Ergonomics Research Techniques

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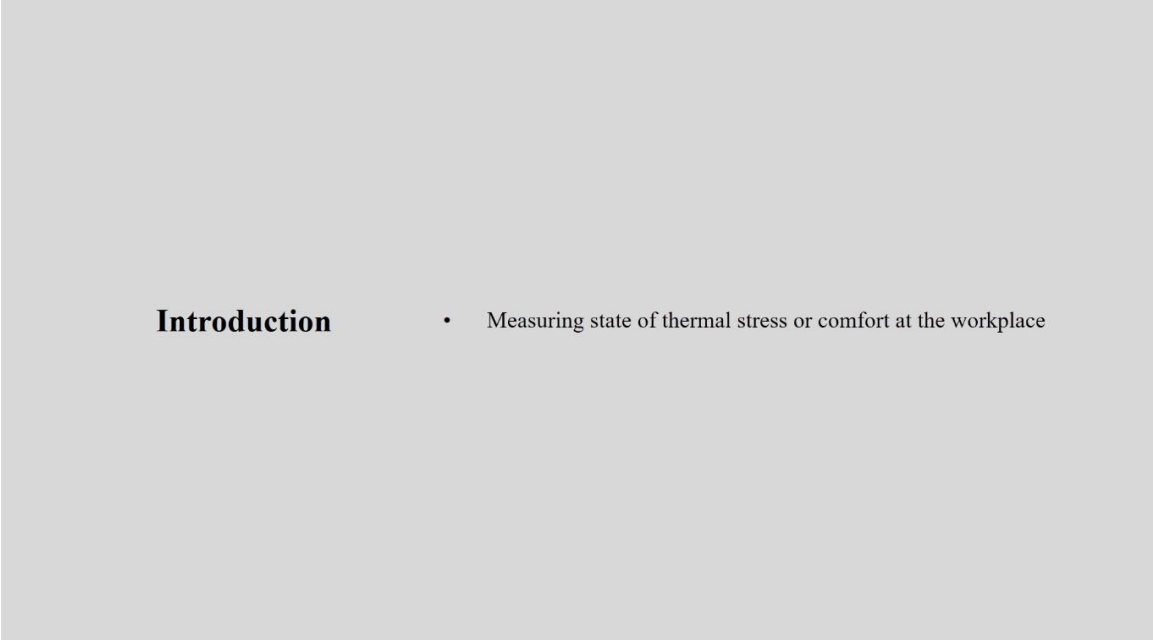
Week 12: Lec 41- Assessment of environmental factors

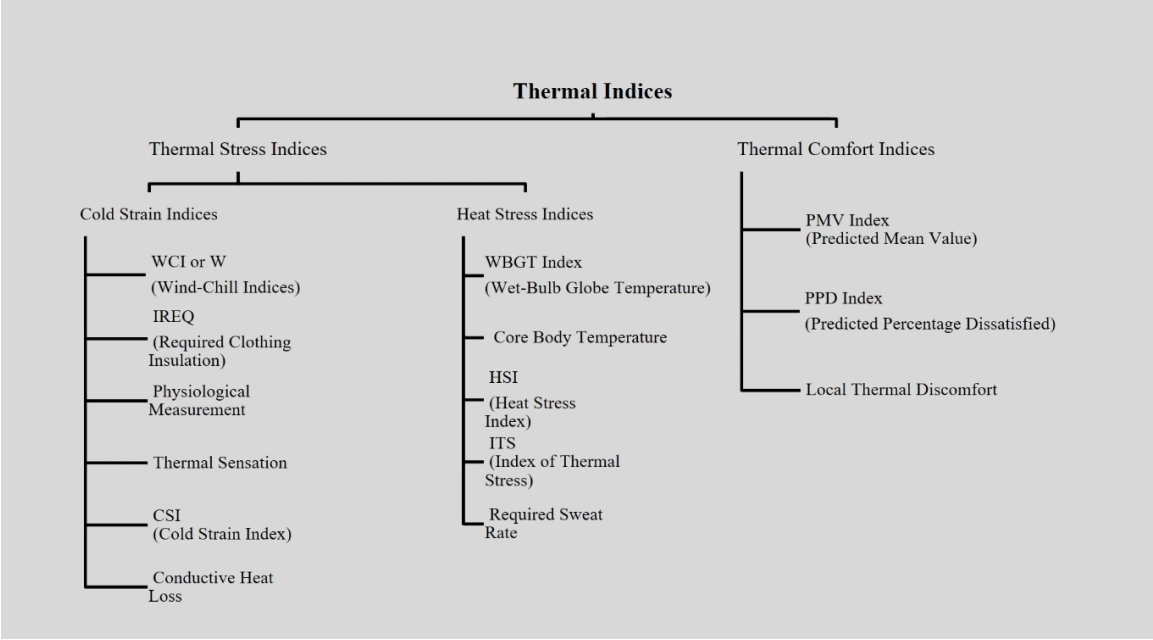
Measurement of different environmental factors- Part I

Hello everyone. So last class we tried to initiate a process where we try to understand that how do we assess and find the various environmental factors. In that we try to discuss majorly about the thermal environment. However, if we talk about the physical working environment, in that it is not only thermal, we have illumination, we have noise, sound, dust, olfactory and many other components okay which actually affects you when you perform any kind of activity, either it is indoor environment or it is outdoor environment. Now concern is we have limited time period to discuss everything. So already we are about to finish our course. So what I am going to do over here that I will try to introduce the very important concepts and then you may try to practice it or learn it at your end in little in more detail right because we have limited scope of time. So first today I will discuss about the thermal indices okay.

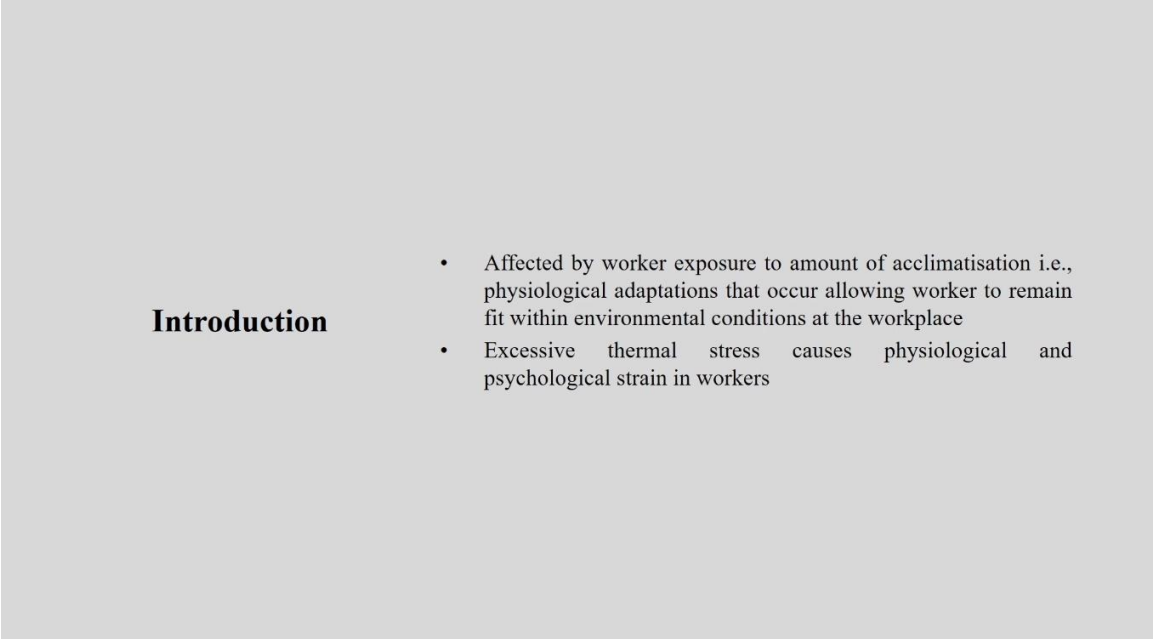


So what it is so what we are trying to do is that measuring the state of thermal stress and comfort at the workplace. So when we are talking about thermal indices, it is very important for us to understand stress. So if it is more heat then also it is stress, if it is less heat then also it is stress. Whereas if it is within a specific region where you feel

comfortable then it is only comfort. So we are going to understand these three different issues in this particular section.



