Human Factors Engineering

Prof. V. K. Tiwari
Prof. P. K. Ray
Department of Agriculture and Food Engineering
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Lecture - 41
Auditory Environment and Human Performance, Measurement of Sound and Noise Exposure, Numerical Problem

The entire the week in 5 lecture sessions, we will discuss the auditory environment related issues. We will be referring to ergonomic the design of auditory environment.

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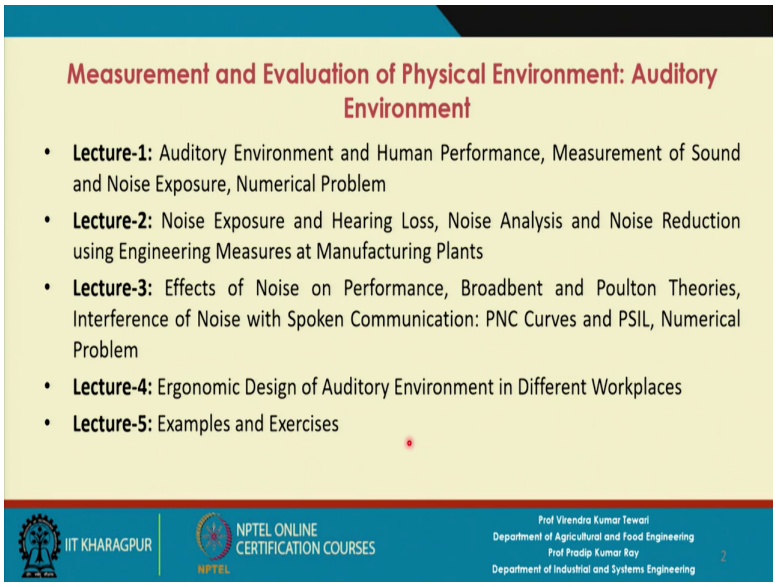

Now, there will be 5 lecture sessions and the next half an hour or so I will be discussing certain topics like say Auditory Environment and Human Performance, how these this these are related. If the auditory environment is very good, we assume that human performance also will be very good. Measurement of sound and noise exposure: how do you measure all these details we will discuss and we will also be referring to one numerical problem.

This will be the coverage of first lecture session. In the second lecture session we will discuss in detail the noise exposure and hearing loss. If suppose the quality of auditory environment is poor; obviously, there may be hearing loss and another important topic

we are going to discuss that is the noise analysis and noise reduction using engineering measures at manufacturing plants.

So, you will come to know what are the possible the preventive measures to improve the quality of auditory environment at a particular workplace. In the third lecture session we will discuss the effects of noise on human performance and there are two important theories related to this effect. One is proposed by Broadbent and the second one is proposed by Poulton.

Then if there is say interference of noise with spoken communication, you will face lot of problems and in this we discuss this important topic and related to this important topic we refer to the PNC curves and the second one is PSIL, that is why a rating scale basically a kind of rating systems.

And then we will conclude this session with a typical numerical problem. Lecture 4 and lecture 5 we will be referring to several other ergonomic design issues related to auditory environment or the different work places. There are varieties of work places and the 5th lecture we will be focusing on several examples and the exercises related to the measurement and evaluation of auditory environment.

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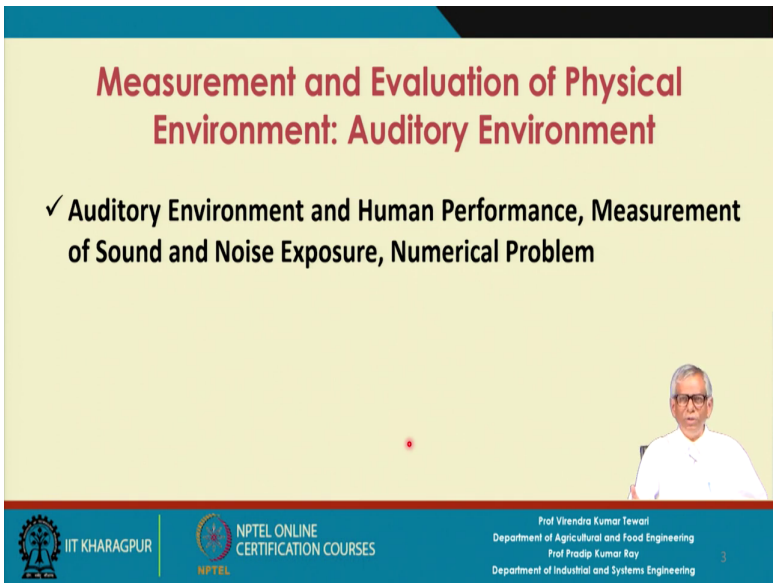

So, this will be our coverage. Now in the next say half an hour or so this time period let me just discuss two important issues. One is auditory environment and human

performance. Everybody knows that human if suppose the auditory environment is poor, suppose the environment is very noisy there are many such cases, in all likelihood the human performance will be affected. A person is working on the job and while he or she is working on the job, there could be different kinds of noises and if this noise level crosses the tolerance limit, then; obviously, you cannot concentrate on your job fully and your performance will be affected.

