Human Factors Engineering

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Lecture - 43

Effects of Noise on Performance, Broadbent and Poulton Theories, Interference of Noise with Spoken Communication: PNC Curves and PSIL, Numerical Problem

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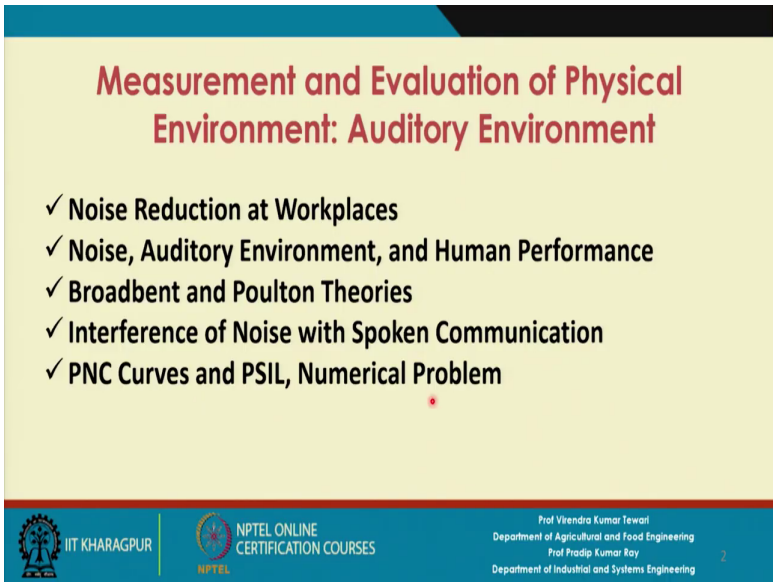

Dear students and participants, during the 3rd lecture sessions of the 9th week, I am going to discuss few important issues, related to the design of Auditory Environment from Human Factors Perspective.

1. First topic is the noise reduction at workplaces and there must be engineering solution. I will the mention the preventive measures.

2. The second topic is Noise, Auditory Environment, and Human Performance

3. Third topic is Broadbent and Poulton Theories

4. Fourth topic is Interference of Noise with Spoken Communication

5. And last one is PNC Curves and PSIL, Numerical Problems.

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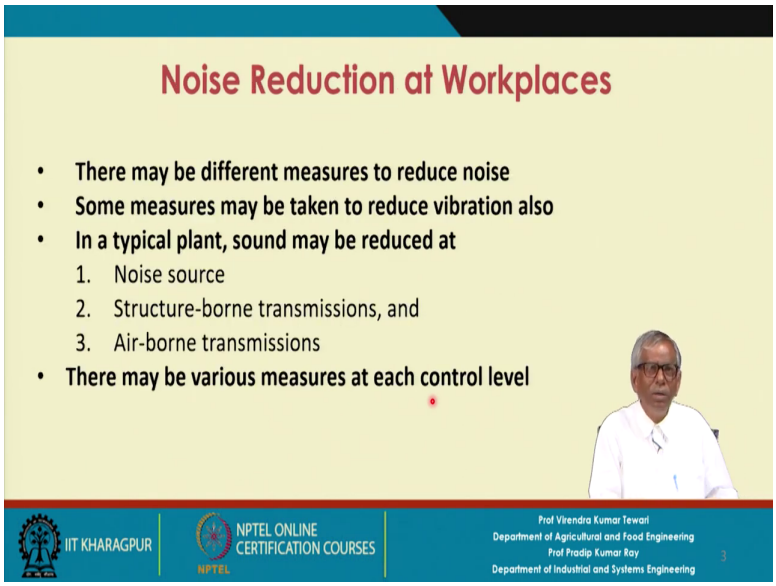

Now, let us first talk about noise reduction at work places. There may be different measures to reduce noise.

Some measures may be taken to reduce vibration also.

In a typical plant, sound may be reduced at

a) Noise source

b) Structure-borne transmissions, and

c) Air-borne transmissions

There may be various measures at each control level.