If we talk about thermal indices, we can understand that it is mainly divided into two component that is the thermal stress indices and thermal comfort indices. Under thermal stress indices we have cold strain indices because as I mentioned if it is beyond or less than the comfortable temperature then also we perceive some kind of stress. If it is more than that then also we perceive discomfort or stress. So we have cold strain indices and we have heat strain indices okay. Among cold stress we have several indices like WCI or revised name is W. Then IREQ that is the required clothing insulation, physiological measurement, thermal sensation, cold strain index, conductive heat loss okay. These are all varieties of methods available or indices available to understand the cold stress. Whereas if we talk about heat stress we have WBGT index, we have core body temperature, heat stress index, ITS that is the index for the thermal stress and required sweat rate. Now coming to thermal comfort we have very specific three assessment technique that is the PMV that is the predicted mean value, PPD index that is the predicted percentage dissatisfied and local thermal discomfort okay. Now due to time constraint probably we will be discussing each one of them like one from here, one from here okay like that we will be discussing.



So let us understand first the under thermal indices, stress indices what it is. So it affected by the worker exposure to amount of acclimatization that is physiological adaptation that occur allowing the worker to remain fit within environmental condition at a particular workplace. So excessive thermal stress may cause the physiological and psychological stress among the worker. Because if we are talking about you know working in a very hot environment or working in a very cold environment, it is not only physiologically we will get disturbed, you know psychologically also we will be disturbed and finally what will happen it will affect our performance level. So it is very important for us to understand that. So let us begin with the cold strain index. I will give only one example that is the wind shield indices.

Wind Chill Indices

WCI (Siple and Passel, 1945)

- Based on empirical experimentation
- Amount of heat loss in given ambient temperature and concurrent air movements
- Provides temperature equivalent under calm conditions

W (Steadman, 1984)

- Based on heat-balance equations
- Improved & redeveloped in 2000-2001

Very early that is the 1945, Sipel and Passel invented or tried to establish this method. It is based on the empirical experiment and the amount of heat loss is given ambient temperature and the concurrent air movement this particular indices is being built upon. It also provides the temperature equivalent under in a particular calm condition. Now slowly it is being revised in 1984 and we call it only the wind indices. So it is based on the heat balance equation and it is improved and redeveloped in 2000 and 2001. So you can understand that wind shield indices or wind indices whatever we call it according to the knowledge upgradation it is being changed and revised. So let us understand how it works.

Interpreting W

Exposure Duration	Temperature	Wind Speed	Frostbite Risk
> 30 minutes	- 28°C	calm avg. (~ 4.8km/h)	medium
in 10 minutes	- 40°C	> 50km/h	high
in 5 minutes	- 48°C	> 50km/h	high
in 2 minutes	- 55°C	-	very high

Interpreting cold strain while considering risk of frostbite

So if we see that there is a temperature of minus 28 degree centigrade and the exposure limit. So again it is a very important thing. So exposure limit as we do practice in the musculoskeletal disorder, not only one impacting factor like repetition. If repetition is only once in a while, it may not affect the whole musculoskeletal system right. But if the duration of exposure is very high then only it affects. So here also similar concept as per the as and when the duration of exposure is increasing what happens the strain indices also giving like sad result like you know it is more affecting to the person. So if it is more than 30 minutes and it is 28 degree temperature and wind speed which is you know kind of calm average.

So average 4.8 kilometer per hour then the risk of frostbite will be. So actually basically what W does? W try to understand or give an indication that what is the kind of risk you have to develop the frostbite because that is the kind of stress you are going to develop when you are working in a very cold condition ok. So it is medium whereas if you are working for 10 minutes in a minus 40 degree centigrade and the kind of velocity of wind is more than 50 kilometer per hour then also it is high. Now here it is a very nice equation that if it is 10 minute the combination 10 minutes 48 minus 48 degree centigrade and more than 50 kilometer per hour then also it is high. Whereas it is 5 minutes more than like the temperature is like minus 48 and the same thing which is the more than 50 kilometer per hour then also here it is high. So what is the affecting factor this temperature and the exposure level ok. Now coming to this temperature that is the minus 55 degree centigrade if it is that then we can say whatever the speed is speed of wind is, if you get exposed for that particular type of temperature you know kind of duration of 2 minutes, then risk of frostbite is very high according to this particular pre calculated indices ok. So this is very important for us whoever is going you know or working in a conditions like you know soldiers or you know people who are climbing mountains and all to understand this cold strain index very properly otherwise they may develop frostbite and risk of frostbite development if it is very high then you know health hazards are very in a bad condition. So they should recover themselves very fast, otherwise they may face the further consequences. So this is very important for us. Now I would not discuss all other like cold strain indices. I will move forward for very important heat stress in this that is the we can say WBGD index.

Risk factors for Heat Stress

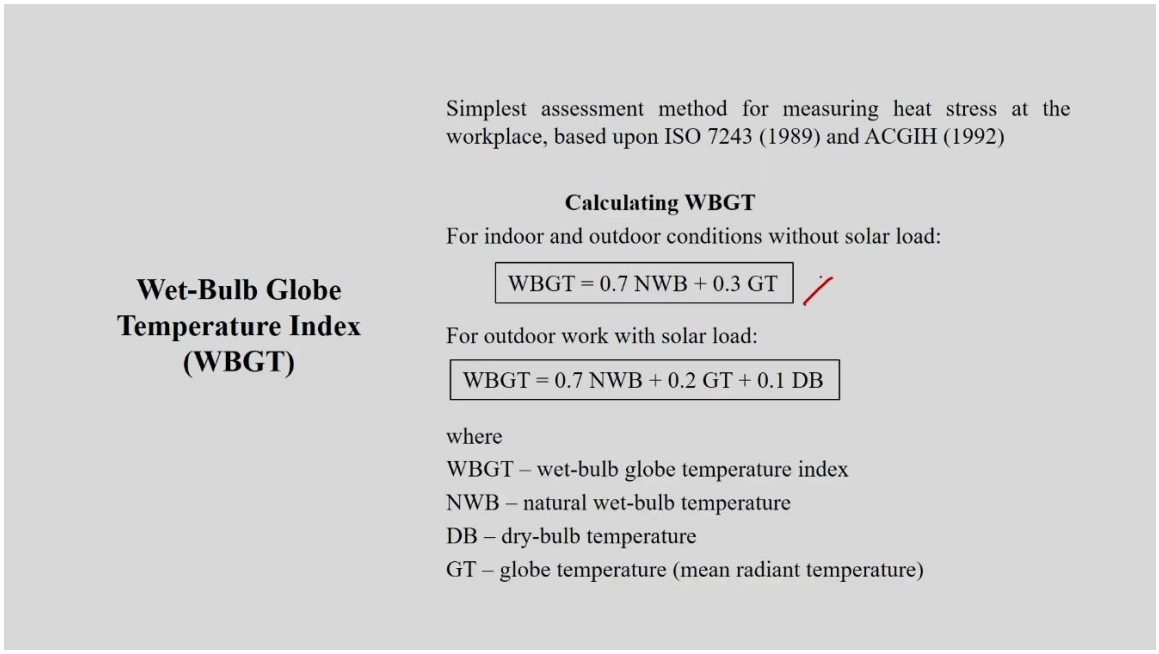
Environmental Risks	Physiological Risks	Behavioural Risks
High air temperature	Age	Strenuous activity
High humidity	Weight	Dehydration
High radiant temperature	Physical fitness	Alcohol consumption
Direct contact with hot objects	Metabolism	Drug use
Still air	Degree of acclimatisation	Permeability of clothing
	Hypertension	
	Prior heat injury	

Before I go to that I would like to mention here that what are the risk factors for the any heat stress ok. So if we look at this particular chart, you can understand I categorized them into environmental risk, physiological risk and behavioral risk. So if you talk about environmental risk, these are high air temperature, high humidity, high radiant temperature, direct contact with any kind of hot object and still air ok. So these are the environmental risk whereas physiological age like it is a personal you know risk age, weight, physical fitness, metabolism, degree of acclimatization, hypertension prior any prior heat injuries etc. If you talk about behavioral, strenuous activity so if we are doing lot of strenuous activity it is possible there is always a possibility that you will develop heat stress very easily ok dehydration, alcohol consumption, drug use and permeability of your clothing. So if insulation is very high then maybe what will happen you will develop heat stress very easily.

