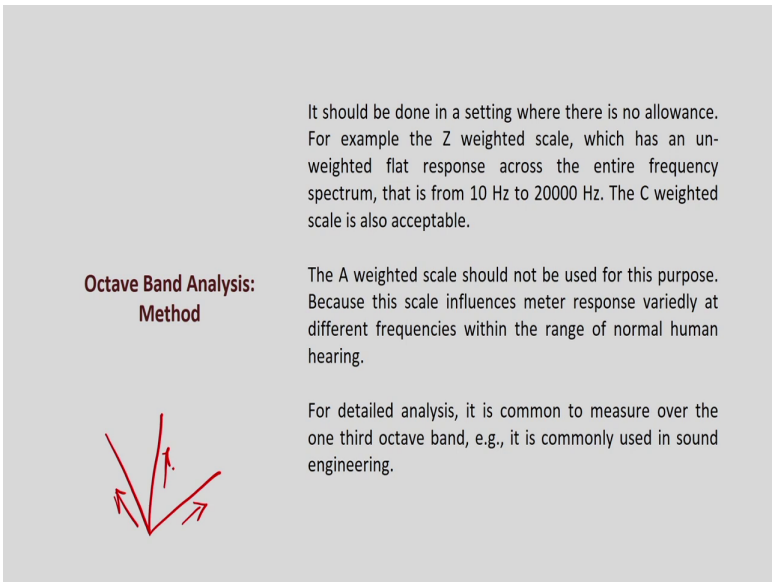

Also we try to understand that you know there is no allowance. For example like when we are talking about weight Z weighted scale. So, see it is three dimensional right. So, x axis y axis and z axis. So, sound or noise propagate on all three direction. So, when we are talking about all these that Z weighted scale that we have like this particular axis, which has an un weighted flat responses across the entire frequency spectrum that which we consider from 10 Hertz to 20000 Hertz.

And for detailed analysis it is very important to measure over the one third of the octave band not the full octave band. What we mentioned here that normally we have octave band or one third of the octave band. So, for detailed analysis we use that one third octave band.

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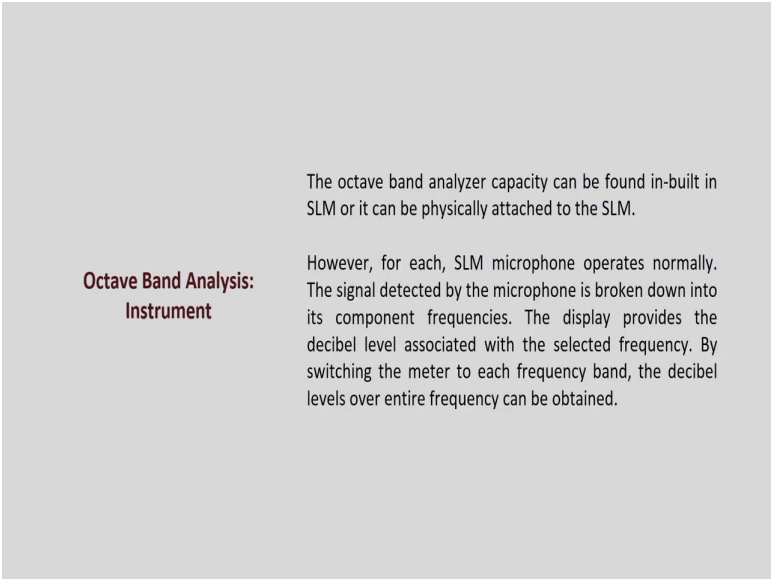

So, it is a sound level metre we normally use. Physically we attach it for this purpose. This sound level metre a microphone operates we normally operates and the signal detected by the microphone is going to be broken down into the component of frequencies and the display provides the decibel level associated with the selected frequency. So, by switching the metre to each frequency band the decibel levels over entire frequency we can determine or obtain. So, this is the way how we are going to use or measure the octave band.