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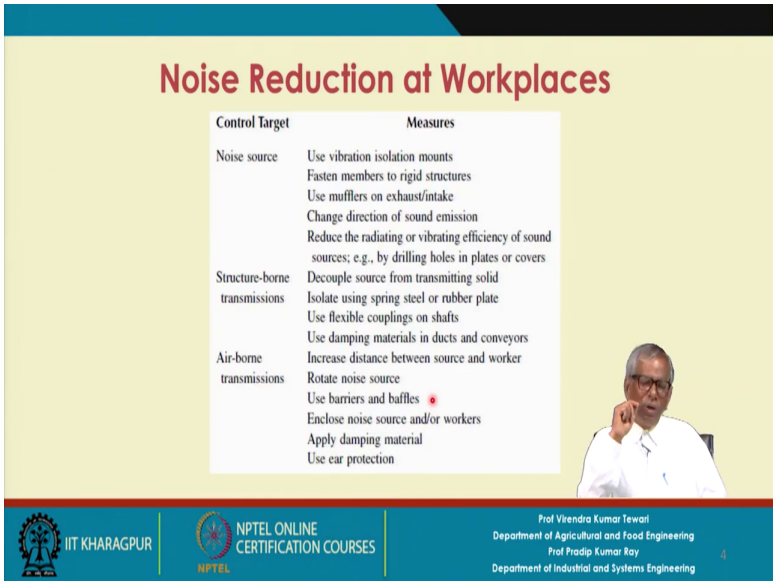

I will give certain examples like when you try to control noise at the source. At the noise source there could be several measures for noise reduction like use of vibration isolation, mounds, then fasten members to rigid structures, Use mufflers or exhaust or intake, Change direction of sound emissions and Reduce the radiating or vibrating efficiency of sound source example by drilling holes in plates are covers.

Similarly, when you try to the control noise referring to the structure-borne transmissions of noise then there are many ways you can Decouple Source from the transmitting solid, isolate using spring steel or rubber plate, use flexible coupling on shafts, use damping material in ducts and conveyors.

Then, we refer to air-borne transmission of noise and increased distance between source and worker that is the best method, if you can do that. In many cases you cannot do, if it is feasible no problem. Rotate noise source if it is also technically feasible or not use barriers and baffles this is widely used, enclose noise source and or workers.

So, that is very important like for particularly for the forging shop and many other shops some special measures you have to take such as increase the distance between source and worker, rotate noise source, enclose noise source and/or worker, apply damping material or use ear protection.

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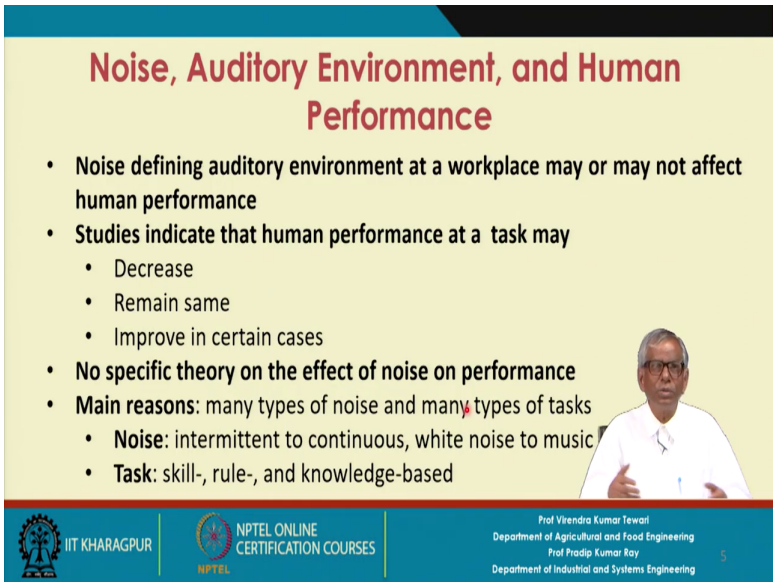

So, what is the relationship between noise auditory environment and human performance like the noise defining auditory environment at a workplace may or may not affect human performance. So, many people will find they do not mind working in a noisier environment whereas, some people become very responsive and sensitive. As soon as noise level increases, they start complaining. So, there will be individual differences.

Noise defining auditory environment at a workplace may or may not affect human performance

Studies indicate that human performance at a task may

a) Decrease

b) Remain same

c) Improve in certain cases

There is No specific theory on the effect of noise on performance.