Heat Disorders & Symptoms

Disorder	Processes	Symptoms
Heat Fatigue	Lack of acclimatisation to hot conditions	Impaired performance of skilled sensorimotor, mental, or vigilance tasks
Heat Rashes	Sweat glands plugged by salt deposits from evaporated sweat Unevaporated sweat accumulates in glands	Small, red, blister-like papules on areas of the skin w/ restrictive clothing Prickling sensation on skin Symptoms reversed in cooler conditions
Heat Collapse	Loss of consciousness due to blood pooling in extremities causing brain anoxia	Rapid and unpredictable fainting
Heat Cramps	Excessive sweating leading to electrolyte imbalance due to salt loss	Painful muscle spasms – abdomen, arms, legs – during or after performing certain activity
Heat Exhaustion	Dehydration, poor heat acclimatisation, poor physical fitness	Headache, nausea, vertigo, thirst, giddiness
Heat Stroke	Failed thermoregulation causing critical rise in core temperature	Confusion, irrational behaviour, loss of consciousness, convulsions, unusual lack of sweating, hot & dry skin, abnormally high body temperature (> 41°C) leading to fatalities

So there are stages of heat stress so it starts with heat fatigue then it cause the heat rashes, heat collapse, heat cramps, heat exhaustion and heat stress and here I mention all the varieties of symptoms available for each kind of disorder. So just for example if you talk about heat rashes what will happen? Small red blister like you know papules on the areas of the skin like you know specifically on your hand open skins ok. So there you will get all this kind of thing and then you know some kind of prickling sensation on your skin that you will be actually you will be understanding or you will be facing those problems. The highest like when we are talking about heat stroke that is the maximum possible disorder due to heat high heat. So what happens? It is it may cause the confusion, irrational behavior, so you will not be able to behave properly, loss of consciousness, you may lose your consciousness, then unusual lack of sweating hot and dry skin. So all these symptoms will occur and what will happen what is the process, because it actually fail the thermoregulation process of your body. So that hypothalamus which is involved in the thermal regulation of your body because we are mammals that whole process will fail ok and due to that heat stress will occur and this is the maximum possible condition due to high heat condition.



Now let us understand how do we measure this type of stress indices ok. So very commonly used heat stress index is WBGT index; wet bulb glow temperature. In my earlier presentation I introduced you with the wet bulb with the glow bulb like glow thermometer and wet bulb temperature what all these things. Using those temperature using those measurement how do we calculate WBGT. So this is the formula that we use for the when we are indoor and outdoor condition without any solar load. Whereas if there is solar load then we use this type of formula. So you can see this 0.3 that is the glow temperature is divided into 0.2 and 0.1 in case of it is you are having any kind of solar load and it is you know adopted by this ISO. So you can use it very conveniently and this is the very easy method to understand the heat stress in a particular working environment ok.

Calculating Average WBGT

- Measured over 60-min for continuous heat exposures
- Measured over 120-min for intermittent heat exposures
- Ideal WBGT – measured at head, abdomen & ankle levels
- Weighted average WBGT calculated

Average $WBGT = [(WBGT_i)(t_i)]/(t_i)$

where

$WBGT$ – wet-bulb globe temperature index

t – time (in minutes)

i – individual task

$WBGT = [WBGT_{head} + WBGT_{ankles} + (2 \times WBGT_{abdomen})]/4$

where

$WBGT_{head}$ – WBGT measured at head

$WBGT_{ankles}$ – WBGT measured at ankles

$WBGT_{abdomen}$ – WBGT measured at abdomen

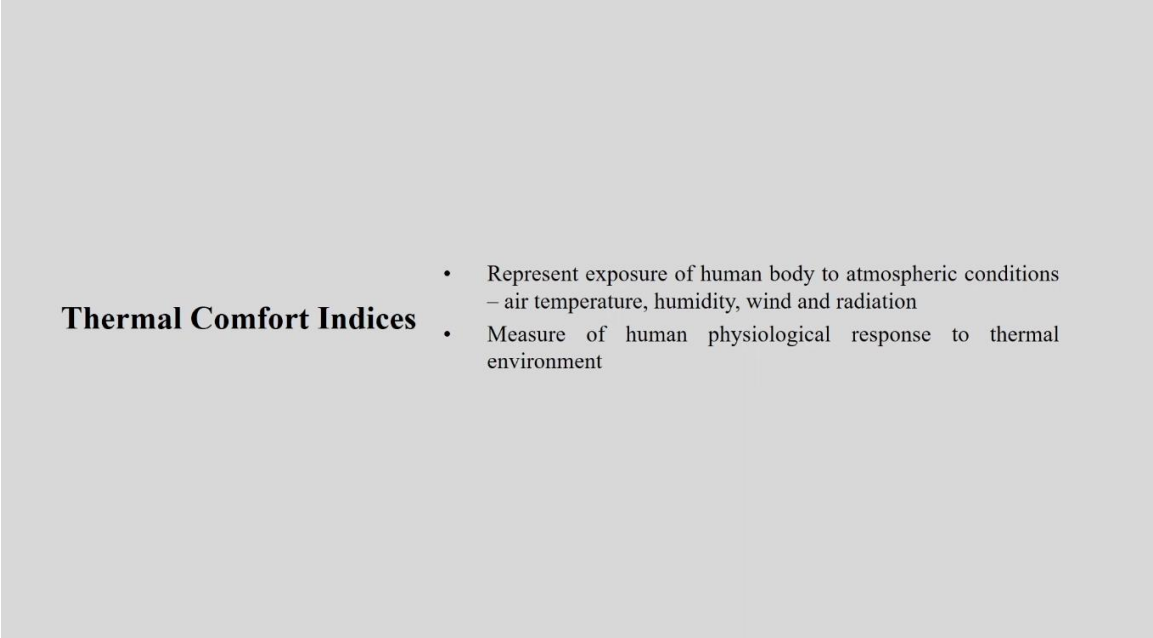
So how do we calculate it? So you can see that measured over 60 minute for continuous heat exposure and you can also do measure over 120 minute for intermittent heat exposure both way you can do. And ideal WBGT is measured at a heat at maybe at the head level at the abdomen level and at the ankle level. So if you are standing and doing your work or if you are sitting and doing your work you can measure at this level, at your abdomen level, at your ankle level. So you can understand that whole body how it is being exposed ok and these are the formula. You can use to average out the condition and then using this this is the basic formula and then you use this to make the average ok. So WBGT is very very important and easy and useful method to understand the heat stress.