These aspects we are going to discuss and then the next important topic is that how do you measure the sound and there are two kinds of measures we have. One is you measure sound at instant of time at the sound level or sound pressure level and then another important aspect is seen in a noisy environment suppose you work for extended time period say two hours or three hours in noisy environment; that means, you are basically exposed to a noisy environment.

So, how do you measure its impact and how do measure these the noise exposures?

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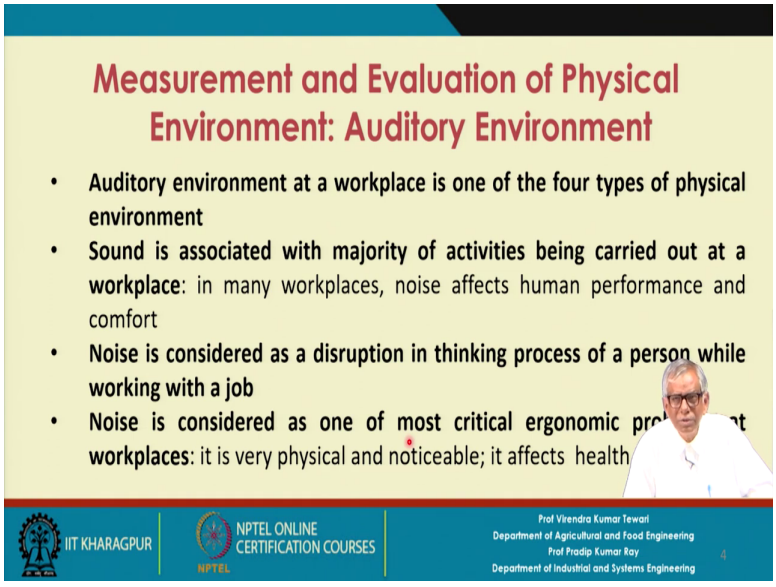

Now, there are certain remarks you find in this particular lecture presentation sheet. One is the auditory environment at a workplace; it is one of the four types of physical environment.

We have discussed the visual environment; we have also discussed the vibratory environment.

Now, we are discussing the auditory environment. How to design auditory environment which is considered to be a quality one? The sound is associated with majority of the activities. Whenever you carry out certain task, there will be some kind of sound.

Suppose it is a metal cutting operation, there will be sound at various levels. The majority of the activities while being carried out will create the sound. In many works places, noise affects human performance and comfort as a typical manufacturing plant having a forging shop forging machines obviously.

It will be very noisy, and with over exposure to this sound you will find that many operators have this problem of hearing loss- either temporary or the permanent, partial or total.

What are the preventive measures you should take so that the performance of the persons as well as the health or the or the comfort of the of the person while he or she is working with the job is assured? Noise is considered as a disruption in thinking process of a person while working with the job. In certain jobs it may not affect, but majority of the jobs. If it is a noisy place definitely it will affect your thinking process.

Noise is considered as one of the most critical ergonomic problems at work places. It is very physical and noticeable and it affects the health and comfort.

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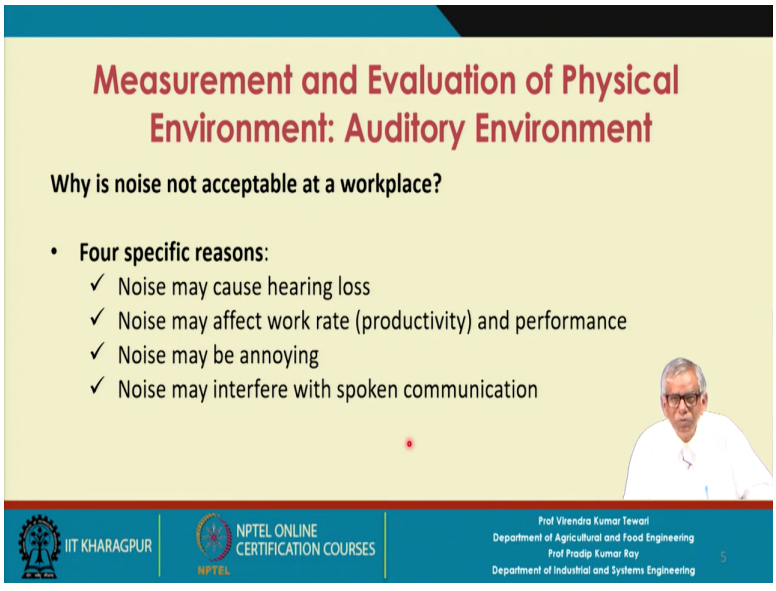