Main reasons are many types of noise and many types of tasks such as:

a) Noise: intermittent to continuous, white noise to music

b) Task: skill-, rule-, and knowledge-based

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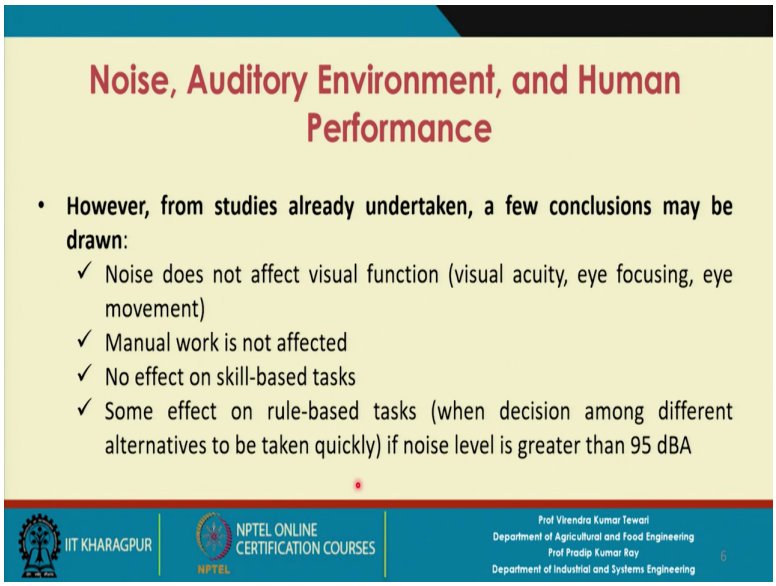

However, from studies already undertaken, a few conclusions may be drawn:

a) Noise does not affect visual function (visual acuity, eye focusing, eye movement)

b) Manual work is not affected

c) No effect on skill-based tasks

d) Some effect on rule-based tasks (when decision among different alternatives to be taken quickly) if noise level is greater than 95 dBA.

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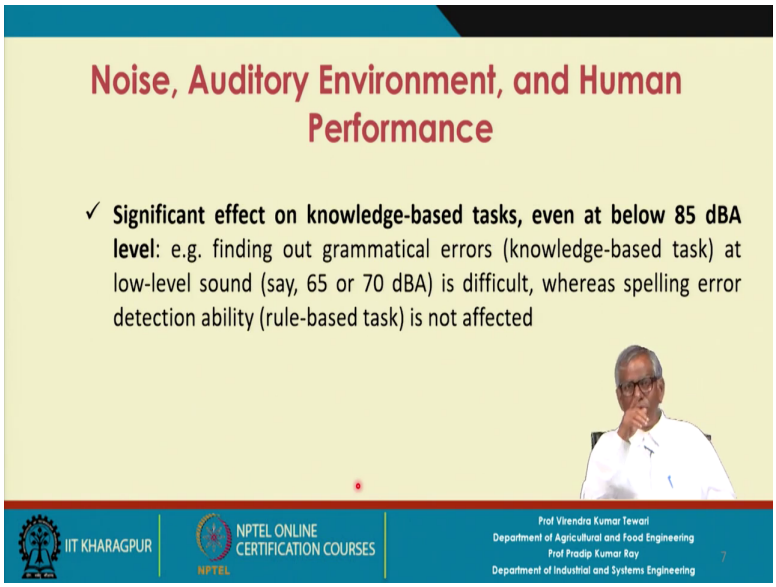

Now, the main the consideration is you have to consider these aspects because there are many kinds of knowledge-based jobs you have to carry out. Significant effect on knowledge-based tasks, even at below 85 dBA level: e.g., finding out grammatical errors (knowledge-based task) at low-level sound (say, 65 or 70 dBA) is difficult, whereas spelling error detection ability (rule-based task) is not affected.

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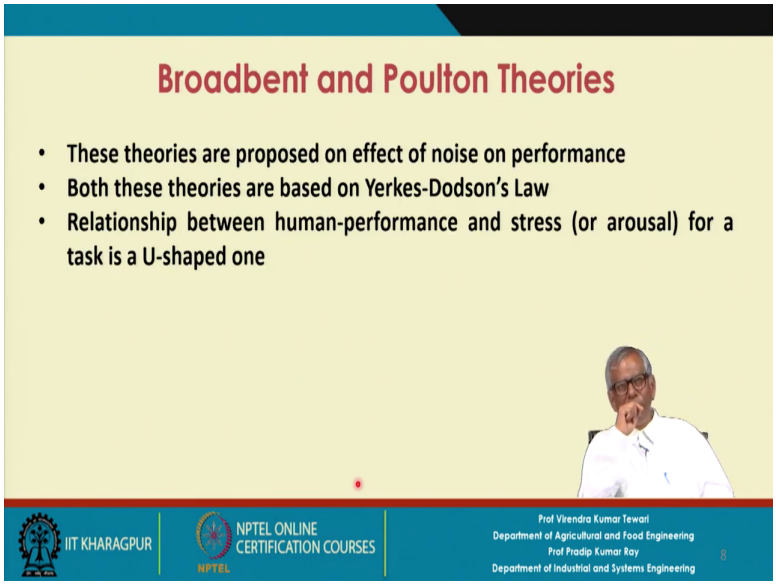

Now, in this context whether the noisy environment or the noise are affecting your performance or not- there are two the theories. These theories are a debatable issue. So, the Broadbent he proposed one particular theory and the Poulton also has proposed an alternate theory. Now, which one is applicable?