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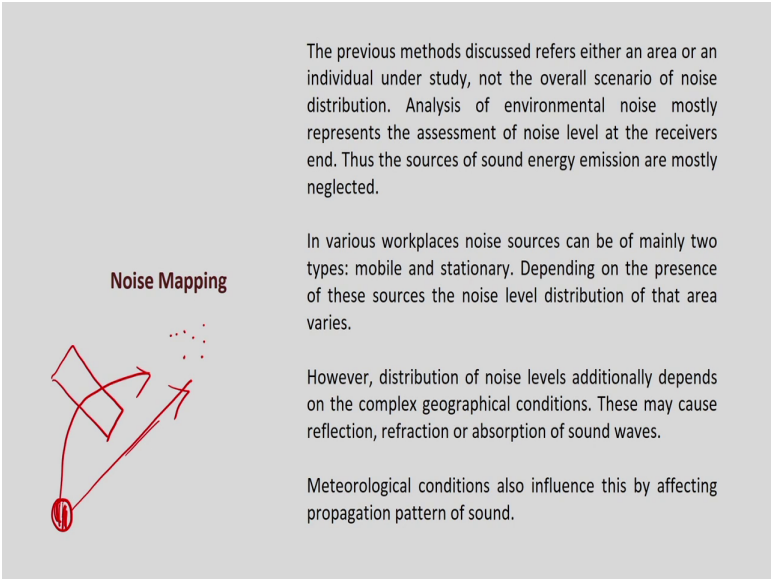

Now, let us understand the Noise Mapping, it is very recent technique. Now a days lot of industry especially mining industry and those people are working in the urbanization, then try to understand the positioning of the industry in a particular city or specially this what we call it modern city. So, those architects actually follow the noise mapping to create to un to cater that how where this industry should be and where the normal population like you know civil population should be located. Where residential building should be and how it should be arranged. So, all these things are mainly based on the noise mapping technique.

Now take a example of shop floor design. If there is a noisy machine so how the workers should be located. So, that it has least impact of that particular noise on the human ear. How these are we are going to do is only the after we measure the noise mapping.

It says that the octave band analysis refers either the area or any individual under that particular site study. But in this particular case we talk about the overall scenario or noise distribution rather. Analysis of environmental noise mostly represent the assessment of noise level at receivers end. At my end if there is a noise source how it is going to impact to me, how it is coming to me, how it is travelling towards me.

In various workplaces noise sources can be of mainly two types one is mobile or stationary. Now what is this mobile? Suppose in mine one driller is there. So, it is drilling it is moving towards some other source again it is drilling, but noise same kind of

noise it is generating right but it is moving. It is moving where as some instruments are there which is stationary it is throughout year is in the same place. This distribution of noise level additionally depends on the complex geographical condition. Now take example if this is the noise source this is the source of noise and workers are working here, so these are the location of receiver.

Now here one natural barrier is there maybe mountain maybe deep forest; but here it is open space this space is open. When noise will come here the propagation will be different than through here. It will come, but the speed of propagation the nature of propagation will be different. In noise mapping we are going to visualise it, we are going to understand that and accordingly we will be relocating these people.

We will be creating their workplace in such a way that exposure level is least or as much as possible we will reduce it. So, distribution of noise level additionally depends on various complex geographical condition, what we are trying to explain over here.

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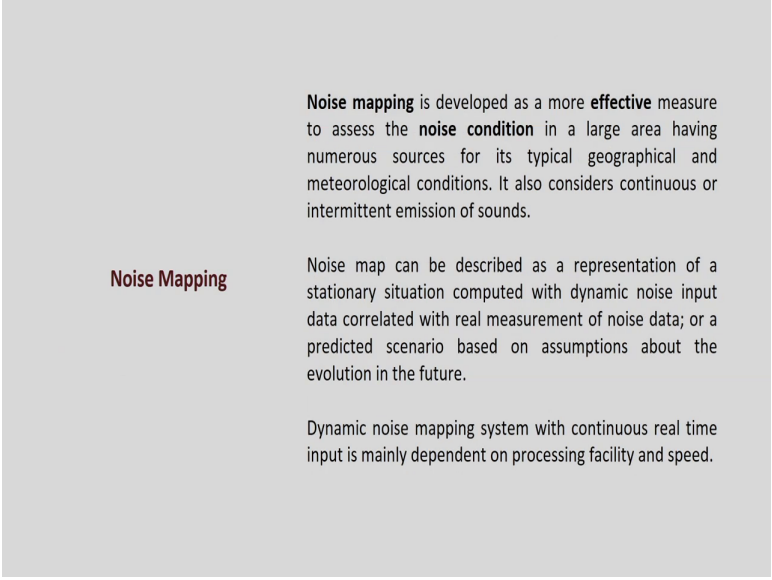

Noise mapping is developed as a more effective measure to assess the noise condition, in a large area having numerous sources of it is typical geographical and meteorological condition. If humidity is less, humidity is different, temperature is less radiant is different. All this actually affect the whole propagation pathway right speed of propagation.