That is why what we must know that suppose at a particular place there is lot of complaints regarding this noise, the persons are complaining. Now, why do they complain? There are four specific reasons. The first one is noise can cause hearing loss.

Hearing loss could be partial or total, it could be temporary or it could be permanent. Second negative effect is the noise may affect work rate that is the productivity and performance. Noise may be very annoying.

The fourth reason is noise may interfere with spoken communication. How to create an auditory environment at a workplace in such a way that there is no interference with spoken communication right and between the speaker and the listener?

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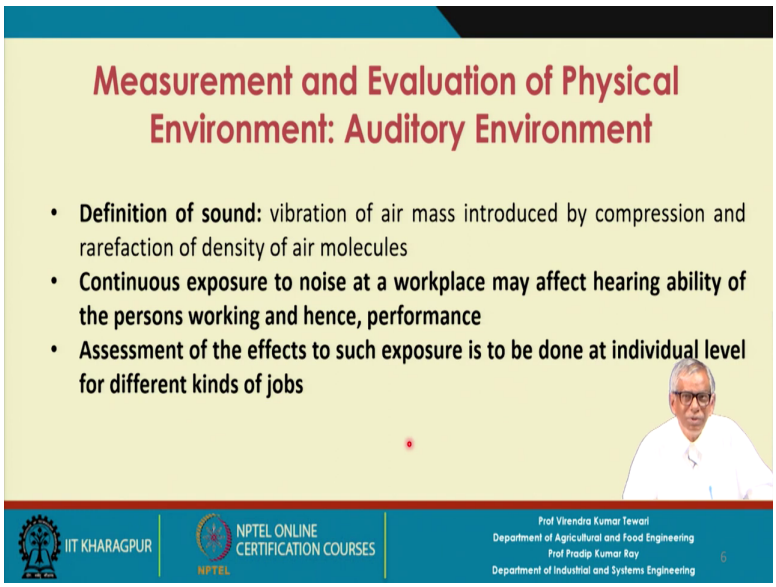

Now, many of you must be knowing the definition of sound, The sound is basically vibration of air mass introduced by compression and rarefaction of density of air molecules air molecules.

Continuous exposure to noise at a workplace, like the case of forging shop, might affect the ability hearing ability of the persons.

Hearing ability of the concerned persons will be affected and hence the performance also will be affected negatively. Assessment of the effects to such exposure is to be done at the individual level for different kinds of jobs, So, that is always we say that whenever you we go for ergonomic design; these designs must be applicable at the individual level.

There will be the differences in the tolerance level among individuals as well as there will be differences in hearing ability among the individuals. You have to create an auditory environment in such a way that it feeds to individual characteristics of the persons as far as hearing ability is concerned.

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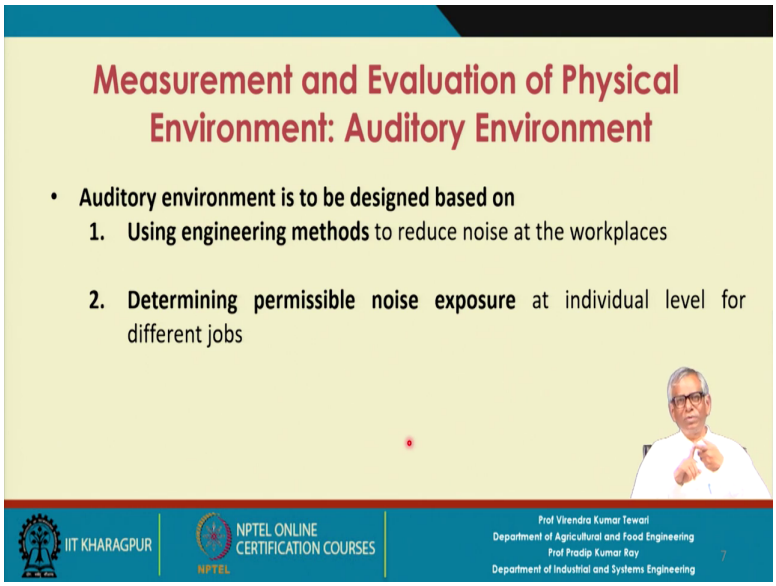

How do you design an auditory environment? First one is using engineering methods to reduce noise at the work places. There could be several such methods. Second one is that even if you have the best possible engineering methods implemented, it may so happen that the noise exposure may not be within the permissible level, So, you have to determine the permissible noise exposure at individual level for different jobs.