So, depending on the type of task you carry out or the type of work environment you have designed, either explaining the performance of a particular person in an auditory environment either one of these theories may be applicable or both are applicable, but you have to study your system deeply and then only you can conclude that which particular theory is applicable.

These theories are proposed on effect of noise on performance. Both these theories are based on Yerkes-Dodson's Law. Relationship between human-performance and stress (or arousal) for a task is a U-shaped one.

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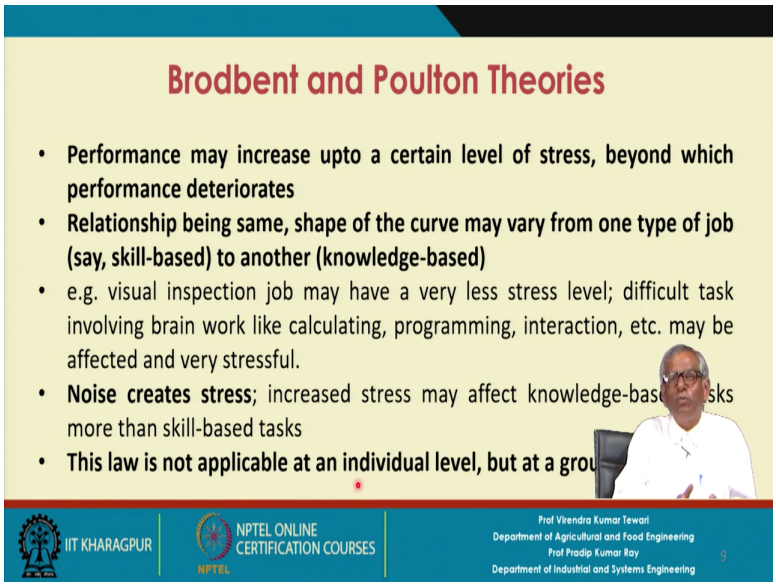

Performance may increase upto a certain level of stress, beyond which performance deteriorates

Relationship being same, shape of the curve may vary from one type of job (say, skill-based) to another (knowledge-based)

e.g., visual inspection job may have a very less stress level; difficult task involving brain work like calculating, programming, interaction, etc. may be affected and very stressful.

Noise creates stress; increased stress may affect knowledge-based tasks more than skill-based tasks

This law is not applicable at an individual level, but at a group level.

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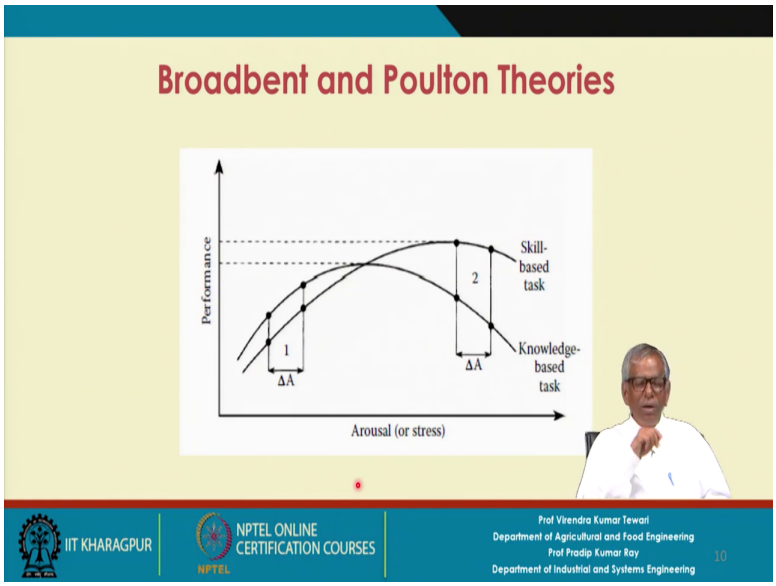

But, at the group level what is the theory? this is basically Yerkes Dodson law as applied for performance for the skill-based task as well as the knowledge-based task.

