Human Factors Engineering

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Lecture - 38
Quality of Thermal Environment, Evaluation of Thermal Environment

Now, this is the third lecture session on the on design of Thermal Environment.

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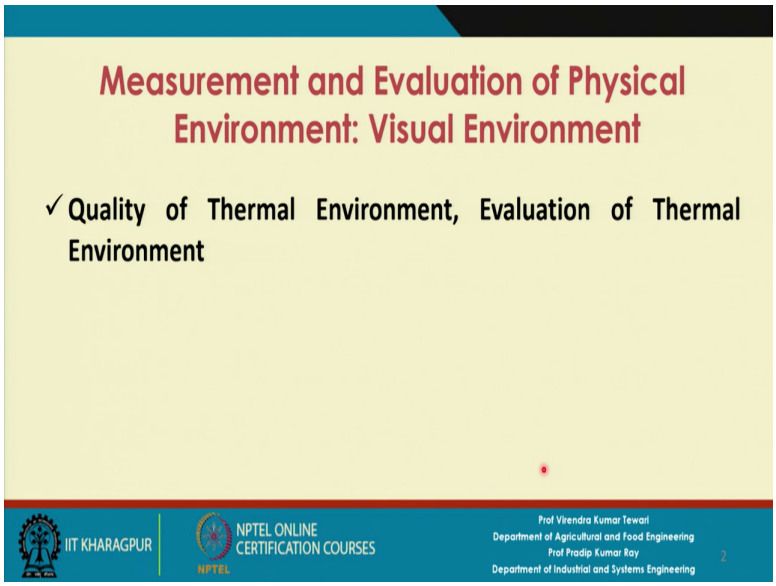

Now, I am going to discuss one important issue that quality of thermal environment and evaluation of thermal environment.

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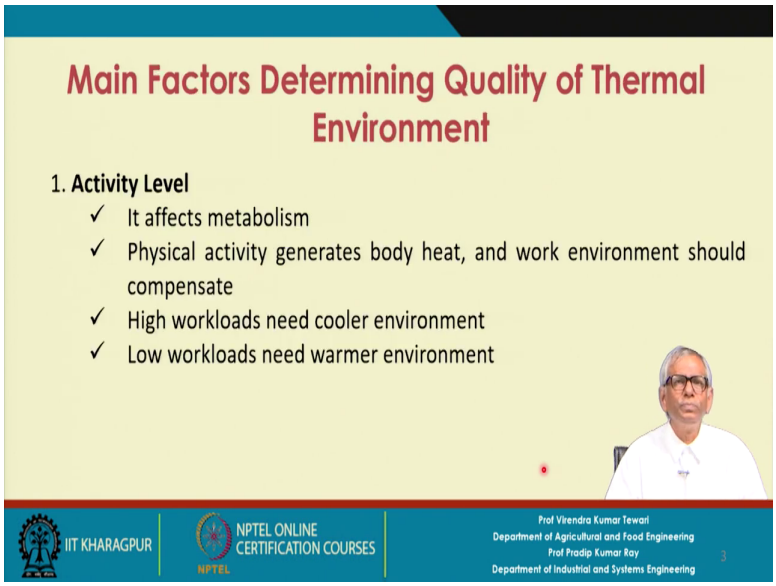

So, already we have discussed the basic issues related to the thermal environment. And we have considered both the conditions whether it is a heat stress condition or the cold stress condition and what are the improvement measures you can implement for improving the quality of thermal environment of heat stress and cold stress. Now here first what we try to focus on that is what are the majors determining quality of thermal environment? Because you have to create quality assurance system.

First one is Activity level;

1. It affects metabolism.
2. Physical activity generates body heat, and work environment should compensate.
3. High workloads need cooler environment.
4. Low workloads need warmer environment.

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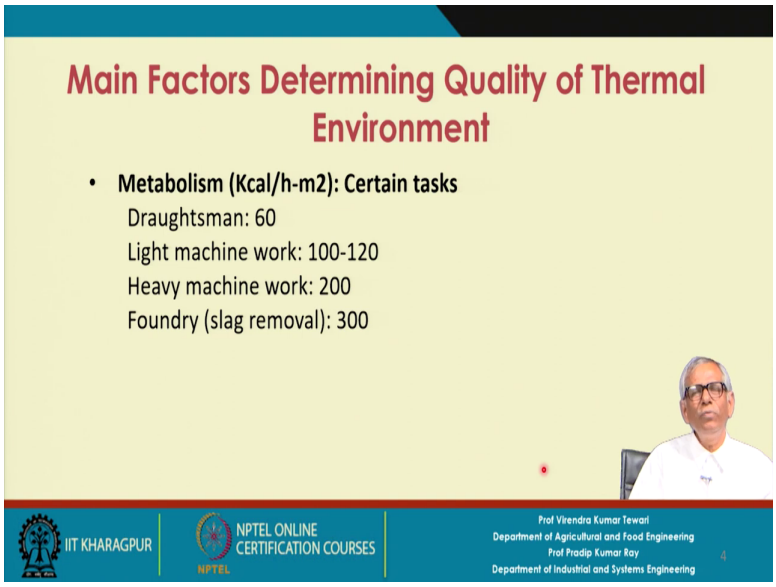