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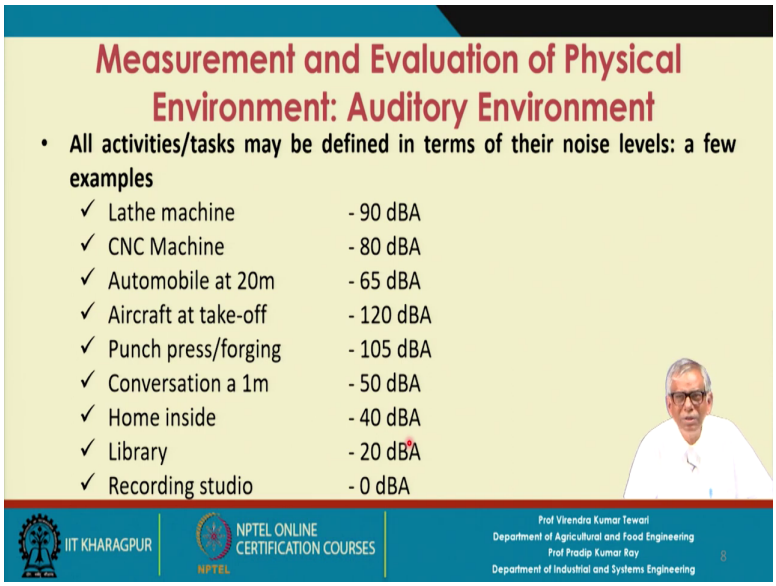

Measurement of the sound level plus the measurement of the noise exposure, its effect in terms of the noise.

For the typical lath machine, noise level is around 90 dBA. If you run a CNC machine the noise level is slightly reduced. It is 80 dBA. Similarly, automobile at 20-meter distance, you get a sound level of 65 dBA. Aircraft at takeoff is very noisy. Its touches 120-125 dBA. The punch press or the forging shop is as high as 105 dBA.

Conversation at 1 meter at a distance; it will be around 50 dBA. Home inside 40 dBA, library 20 dBA is a quiet place, and ultimately if it is a recording studio make sure that the sound level is at 0 dBA; that means, there is hardly any sound.

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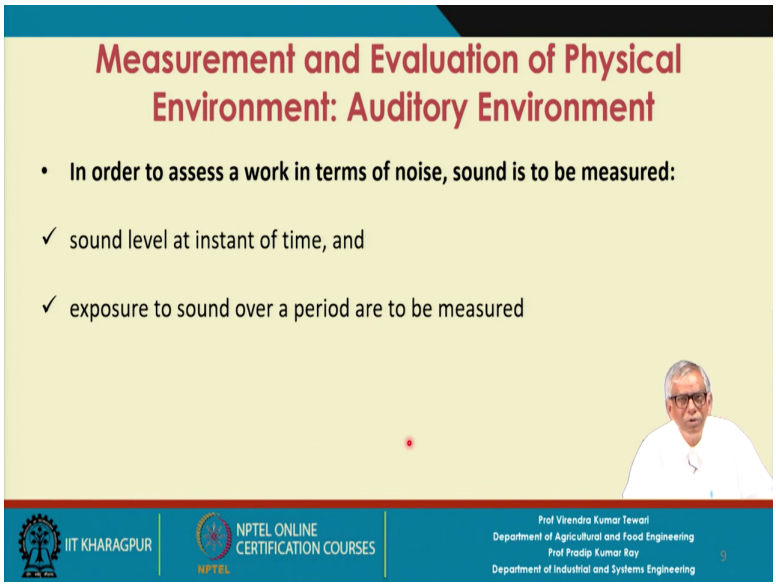

These are the standards you may assume. When you come across hundreds and thousands of jobs at different work places for different manufacturing plants, you have to set the standards for the sound level for all these jobs. Once these standards are known, it may help you in designing the best possible auditory environment at a workplace in order to assess a work in terms of noise sound is to be measured. Now the question is how do you measure the sound level at instant of time? What kind of instrument you should use and exposure to sound over a period are to be measured? There is noise exposure and the sound exposure.