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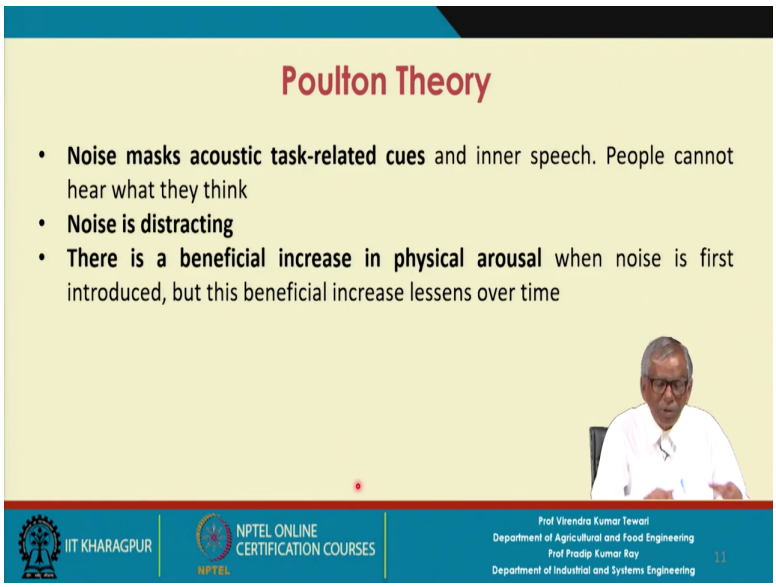

So, and the context is essentially this are is these two theories.

Now, let me just read the salient points related to Poulton theory.

He says that the noise masks acoustics task related cues that means, suppose your operation is a metal cutting the turning operation. So, while the turning process is on you

will get one kind of sound as soon as the turning process is over you that sound level changes immediately. So, that is task related cue.

So, if the environment becomes very noisy, it is very difficult to the identify these cues and the quality of machining may be affected so, your performance will also be affected. You cannot listen to your inner speech because of the noise, so the people cannot hear what they think.

Noise is distracting. There is a beneficial increase in physical arousal when noise is first introduced, but this beneficial increase lessens over time.

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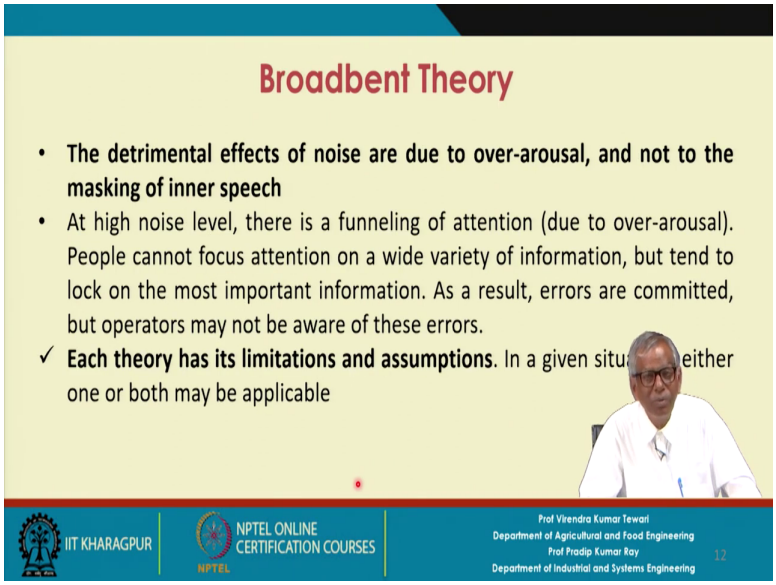

So, this is his observation, but Broadbent's observation is slightly different. He says that the detrimental effects of noise are due to over arousal and not to the masking of inner speech. So, he refers to the stress or the arousal level.

At high noise level, there is a funneling of attention (due to over-arousal). People cannot focus attention on a wide variety of information, but tend to lock on the most important information. As a result, errors are committed, but operators may not be aware of these errors.

Each theory has its limitations and assumptions. In a given situation, either one or both may be applicable.