Permissible Heat Exposure

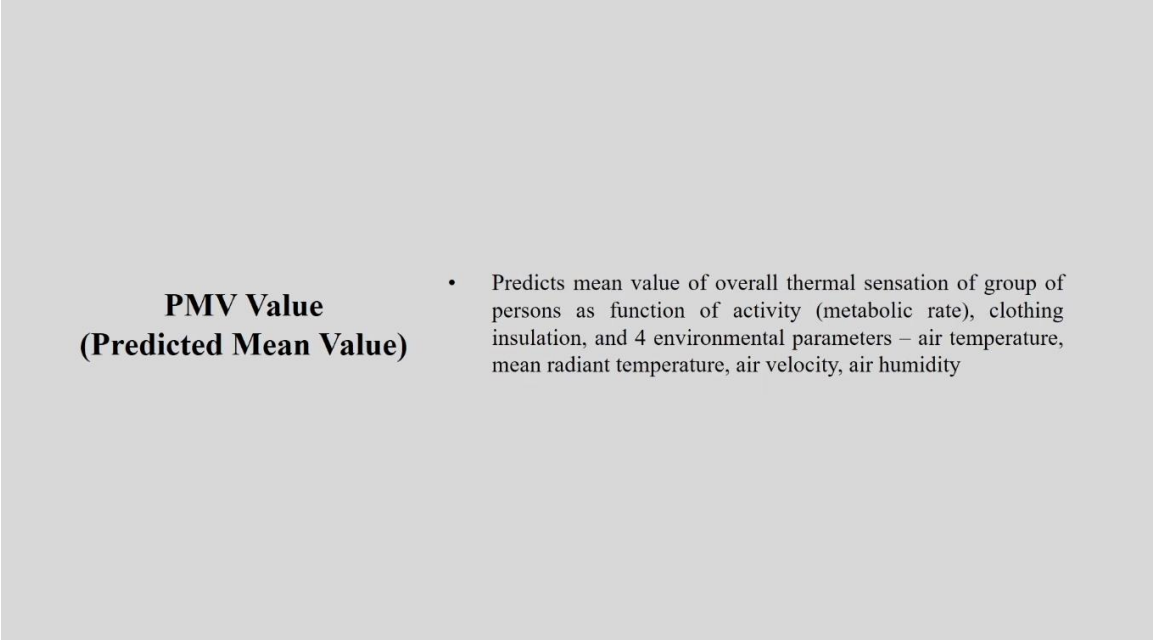
Work/Rest Regimen		Work Load (WBGT in °C)		
		LIGHT	MODERATE	HEAVY
continuous work (per hour)		30.0	26.7	25.0
75% work	25% rest	30.6	28.0	25.9
50% work	50% rest	31.4	29.4	27.9
25% work	75% rest	32.2	31.1	30.0

Permissible Heat Exposure Threshold Limit Values

So what is the permissible heat exposure? Here I have a chart it is not that it is referred from definitely the original paper. So what it says we see here the work and rest regimen. So 75 percent work and 25 percent rest if that is the combination, then WBGT index you can see if it is light, then it is this, this and like this ok. So if you have temperature of this, then you with this particular condition that 75 percent you are working and 25 percent you are taking rest. You are getting stress of this ok. So that is the permissible value. Now if you see in your situation it is beyond your permissible value, definitely there is a chance for introducing your design intervention. So that is why being a designer, being an ergonomist, we practice to understand the heat stress indices in this particular context ok. So coming to the thermal comfort indices.



So what thermal comfort indices? So it represents the exposure of the human body to atmospheric conditions, air temperature, humidity, wind and the radiation; measure of the human physiological response to thermal environment.



So very basic one is the PMV. I mentioned it earlier that is the predicted mean value. So predicts mean value of overall thermal sensation of group of person. So it is not a single person. It is a group of person as function of activity, clothing, insulation and four environmental parameters that is the air temperature, mean radiant temperature, air velocity and air humidity. So when we are talking about a group of people giving their

comfort responses you know considering clothing the activity that they are performing and other environmental parameters, that is the temperature, air temperature mean radiant temperature, air velocity and air humidity that we will consider the predicted mean vote or mean value ok.

Measuring PMV Index

- Measurements made in occupied zone – workstations or seating areas
- Can be directly measured via integrated sensors
- Complicated and practically unsuitable mathematical expression
- Calculated via computer codes based upon ISO 7730 and ASHRAE 55-1992R

Parameter	Range
PMV value	-2 to +2
Metabolic Rate	0.8 met ot 4 met
Clothing Insulation	0 clo to 2 clo
Air Temperature	10°C to 30°C
Mean Radiant Temperature	10°C to 40°C
Relative Air Velocity	0 to 1 m/sec

Recommended Range for using standard PMV index

So how do we do that? So we measure means made in a particular occupied zone that is the workstation or in a area where people are working can be directly measured via integrated sensors and complicated by and particularly unsuitable in a you know mathematical expression. This is not possible and you can see that this particular this one. So ISO this is being adapted for for PMV ok. So PMV value and metabolic rate that is the you know you can see the ranges are mentioned here. So these are the recommended range for using standard PMV index. So you can use these as a parameter and these are the ranges available, so you can use this particular thing and you can get your PMV value for your you know tested scenario.

PPD Value (Predicted Percentage Dissatisfied)

- Derived from PMV index, predicts percentage of thermally dissatisfied persons among a group
- Buildings & vehicles w/ different HVAC systems (heating, ventilation, air conditioning)
- Different combinations of activity, clothing habits and environmental parameters

The next one very important one is the PPD. PPD value is the predicted percentage dissatisfied. So it is derived from the PMV index and predicts the percentage of thermally dissatisfied persons among a particular group. So buildings and vehicles with respect to different HVAC system whereas we are talking about heating, ventilation, air conditioning and everything ok. Specifically when we are talking about you know in a specific working environment in a building. So those cases we use this particular index, comfort thermal comfort index ok. So different combinations of activity, clothing habits and environmental parameters you know get actually affect this PPD value.

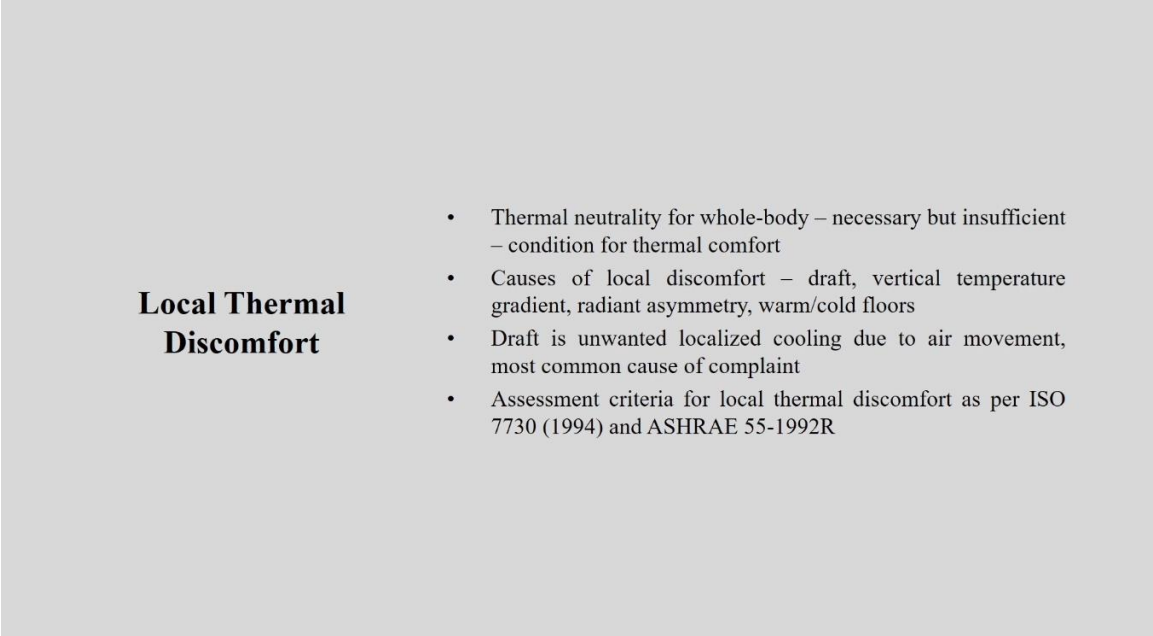
Measuring PPD Index

- Individual thermal sensations scattered around the mean value
- Predicting number of people likely to feel uncomfortably warm or cool
- Determine via 7-point thermal sensation scale
- For acceptable thermal conditions:
  10% dissatisfaction criterion for whole-body thermal comfort, corresponding to PMV range -0.5 to +0.5

+3	+2	+1	0	-1	-2	-3
hot	warm	slightly warm	neutral	slightly cool	cool	cold

7-point thermal-sensation scale

So how do we measure it? It is based on a 7 point thermal sensation scale where whereas plus 3 talks about it is a hot environment whereas minus 3 talks about cold environments. All are verbal expression. So individual thermal sensations scattered around the mean value and it predicting number of people likely to feel uncomfortable, warm or cool. So uncomfortability can be warm, can be cool as well ok. And this is the scale that we use for the PPD index.