We are going to monitor or measure through or understand through noise mapping. So, dynamic noise mapping system with continuous real time input is mainly dependent on processing facility and definitely speed.

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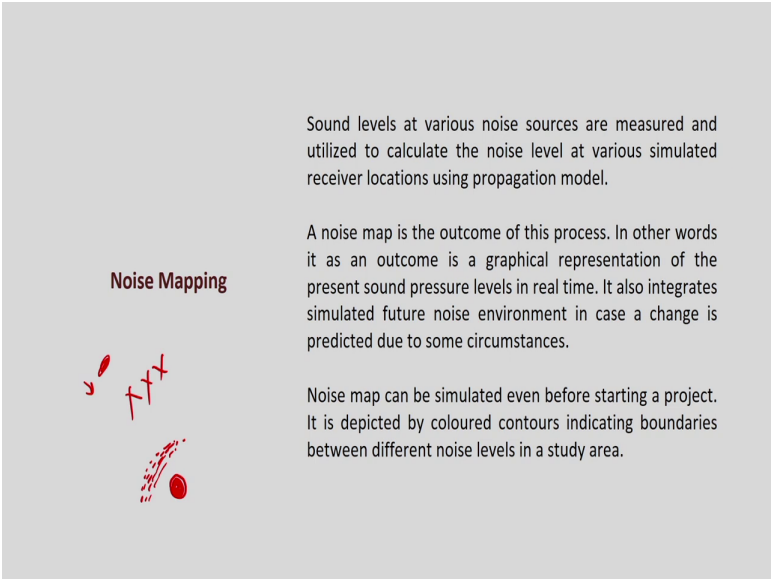

Sound level at various noise sources are measured and utilised to calculate the noise level at various simulated receiver location using propagation model. Once we do all these noise map is the outcome of it. Once we are done with that we get a noise map and we understand once we see a particular noise map. I do not have any photography or you can check any photograph or any kind of noise map from different sources you see different colours location. Suppose, if this is the source of noise you will get all heat area like which are have lot of impact.

If you have this is near to this probably you will a get heat area, slowly that concentration and density will reduce as per the distance will increase also if there is some obstruction. If there is some obstruction here the heat will reduce the density or the concentration will reduce, so colour will change of that particular map. So, there are different indication and mainly heat we defined by a red and slowly we go for different other colours and blue we try to prefer for cool like you know less amount of noise. So, that way we actually map the whole area.

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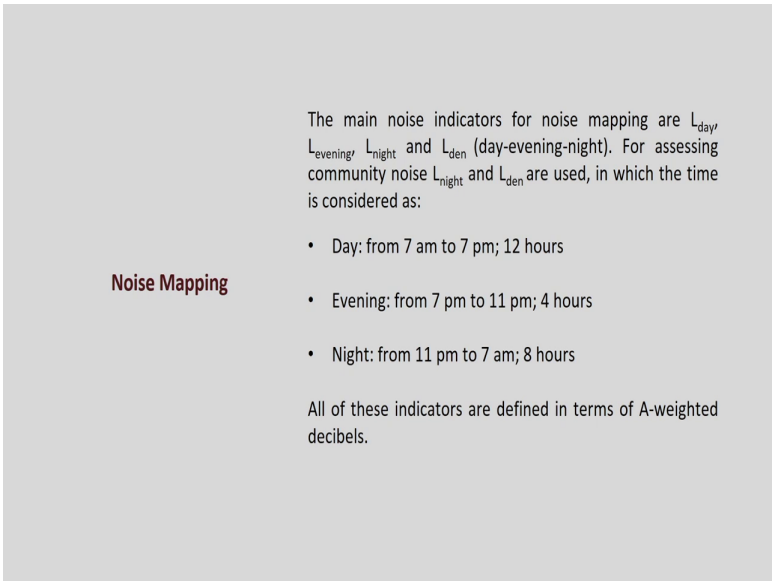

These are the variables we try to a measure: L day, L evening, L night, L den and this is the you know definition when we try to measuring. So, these are the timing we try to follow when we are talking about a weighted decibels.