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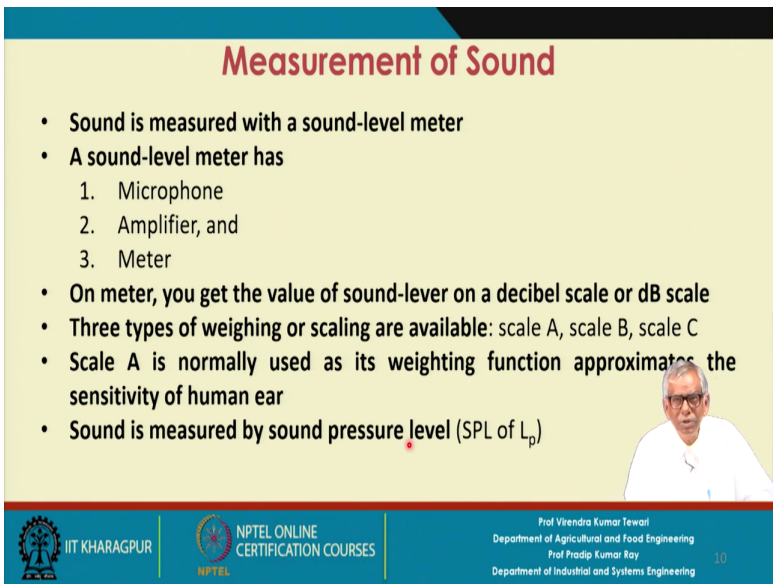

The sound is measured with a sound level meter. A sound level meter has three components. First one is the microphone, the second one is the amplifier and the third one is the meter.

On meter you get the value of sound level on a decibel scale or dB scale. In dB scale three types of weighing or scaling are available - scale A scale B and scale C.

Now out of these three scales, scale A is normally used as its weighting function approximates the sensitivity of human ear.

Sound is measured by sound pressure level SPL or L_p.

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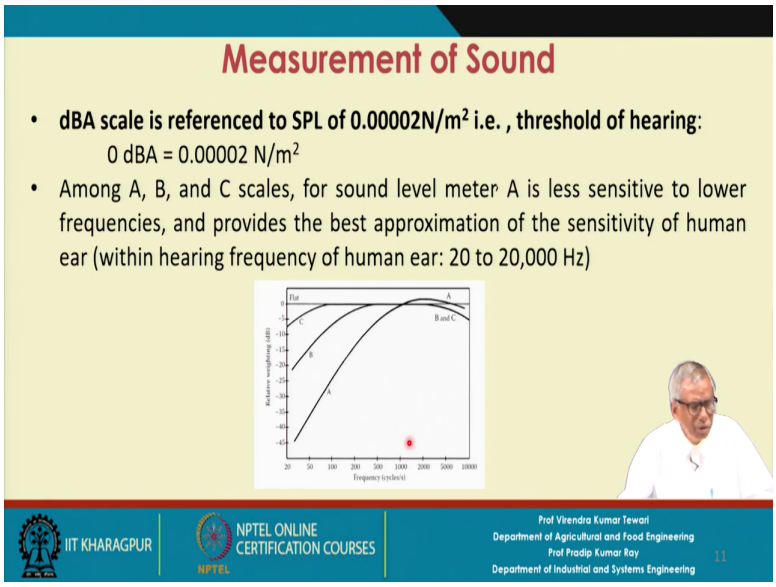

The reference value of dBA scale SPL is 0.00002 N/m^2, that is basically the threshold of hearing.

What is this threshold of hearing? It is considered 0 dBA, that is the reference point. Sound level meter A is less sensitive to lower frequencies and provides the best approximation to the sensitivity of human ear.

The hearing frequency zone for human ear is between approximately between 20 to 2000 hertz. A is not sensitive to low frequencies, it is sensitive to the human ear. Sound pressure level that is intensity will be there along with the frequency along with the exposure of sound.

These are the three the factors you need to consider while you design a workplace and keeping in mind that auditory environment is must match with the workplace the requirements.