If you are allowed to work at a slow pace. Now here when we refer to the Metabolism, we measure it in Kcal/h-m^2.

Metabolism for certain task are:

a. Draughtsman: 60

b. Light machine work: 100-120

c. Heavy machine work: 200

d. Foundry (slag removal): 300

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So, the first factor is metabolism for the work or for the activity, second important factor is the clothing what type of clothing you are you are using. First whether you have to use some special clothing or you have certain dress habits. Now special clothing worn for a job may change heat loss equation.

Dress habits change seasonally, not due to work environment primarily.

Clothing unit: clo (clothing insulation)/tog (0.645clo) or in ordinal scale: light, medium, winter, etc.

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Now, for different the clothes with respect to the human body. Clo factor: Certain cloths

- No clothing- 0
- Light summer cloths (male) - 0.5
- Heavy business suit- 1.5
- Polar weather suit- 3 to 4

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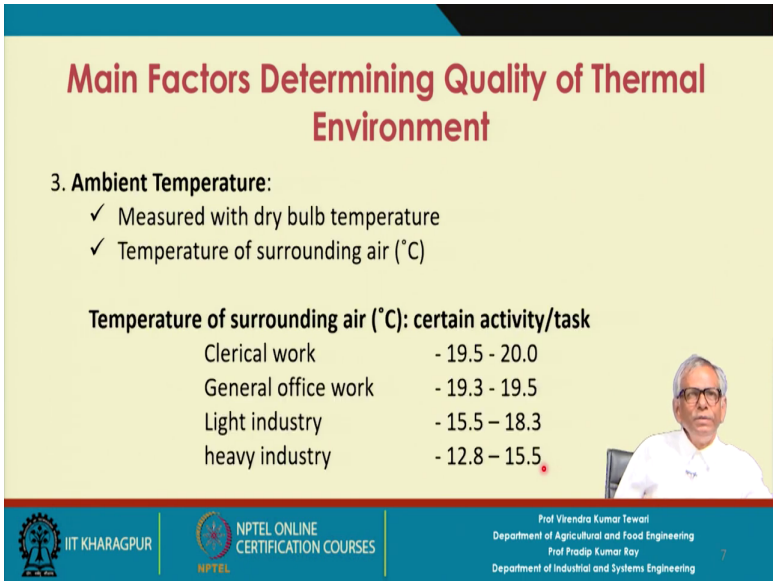

Now, the third important factor is the ambient temperature. Ambient temperature measured with dry bulb temperature.

Temperature of surrounding air that also you can measure, so that is in degree Celsius.

Temperature of surrounding air (˚C): certain activity/task

Clerical work - 19.5 - 20.0

General office work- 19.3 - 19.5

Light industry- 15.5 – 18.3

heavy industry- 12.8 – 15.5

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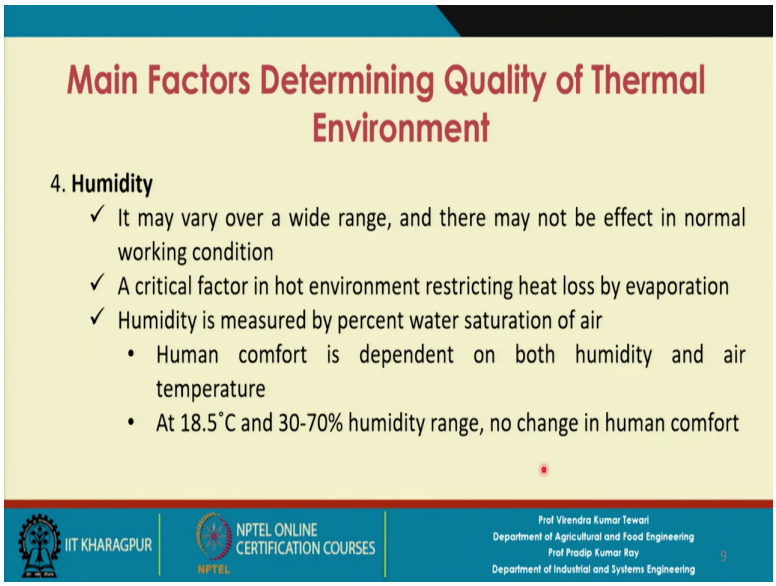

So, the 4th factor is the humidity. So, while we refer to the humidity now the certain points you should consider.