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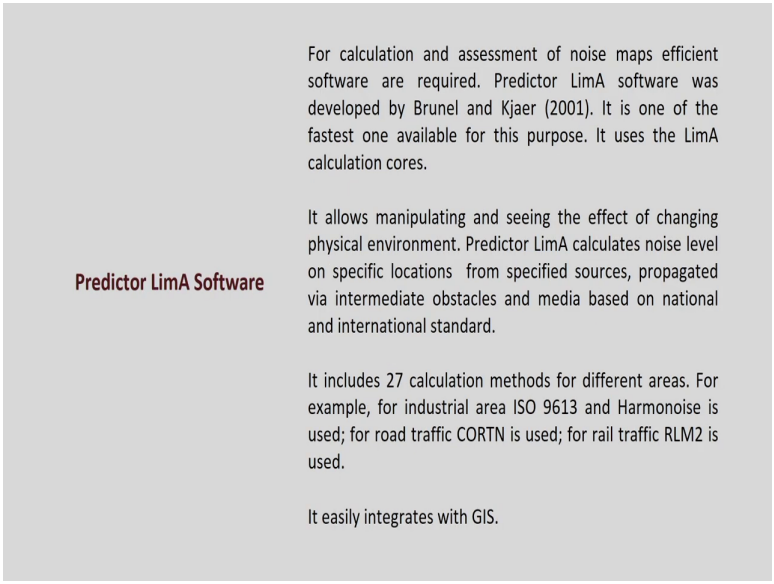

I will tell about only one software which is now-a-days is very famous and popularly used. That is the predictor Lima software. I do not have that in our in my lab right now, but I used it some other time. If you get a chance to see that or use that it will be very useful software for noise mapping. So, it is very recent it is 2001 Brunel and Kjaer they

develop this one. We really can understand how the propagation is happening using this predictor Lima software.

It is a very very important tool if somebody is working in the field of noise it is impact in and surrounding design consideration. Also it is integrated with GIS which is very very important. So, you actually get to know the different geographical locations and you know how the natural barriers or builders are there. How the propagation will happen and how civilization can be reoriented. So, that is a very important concept. We approximately covered all the aspects of how we are going to identify the potential noise hazards.

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Now, let us understand or evaluate the noise risk.

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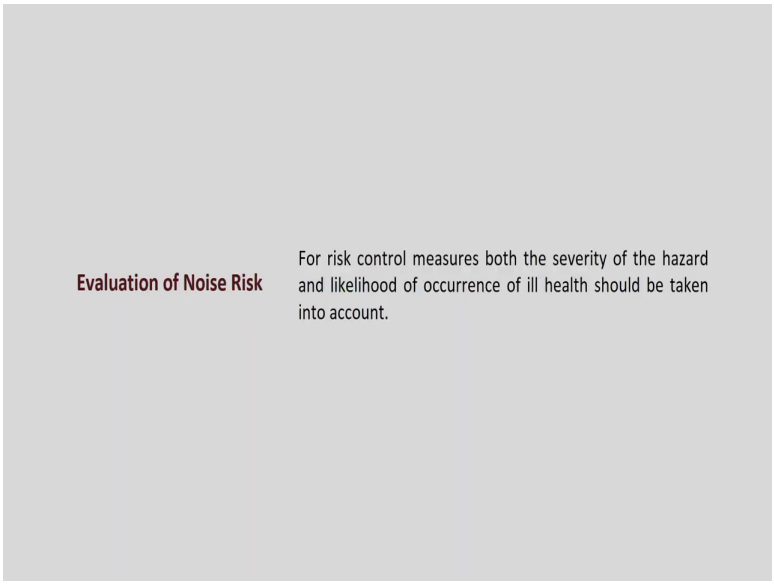

For risk control measure both the severity of the hazard and likelihood occurrence of the ill health should be taken into account.