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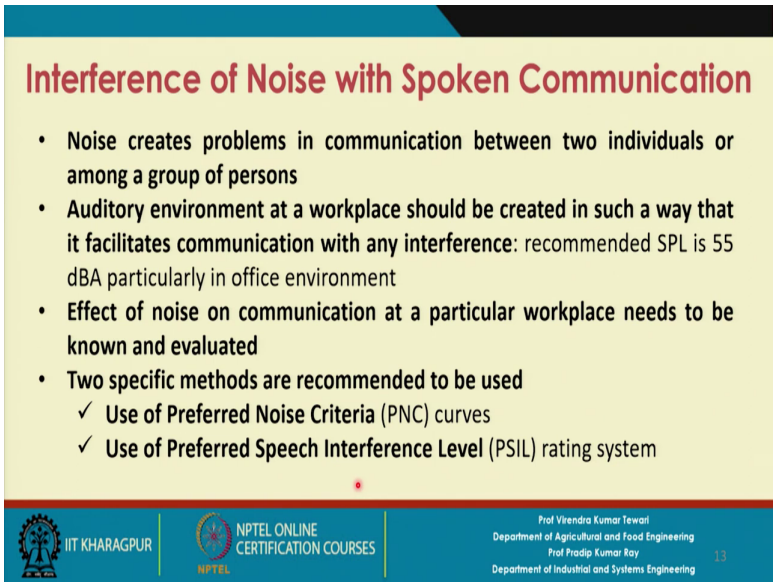

Noise creates problems in communication between two individuals or among a group of persons.

Auditory environment at a workplace should be created in such a way that it facilitates communication with any interference: recommended SPL is 55 dBA particularly in office environment.

Effect of noise on communication at a particular workplace needs to be known and evaluated.

Two specific methods are recommended to be used

1. Use of Preferred Noise Criteria (PNC) curves
2. Use of Preferred Speech Interference Level (PSIL) rating system.

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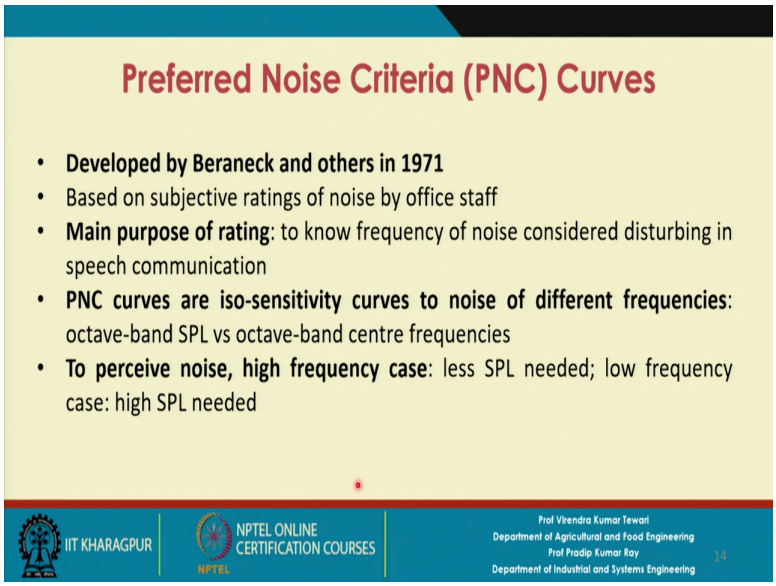

Now, PNC curves were first developed by Beraneck and others way back in 1971 based on subjective ratings of noise by office staff. The main purpose is to know the frequency of noise what is frequency of noise consider disturbing in speech communication.

PNC curves are iso-sensitivity curves to noise of different frequencies: octave-band SPL vs octave-band centre frequencies. To perceive noise, high frequency case: less SPL needed; low frequency case: high SPL needed

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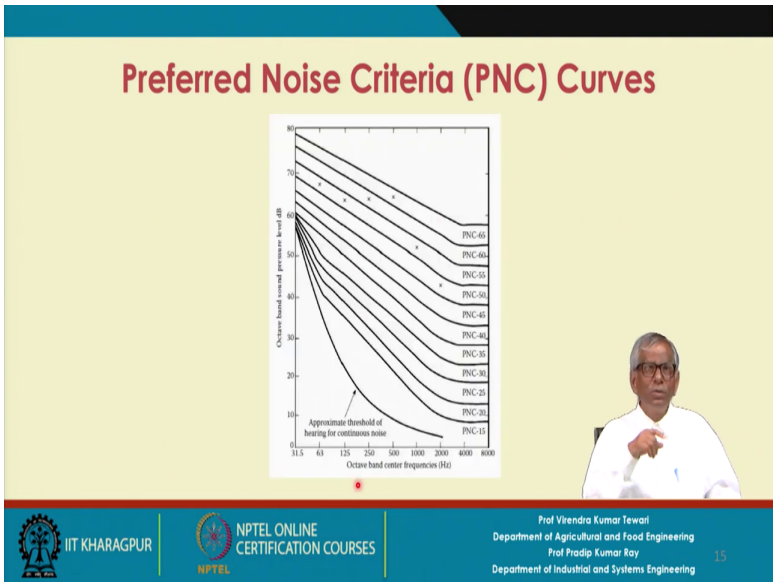

The given figure is of PNC curves as they have developed, what you find that there are the different curves we have. So, x-axis is the octave band central frequencies and y-axis basically refers to the octave band sound pressure level. You will find all-PNC curves we find that approximate threshold of hearing for continuous noise.