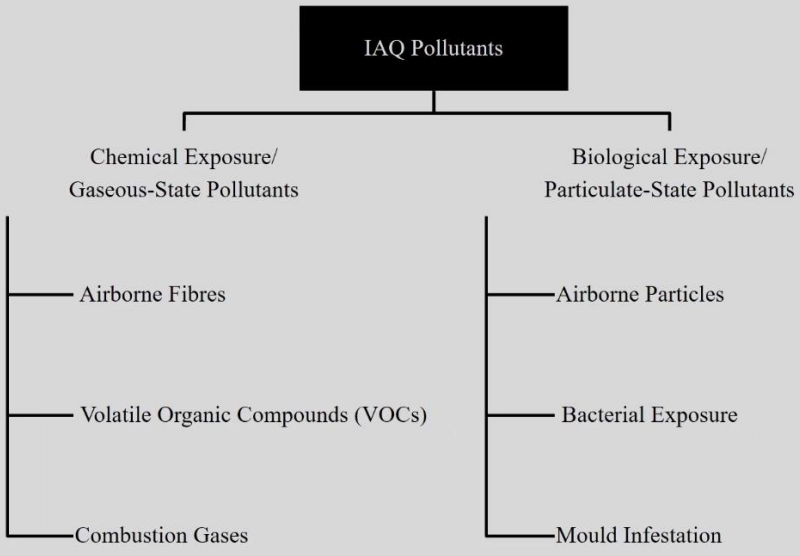


Now local thermal discomfort is also very important for us to understand because many cases maybe we may not use PPD or PMV. So those cases we use local thermal discomfort. So what it is? So thermal neutrality for whole body that is the necessary, but insufficient you know maybe it is insufficient and condition of for the thermal comfort. So those cases we use local thermal discomfort and causes of local thermal discomfort may be draft, vertical temperature gradient. So maybe you are standing in a particular position where you have different temperature at ankle level, different temperature at abdomen level and different temperature at your head level. So because of this difference in the, it is a gradient change ok. So because of that you may develop some kind of thermal stress and how comfortably you are handling it that talks about the local thermal discomfort. So it is local, very much local right. So that is why we talk about local thermal discomfort. So ASHRAE also follow this and ISO also follow this. Now once we finish the thermal, thermal environment it is very important that when we are breathing, when we are in a particular workspace, so the kind of air we are consuming, what is the quality of it? Is there any kind of, is it going to affect your performance? Of course it is going to affect your performance. So we also consider the air quality measurement in the physical environment measurement category when we talk about the ergonomical evaluation of any particular workplace.

Introduction

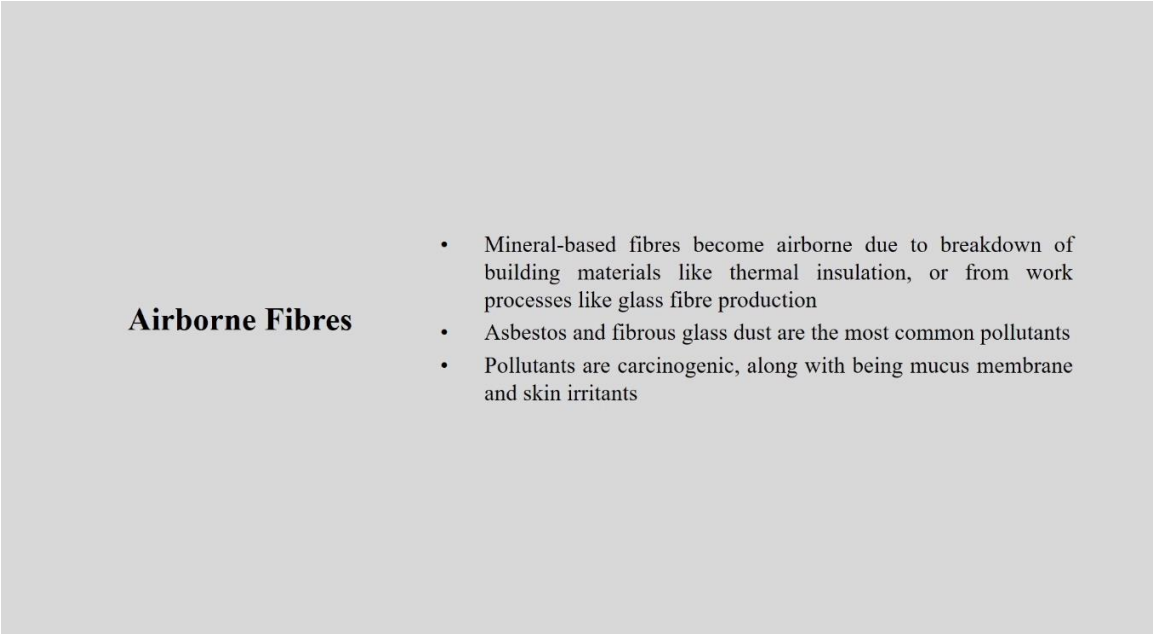
- Indoor Air Quality (IAQ) plays a crucial role in all of the environmental factors.
- Defined by pollutant concentrations and thermal conditions within a building affecting health, comfort and performance of the occupants.

So indoor air quality plays a crucial role in all of the environmental factors. It is defined by the pollutant concentration because you know whatever is available when we are inhaling, what is the kind of concentration of those pollutant and thermal conditions within a building affecting the health, comfort and performance of a particular occupant.



So when we talk about air, indoor air quality is very important. We are talking about right now the indoor air quality. We have two separate divisions. One is the chemical exposure or gaseous state pollutant, another is biological exposure or particulate state pollutant. Among this chemical exposure we have airborne fibers, we have volatile

organic compounds, we have combustion gases. We may not discuss all three, maybe we will be discussing any one of them. Whereas we talk about biological, here also we have airborne particles, bacterial exposure and mold infection. Here also we will be discussing one of them.

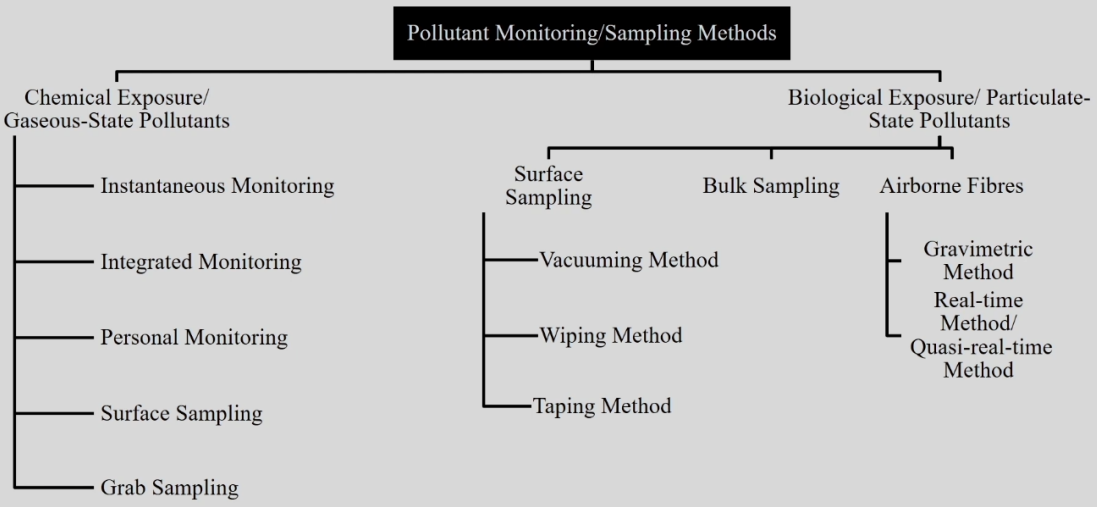


So first discuss airborne fibers. So it is mineral based because we are talking about airborne. So it is a mineral based fibers when it becomes airborne due to the breakdown of the building, material like thermal insulation or from work processes like glass fiber production. So suppose you are working in a place where lot of dust is coming which is due to work. So those type of cases and it is like asbestos, silica and fibrous glasses dust are most common pollutant if we talk about the airborne fibers. And pollutants are carcinogenic definitely and along with being mucous membrane and it is a skin irritants. Mostly these are all skin irritants. So it is very important for us to know that how, what are the varieties of airborne fibers available and which is affecting the indoor air quality.