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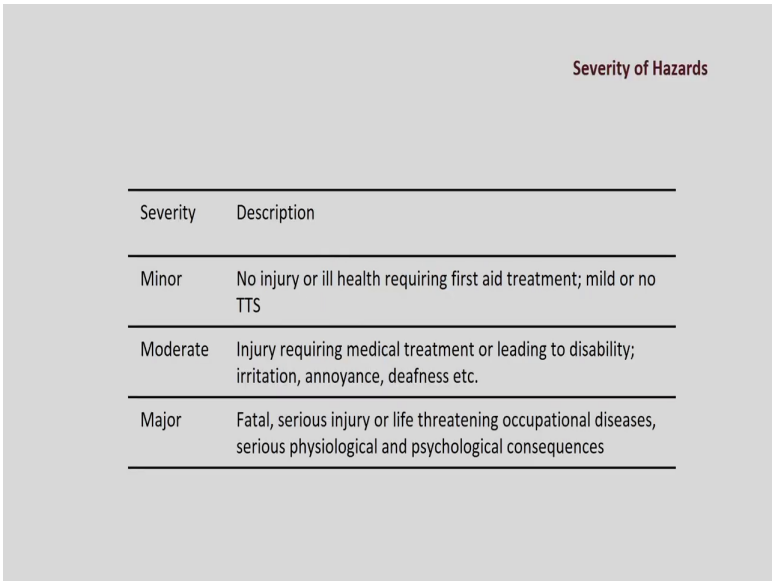

If we are talking about Severity, it is: Minor Moderate and Major and we have these very specified definition so you can follow this.

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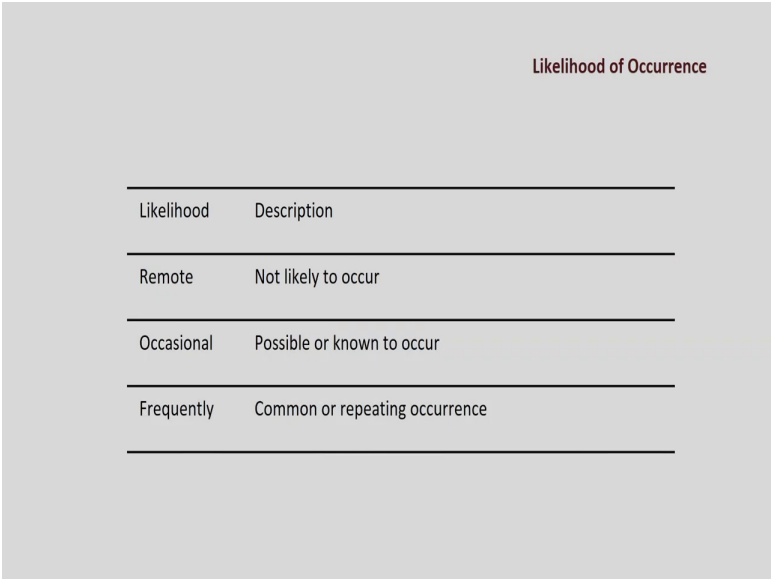

Whereas, likelihood to occurrence of different chances. So, in that case we have remote occasional and frequency and we have the definition of a description of all these three factor. Now let us make a matrix of out of these six variable three from likelihood of occurrence and three from the severity.

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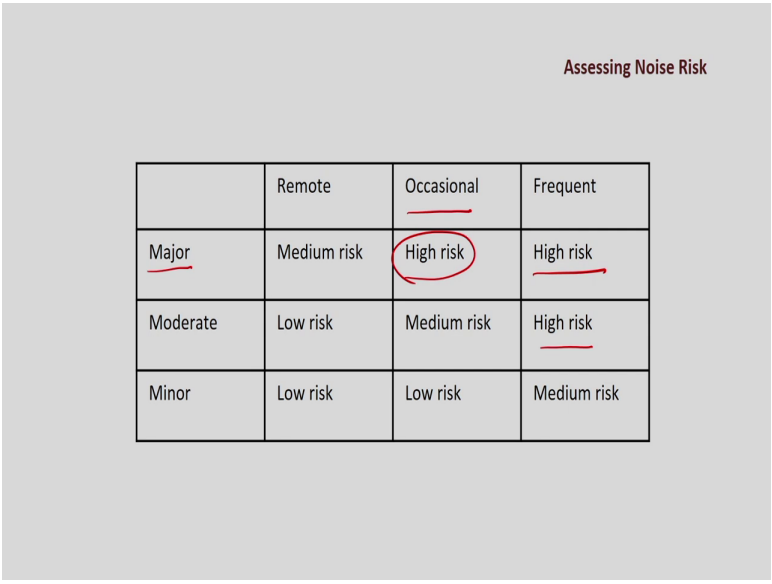

If we make this type of matrix you will come to know what are the location or what are the combinations if available in a particular area or particular occupational setup and we are going to get the high risk from the noise related exposure.