Suppose you have opted for PNC 60 and you find that sound pressure level in dBA at different frequencies they have not crossed PNC 55. But, if you opt for the PNC 60, then you find that at this frequency 500 this frequency has crossed this particular curve the PNC curves; that means, this is a problem and you have to search for the solution. This PNC curve you can use.

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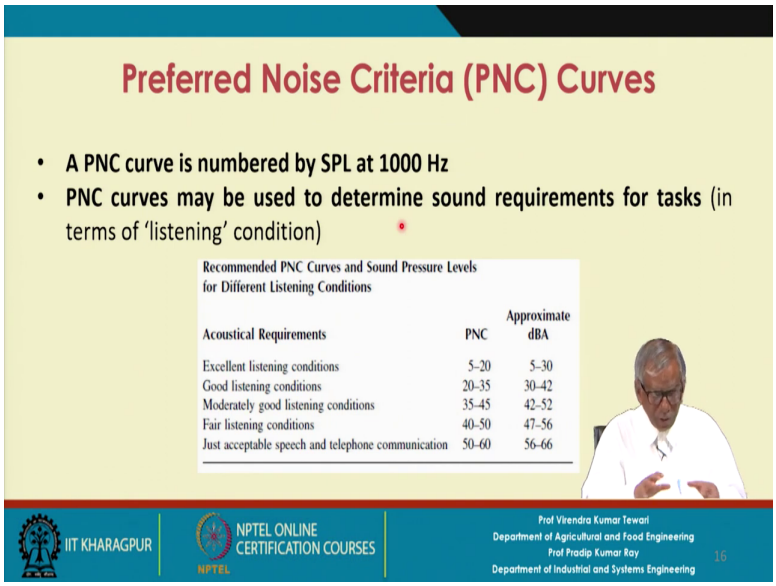

A PNC curve is numbered by SPL at 1000 Hz. PNC curves may be used to determine sound requirements for tasks (in terms of 'listening' condition).

Recommended PNC Curves and Sound Pressure Levels for Different Listening Conditions

Acoustical Requirements	PNC	Approximate dBA
Excellent listening conditions	5–20	5–30
Good listening conditions	20–35	30–42
Moderately good listening conditions	35–45	42–52
Fair listening conditions	40–50	47–56
Just acceptable speech and telephone communication	50–60	56–66

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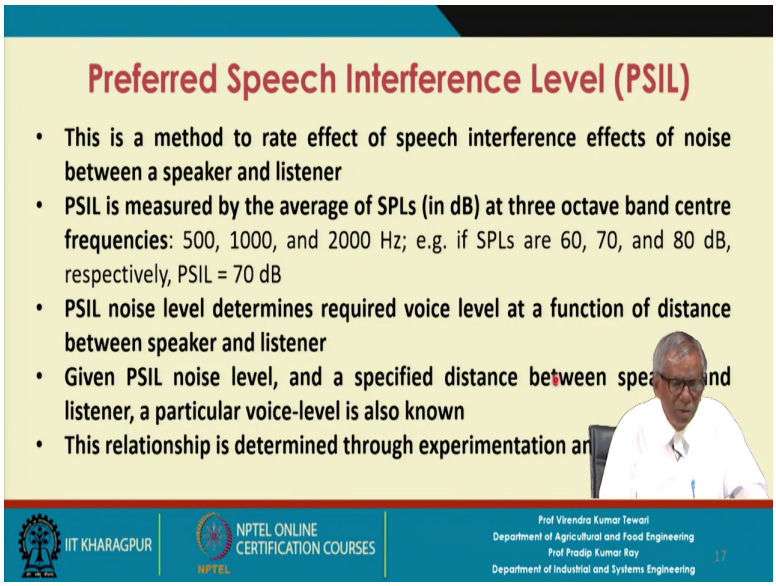

Now, the next important issue I am going to discuss before is preferred speech interference level or PSIL. This is a method to rate effect of speech interference effects of noise between a speaker and listener.