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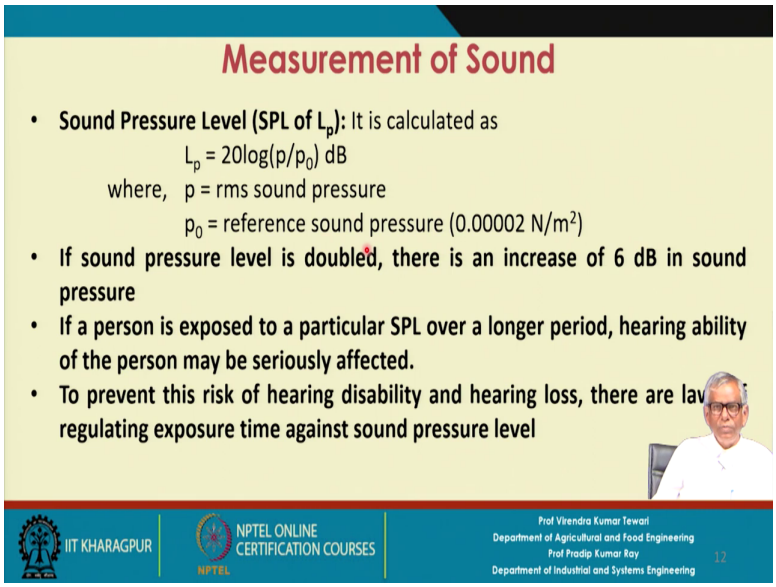

$L_p = 20\log (p/p_0)$ dB, where p = rms sound pressure and p_0 = reference sound pressure (0.00002 N/m^2).

If sound pressure level is doubled, then there is an increase of 6 dB in sound pressure. Suppose, pressure right now is p and now it is changed to 2p. If we use a log scale, we will find there is an increase of 6 dB.

If a person is exposed to a particular SPL over a longer period hearing ability of the person may be seriously affected. So, that is why the exposure time to a particular sound pressure level is a very critical factor in order to assess present level of hearing ability of the concerned person. To prevent this risk of hearing disability and hearing loss, this risk should be as minimum as possible. There are many ways, there are many rules and regulations already framed to control or to minimize this exposure time against a sound pressure level.

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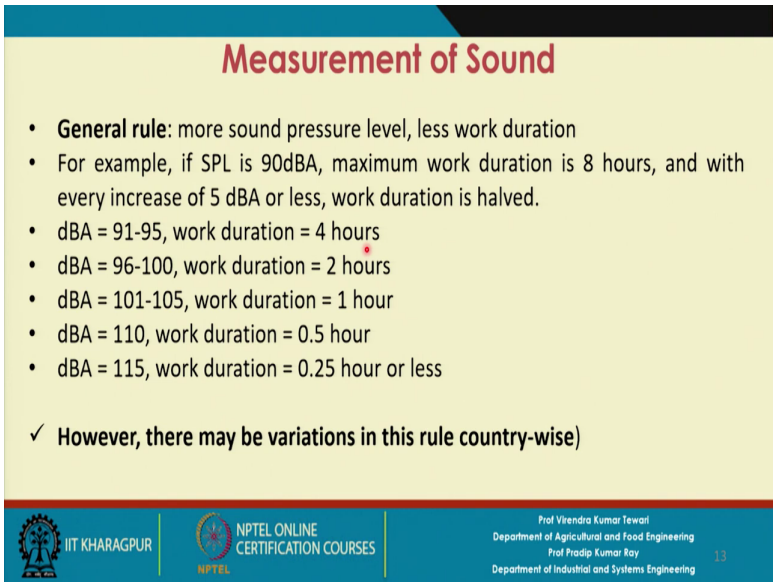

What is the general rule? Different work places different rules are being followed for different jobs. General rule is more sound pressure level less work duration. For example, if sound pressure level is 90 dBA, maximum work duration is 8 hours that is the rule you may follow and with every increase of 5 dBA or less work duration is halved.

For example, if dBA is 91 to 95, work duration is reduced to 4 hours and if it is as high as 115, work duration is just 0.25 hour or less; that means, less than 15 minutes.

However, there may be variations in these rules-country-wise.

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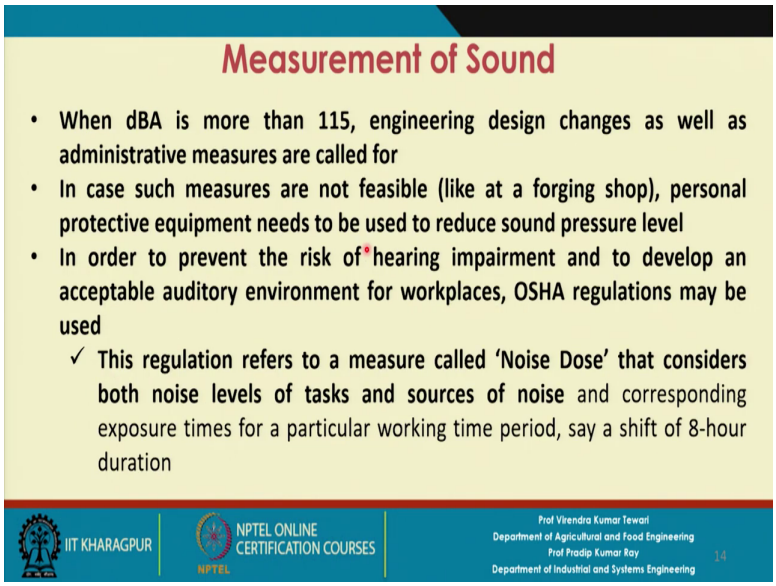