If occasional is likelihood, whereas it is major severity is measured then we are going to get high risk. Whereas others are medium risk and these three are low risk. So, whenever we are going to design our whole system, what is our goal? If anything is there in high risk try to move that particular point from here to here or here or somewhere here. So, after comparing this matrix for any acoustic environment we will justify your work, whether the intervention is correct or not. This is way how we are going to assess or evaluate our acoustic environment. Now let us understand the control measure.

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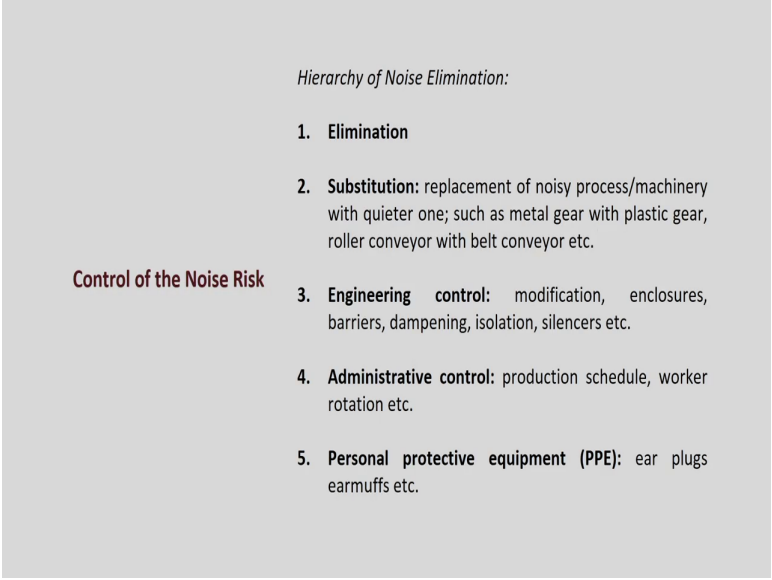

Whenever we are talking about controlling, first is to eliminate that particular noise. If it is possible you do it, but most of the cases it is not possible. Elimination is really not possible and very rarely we can really eliminate. What else what we can do is substitution: we can do something where less amount of noise is there. We can have some kind of engineering control. We can have some administrative control. Here very important is work rest cycle calculation. Also we can design personal protective equipment. Here is the designer really has a big role.

We design different different types of personal protective equipment for the context specific design. If it is at airport maybe plugs are different, if it is at industry plugs are different, if you are travelling plugs are different. Depending on the context depending on the situation and requirement you supposed to design a lot of personal protective equipment.

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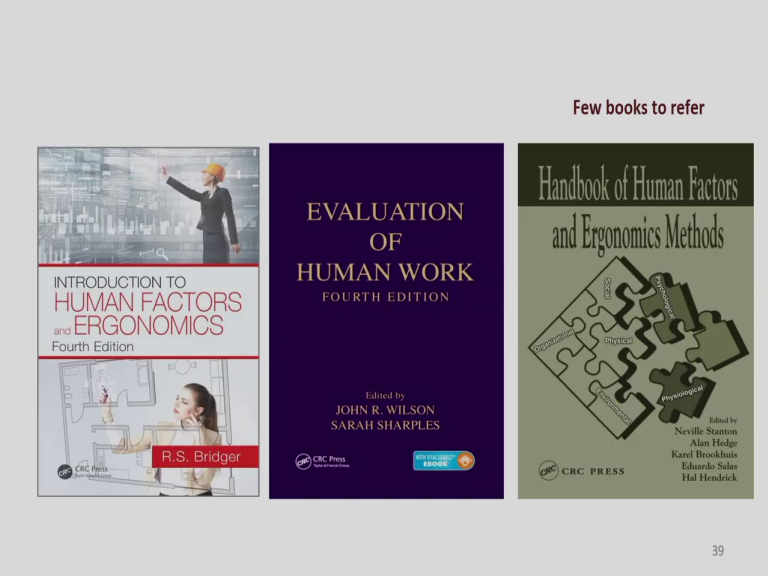

So, we came to the end of this today's class or today's presentation and these are the books I followed to gather all these information. So, I refer all these books for your further study.

So, maybe I do not know how far you will be able to access these instrument. But if you have some kind of raw data then try to analyse it try to predict or try to interpret your data in terms of acoustic environmental assessment tool and then try to give the design modification or any type of ergonomic intervention to improve the situation.

Thank you.