It may vary over a wide range, and there may not be effect in normal working condition

A critical factor in hot environment restricting heat loss by evaporation

Humidity is measured by percent water saturation of air:

1. Human comfort is dependent on both humidity and air temperature.
2. At 18.5˚C and 30-70% humidity range, no change in human comfort.

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The fifth factor is Air Flow: Velocity of air at a work place

1. Important for cooling and sensation of fresh air
2. Measured by anemometer
3. Air flow measuring unit: m/s
4. Comfortable Air Flow: Workplace Dependent

   For Office

1. 0.11-0.15m/s: Comfortable
2. 0.5m/s: Uncomfortable

For heavy work, higher air flow rate is acceptable

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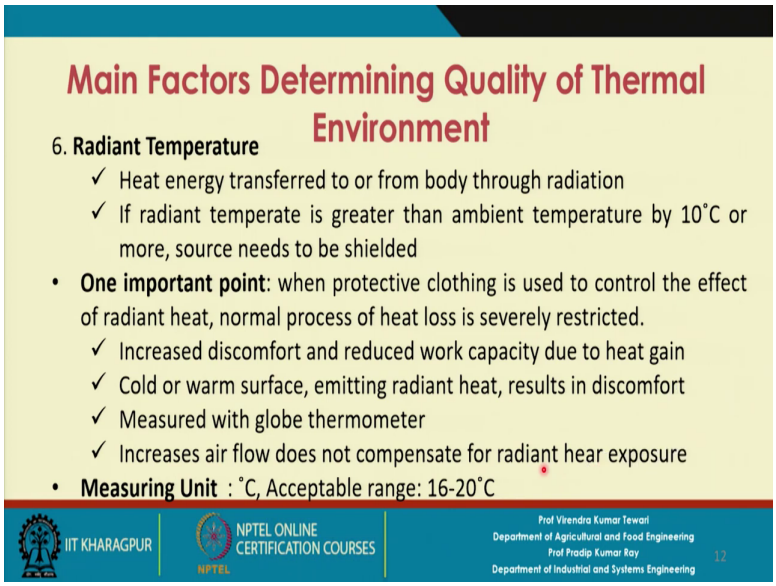

Next important point that is the radiant temperature.

Heat energy transferred to or from body through radiation

If radiant temperate is greater than ambient temperature by 10˚C or more, source needs to be shielded

One important point is when protective clothing is used to control the effect of radiant heat, normal process of heat loss is severely restricted. Which results in:

1. Increased discomfort and reduced work capacity due to heat gain
2. Cold or warm surface, emitting radiant heat, results in discomfort
3. Measured with globe thermometer
4. Increases air flow does not compensate for radiant hear exposure

The Measuring Unit is ˚C, and Acceptable range is 16-20˚C.

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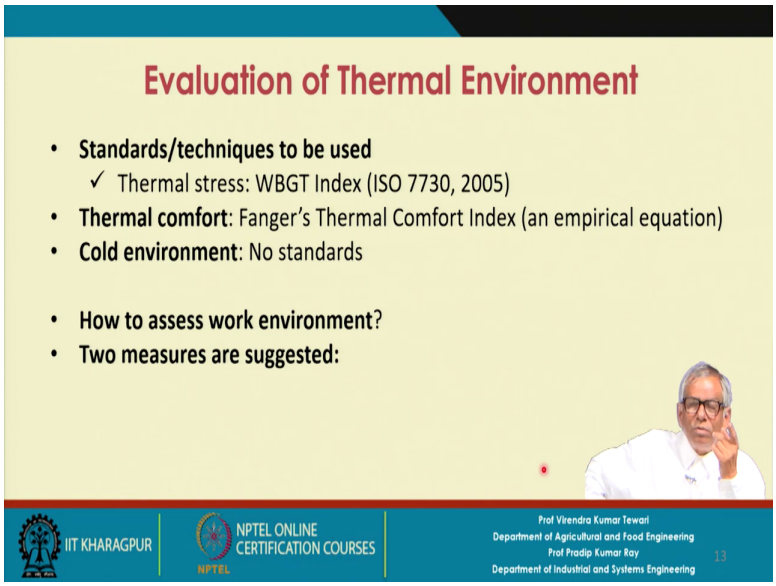

Now, these standards are the technique to be used that is thermal stress (WBGT index) this is as per ISO 7730 of year 2005 standards. Thermal comfort is the Fanger's thermal comfort index.