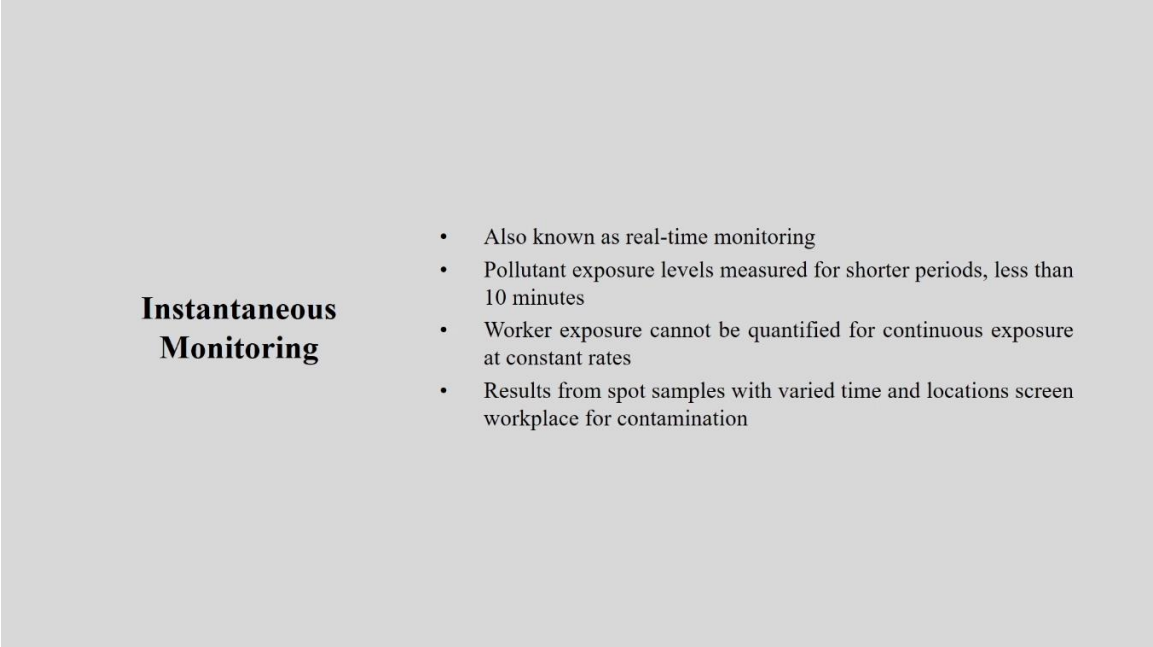
Airborne Particles

- Defined by particle concentrations within buildings
- Measured by using different instrument sampling methods
- Airborne particles categorised according to size ranges – inhalable (≤ 10µm) and respirable (≤ 2.5µm) particles

Now coming to airborne particle, it is defined by the particle concentration within a building and it is measured by using different measurement sampling method like airborne particles categorized according to the size of the ranges. So if it is less than 10 micrometer then it is inhalable. Whereas, respirable if it is less than 2.5 micrometer particle. So that way we actually try to understand. There are varieties of instruments available. You can, so dust analyzer and many other instruments available which you can use to understand the air, indoor air quality. Now you can use airborne particle if it is there. So that way you can evaluate them.

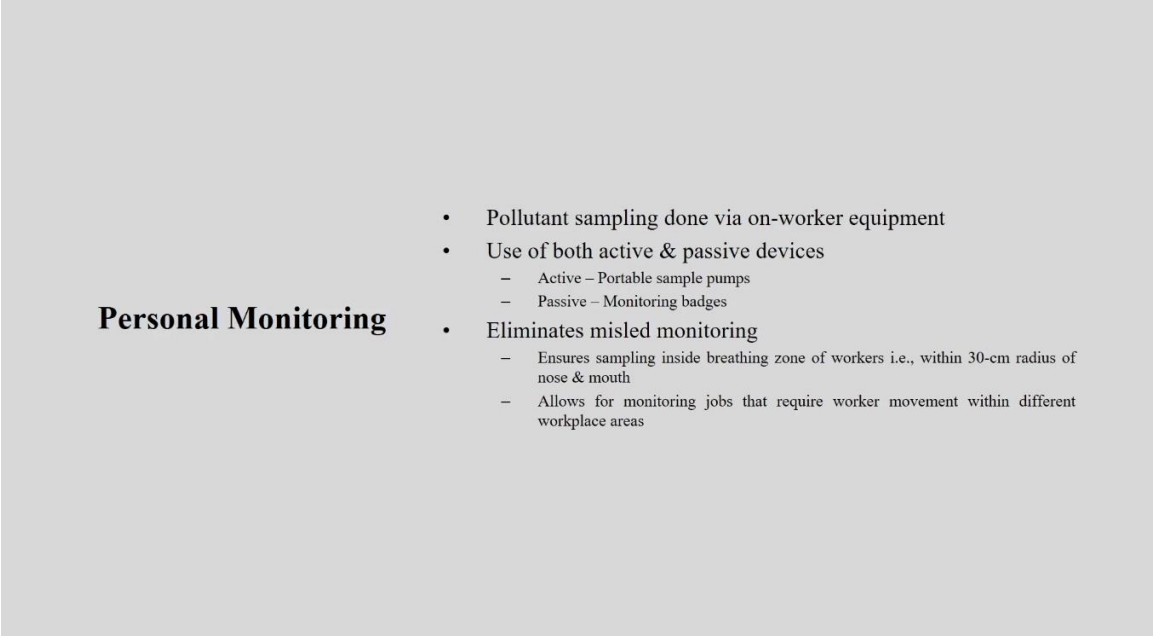


Now coming to the pollutant monitoring and sampling method because you understand that what are the things available in you. Now you need to measure or you need to monitor the pollutants available in the indoor air environment. Okay. So if we talk about the chemical exposure and biological exposure, maybe we have very specific method or sampling technique or pollution pollutant monitoring process. So if we talk about the chemical exposure or gaseous state pollutant, we have instantaneous monitoring system, we have integrated monitoring system, we have personal monitoring system, surface monitoring system or surface sampling and the grab sampling. So these are all the process can be adapted when we talk about the chemical exposure. Whereas we talk about the biological exposure, we have surface sampling, we have bulk sampling and we have airborne fibers. Among the surface sampling, we have vacuuming method, wiping method and tapping method. Whereas for the airborne, we have these two method. Now concern is these are all very much detailed method. So within this, this may be the out of the scope of this particular discussion. So I will be introducing few of them in next slides. So when we are talking about the pollutant sampling technique for gaseous state pollutants, I will introduce you to the instantaneous monitoring.