Now, when dBA is more than 115 there are certain comments, I have written, engineering design changes as well as administrative measures are called for is more than 115, very noisy, in case such measures are not feasible like at a forging shop. It is unavoidable personal protective equipment needs to be used to reduce sound pressure level.

In order to prevent the risk of hearing empowerment and to develop an acceptable auditory environment for workplaces, OSHA regulations may be used.

Noise dose considers both noise level of task and the sources of noise and the corresponding exposure time for the particular working time period say a shift of 8-hour duration.

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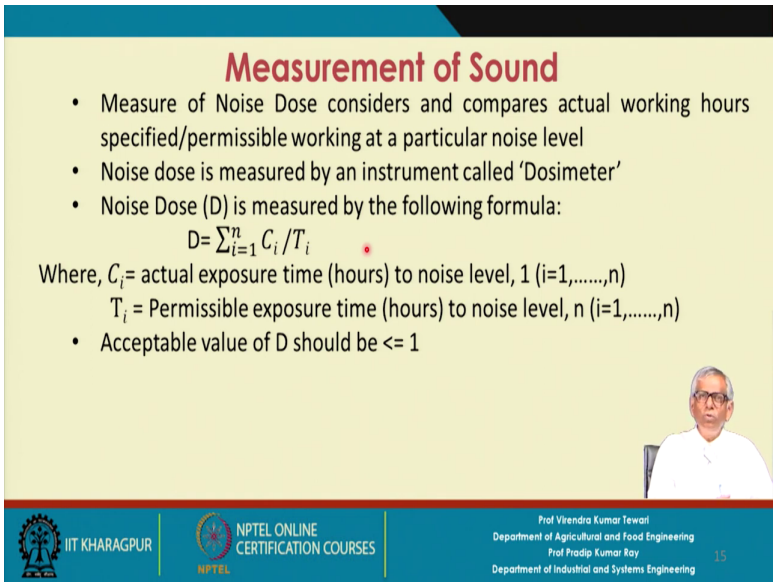

When you work at your workplace for extended time period say 8 hours, there cannot be the same sound pressure level. The sound pressure level also will vary; sometimes it is 90 dBA, sometimes it is 80, sometimes it is 100. Against particular sound pressure, level what is the exposure time?

These data also you collect and then you say that what is my noise dose. So, noise dose is to be calculated and based on the noise dose value you say whether the exposure is highly risky or not risky at all. Measure of noise dose considers and compares actual working hours and specified permissible working hours at a particular noise level.

Suppose it is 90 dBA; so your permissible working hours is 8 hours. This way you compare and ultimately you measure this noise dose. Noise dose is measured by an instrument called dosimeter. Noise dose is measured by the following formula.

$$D = \sum_{i=1}^{n} \frac{C_i}{T_i}$$

C_i is the actual exposure time to a noise level *i* and Ti is the permissible exposure time to noise level *i*. Acceptable value of the D <= 1.

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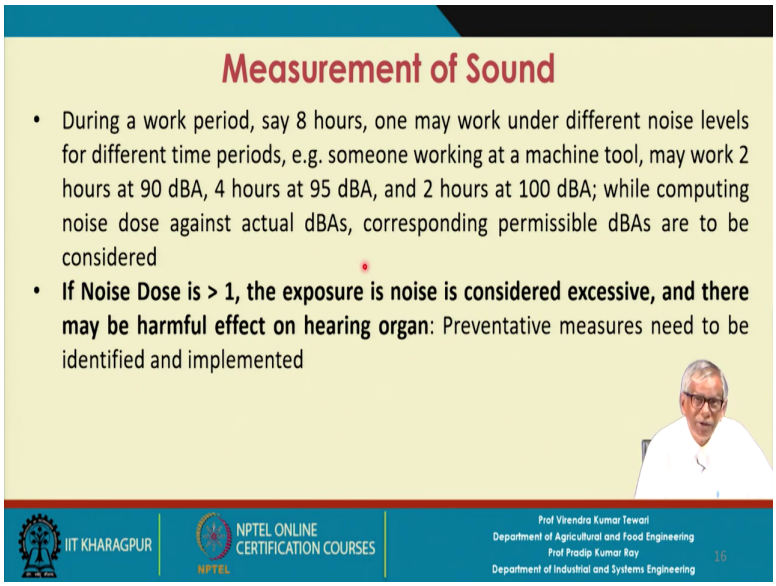