PSIL is measured by the average of SPLs (in dB) at three octave band centre frequencies: 500, 1000, and 2000 Hz; e.g., if SPLs are 60, 70, and 80 dB, respectively, PSIL = 70 dB.

PSIL noise level determines required voice level at a function of distance between speaker and listener.

Given PSIL noise level, and a specified distance between speaker and listener, a particular voice-level is also known.

This relationship is determined through experimentation and validation.

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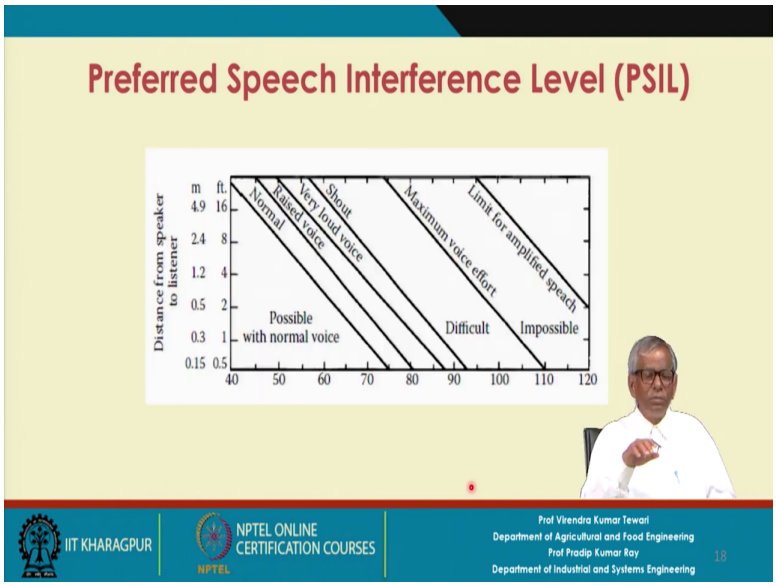

This is the PSIL as they have developed. Y-axis is the distance from speaker to listener, which is either in metric unit. X- axis is basically your PSIL level. At the normal speech, the PSIL value is 75. The distance you can keep between 0.15 to 4.9 meter. But, as this psi value increases, then you have to go for the very loud voice and if the distance is more, you have to shout and this is the maximum voice effort and this is limit for the amplified speech.

So, what is this zone possible with normal voice? 95-110 is a difficult zone and 110 and above is the impossible zone. So, this sort of relationships you have between the distance and the PSIL and your voice level so that there is the least interference in the speech communication between the speaker and the listener.

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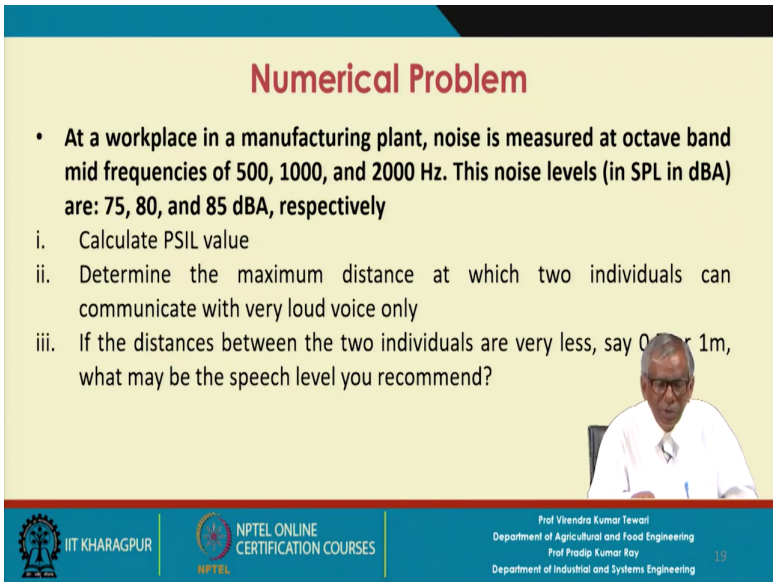

At a workplace in a manufacturing plant, noise is measured at octave band mid frequencies of 500, 1000, and 2000 Hz. This noise levels (in SPL in dBA) are: 75, 80, and 85 dBA, respectively. Calculate PSIL value. Determine the maximum distance at which two individuals can communicate with very loud voice only

If the distances between the two individuals are very less, say 0.5 or 1 m, speech level you recommend?