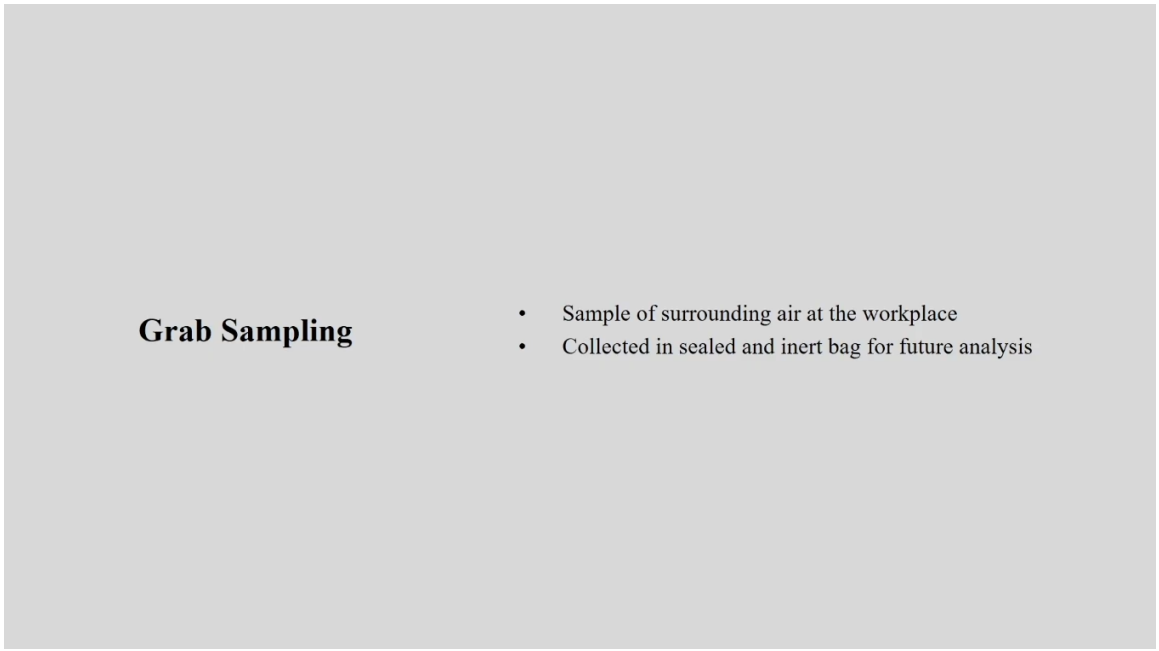
What it is? It is also known as real time because we are talking about instant. Instant we are going to measure it. So pollutant exposure levels measure the shorter periods less than 10 minutes. So worker exposure cannot be quantified for continuous exposure at a constant rate and it may results from a spot sampling. So you have the instrument, you are there when your worker is working and you are doing the spot sampling with a varied time and location wherever you are going, you are doing that. That is the instantaneous monitoring. Whereas integrated monitoring also is a continuous process, but it is little different than the instantaneous. What it is? It is pollutant exposure level

measured for a longer period like from 15 minutes to kind of hours or maybe 1 hour, maybe 2 hour, maybe 3 hours like that. So workers exposure can be quantified and interpreted multifacetedly and highly efficient exposure assessment practice for known pollutants and areas of concern within a particular workplace. Now here it is very important that you should, if you know the kind of pollutant you have within the air, then you can measure what is the kind of concentration, how it is varying due to time changes. So that is why this integrated monitoring system is important for anyone to know.

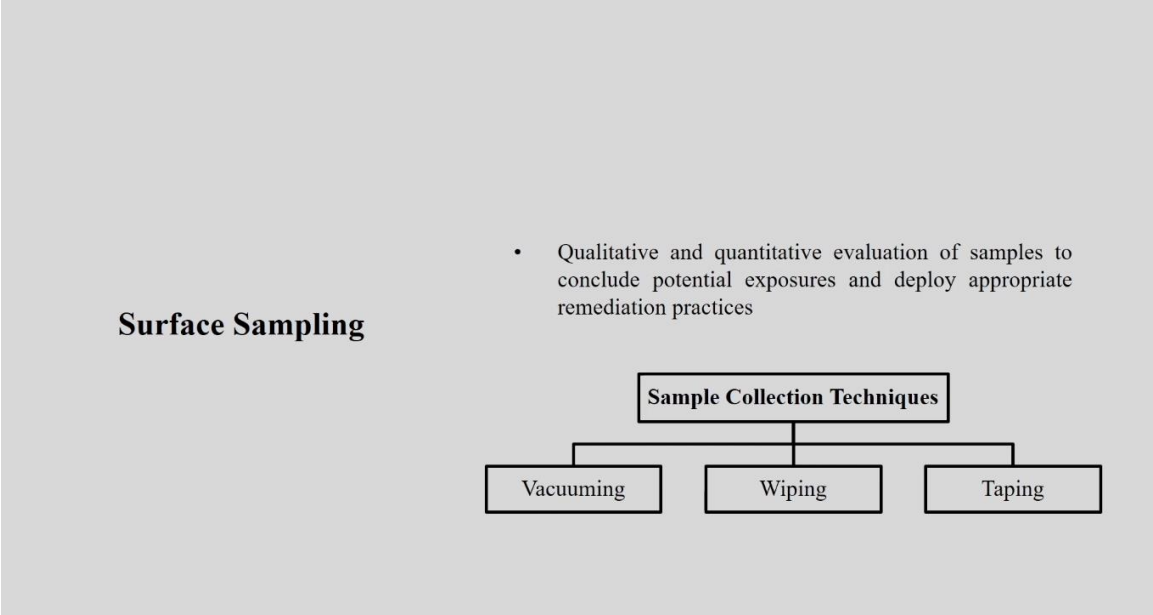


Then definitely personal monitoring. This is also very useful method. So it is the pollutant sampling done by a particular kind of instrument, any maybe dust monitor or dust sampler which is for a particular worker. So very important on a particular worker which is placed within that particular worker and the equipment is attached to that particular worker. So use of both active and passive devices. So if we talk about active, that is the portable sample pumps maybe and passive monitoring badges. So it eliminates the any kind of misleading monitoring because you are on the sampling is done for a particular person when the person is working. So the monitoring system is placed on the worker. So it is very important and it is a very dynamic process altogether.

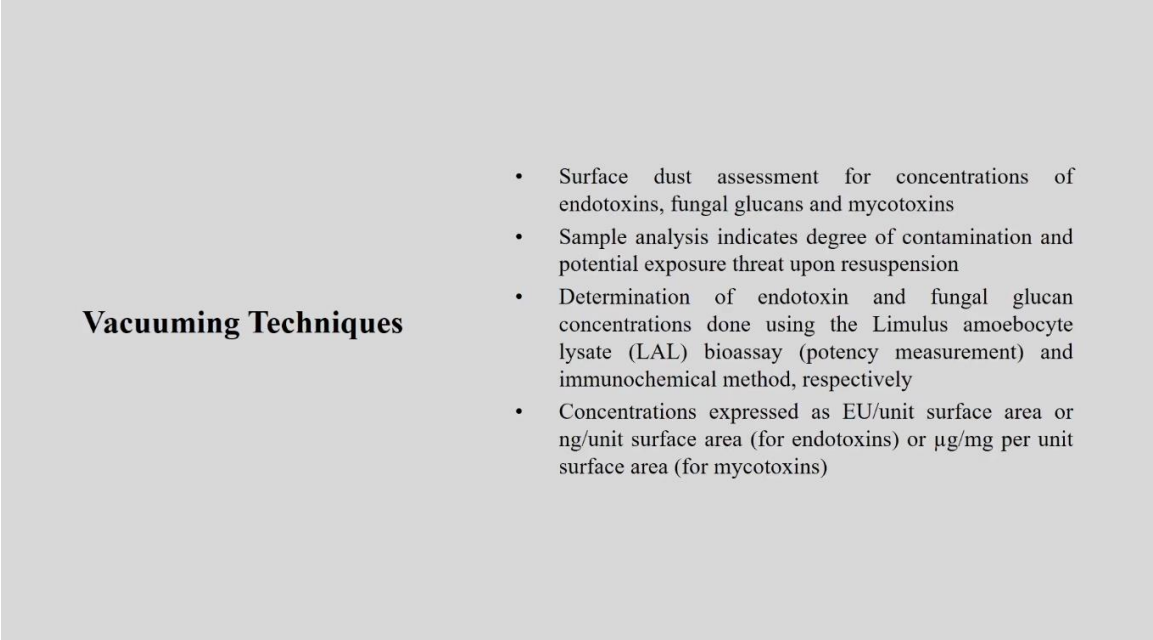
Now when we are talking about surface sampling, like when there is a workplace, there is a surface, how do you collect sample of it? So it is performed on a fiber or particle contaminants and exposure caused via direct connect and inhalation. Also the sampling accumulated dust from a workplace surfaces. This is very also good way where you need to know lot about the overall workspace. It is not about individual exposure, you are talking about the overall exposure level.