This is an example. During a work period say 8 hours one may work under different noise levels for different time periods. For example, someone working at a machine tool may work 2 hours at 90 dBA, 4 hours at 95 dBA and 2 hours at 100 dBA. While computing noise dose against actual dBAs corresponding permissible dBAs are to be considered.

If noise dose > 1, the exposure to noise is considered excessive and there may be harmful effect on hearing organ, So, preventive measures need to be identified and implemented.

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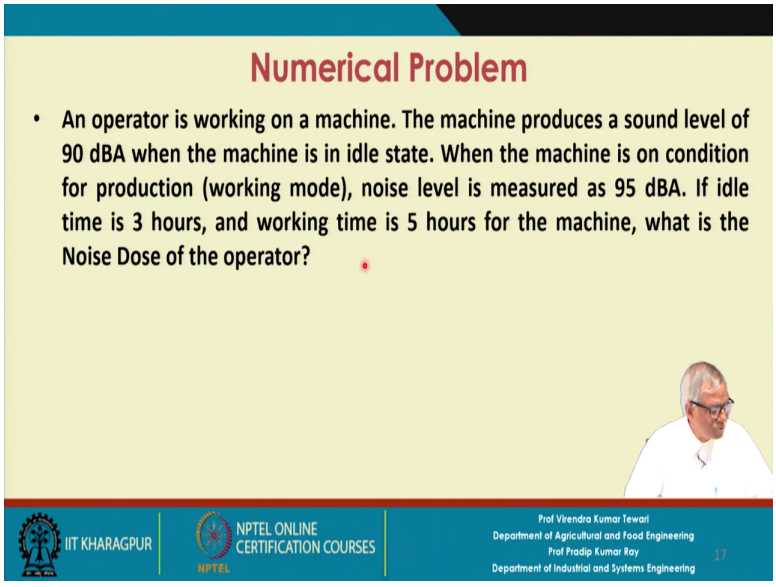

Here is a numerical problem. An operator is working on a machine. The machine produces a sound level of 90 dBA when the machine is in an idle state. When the machine is in working mode noise level is measured at 95 dBA. If idle time is 3 hours and working time is 5 hours for the machine, what is the noise dose of the operator?

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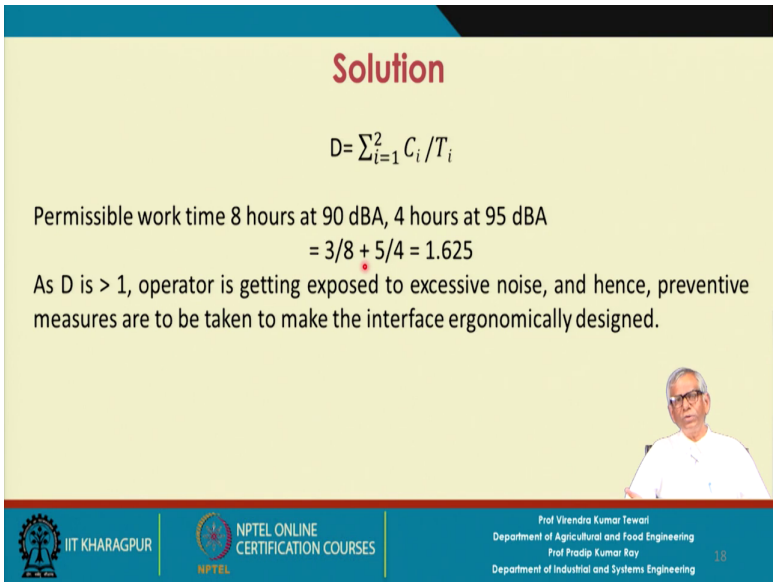

$$D = \sum_{i=1}^{2} \frac{C_i}{T_i}$$

Permissible work time 8 hours at 90 dBA, 4 hours at 95 dBA = 3/8 + 5/4 = 1.625

As D > 1, operator is getting exposed to excessive noise, and hence, preventive measures are to be taken to make the interface ergonomically designed.

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