So, the thermal comfort index is used for assessing the thermal comfort and what he has proposed is an empirical equation. That means, empirical is a work system through data collection through experimentation and validation.

How to assess work environment?

Two measures are suggested:

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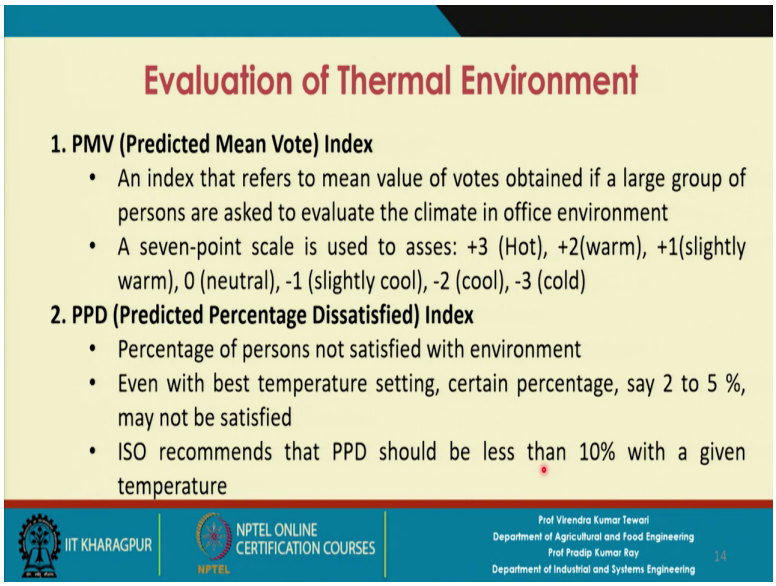

So, 2 measures are suggested.

1. PMV (Predicted Mean Vote) Index

An index that refers to mean value of votes obtained if a large group of persons are asked to evaluate the climate in office environment

A seven-point scale is used to asses: +3 (Hot), +2(warm), +1(slightly warm), 0 (neutral), -1 (slightly cool), -2 (cool), -3 (cold)

2. PPD (Predicted Percentage Dissatisfied) Index

Percentage of persons not satisfied with environment

Even with best temperature setting, certain percentage, say 2 to 5 %, may not be satisfied

ISO recommends that PPD should be less than 10% with a given temperature.

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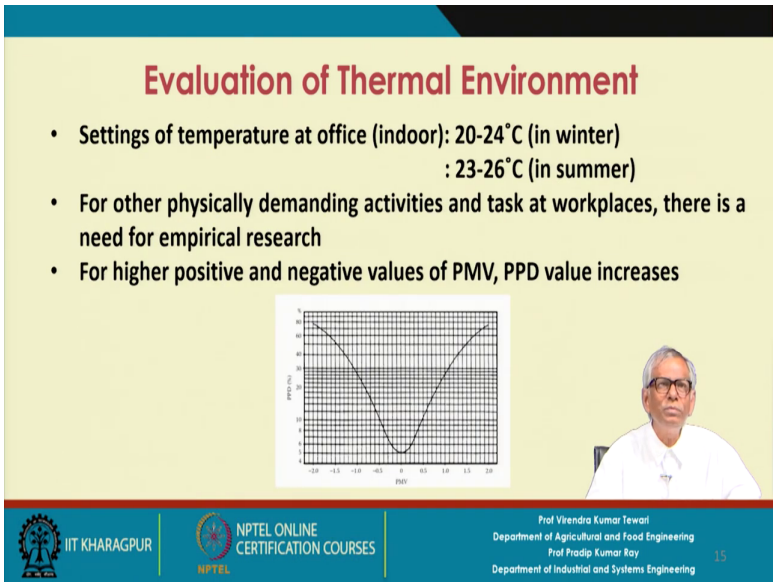

So, these are the observations we have. The temperature is one of the parameters in a given environment of work which affect the productivity of human beings.

Settings of temperature at office (indoor): 20-24˚C (in winter) and 23-26˚C (in summer).

For other physically demanding activities and task at workplaces, there is a need for empirical research.

For higher positive and negative values of PMV, PPD value increases.

List of Reference Textbooks

1. Sanders, M. S. and McCormick, E. J., Human Factors in Engineering and Design, McGraw-Hill, Sixth Edition

2. Bridger, R. S., Introduction to Ergonomics, Taylor and Francis Group, Third Edition

3. Helander M, A Guide to Human factors and Ergonomics, Taylor and Francis Group, Second Edition