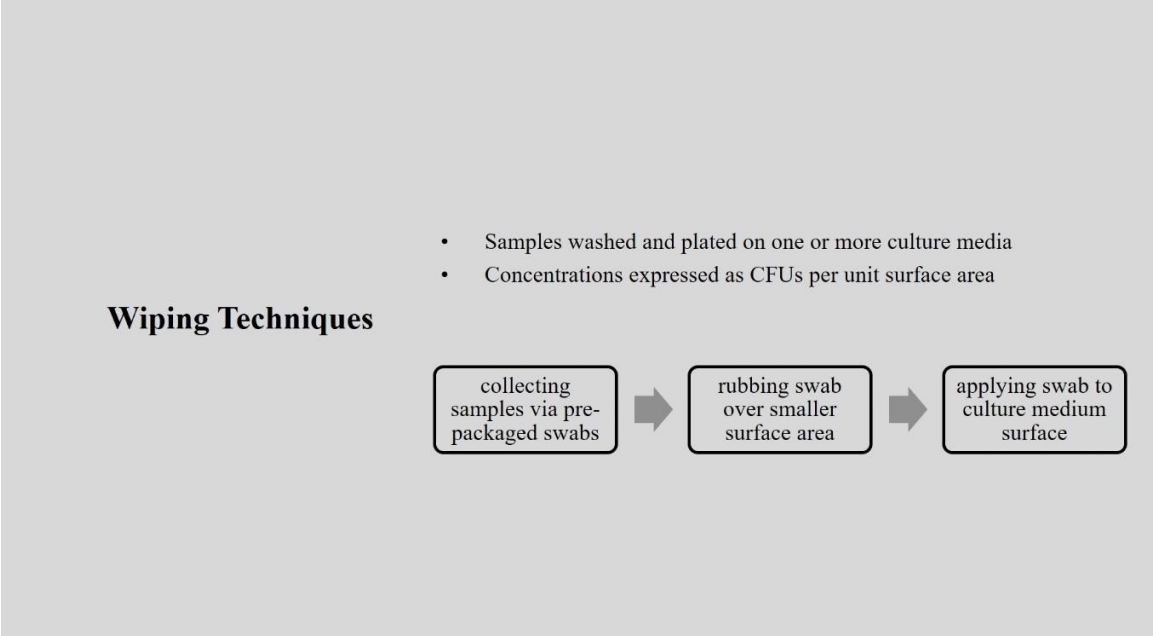
And grab sampling, it is the sample of surrounding air at a particular workplace and collect in a sealed and inert bag for future analysis. So you take it and you analyze it later. So that is all about the grab sampling.



Moving further, when we are talking about the other part, so when I discussed this, you can see that we have chemical exposure under that all this and when we are talking about the biological, we have surface, we have bulk and airborne fibers. So let us discuss the next part. So this is vacuuming, wiping and tapping.



So what is vacuuming technique? So the surface dust assessment for concentration of endotoxins, then fungal glucans and mycotoxins, all these things when we are going to assess from the surface. And the sample analysis indicates degree of contamination and potential exposure threat upon the resuspension. So there is a suspension, again one suspension and then so it is happening. So determination of endotoxin and the fungal glucan concentration done, maybe you can do use the, we call it this particular instrument that is the LAL. So that is Limulus Amiobiotic. So it is like you know you talk about lot of biological elements. So that is the instrument that you use where they do the bioassay. They do the bioassay and this particular thing gives you a very good understanding what are the kind of concentration you have in terms of fungal, in terms of endotoxin, in terms of mycotoxins. So that is all about the vacuum techniques.



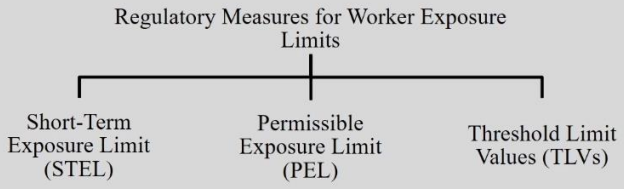
Next is wiping technique. It talks about the collecting via prepackaged swabs. You have prepackaged swabs and rubbing the swabs over a smaller surface area and applying the swabs to the culture medium surface. And then you check what are the varieties of, what is the kind of growth you have in that particular culture. So you can actually retrospect that like if this is the kind of growth you have, then what was there at the surface level and then how it is going to affect and what is the kind of variety it has. So that is called the wiping. So what you are doing? Actually while collecting the sampling through wipe method. So that is why it is called wiping technique.

Taping Techniques

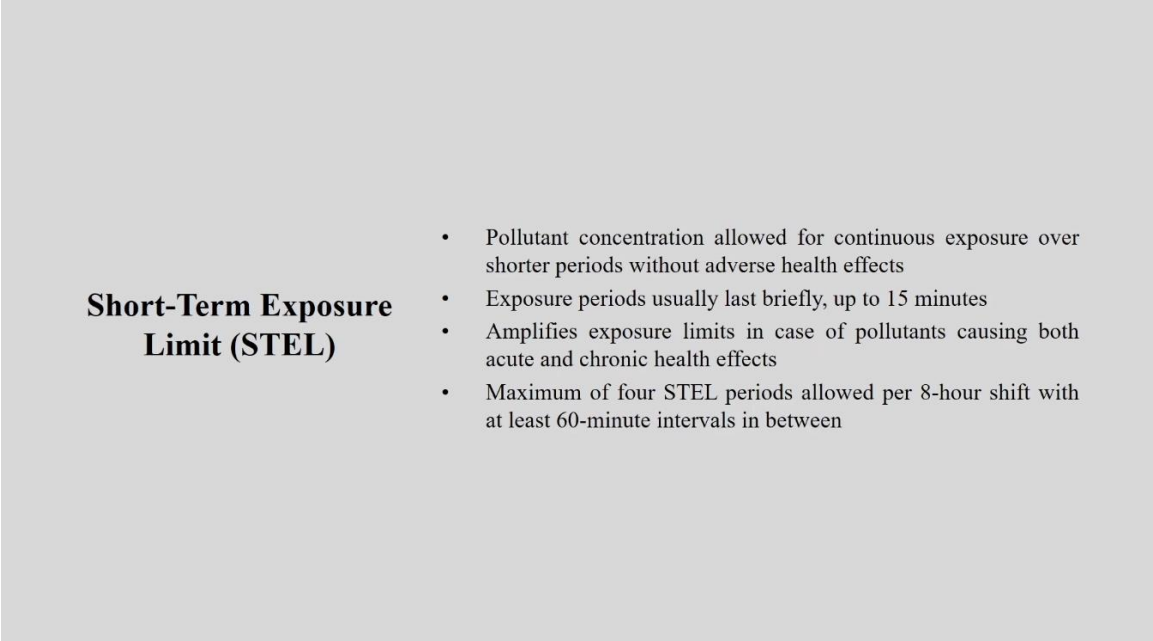
- Used to identify major mould genera (distinct mass of fungal root i.e., mycelium) present on infested surfaces
- Analysis performed by using light microscopes w/ 100-1000x magnification
- Specifically evaluates presence of specific mould types, allowing effective deployment of correction or prevention strategies

The last one is the tapping technique. It is used to identify the major mold genera and analyze the, analysis is performed by using the light microscope with respect to 100 to 1000 magnification. And specifically evaluates the presence of specific mold types because it is like categorization; allowing the effective deployment of correction and prevention strategy. Because if you know this is the specific category is present, definitely you can take measure against it. Okay. It is not generic. It is very specific identification. That is the tapping technique.

Exposure limits



Now if we talk about all those things what is the kind of exposure limits that we can think of. So we have short term exposure limit that is the STEL, then permissible exposure limit that is PEL and the threshold limit that is the TLV. So let us discuss in a very short what these STEL, PEL and TLV.



So STEL is the pollutant concentration allowed for the continuous exposure over shorter periods without any kind of adverse health effect. So exposure periods usually last briefly about 15 minutes and it amplifies exposure limits in case of pollutants causing both acute and chronic health effects. So maximum of 4 STEL period allowed per 8 hours shift with at least 60 minutes interval in between. So if you do follow this rule then there will be no hazard or minimal hazard at the exposure level. Now permissible. How much you can give the permission to expose.

Permissible Exposure Limit (PEL)

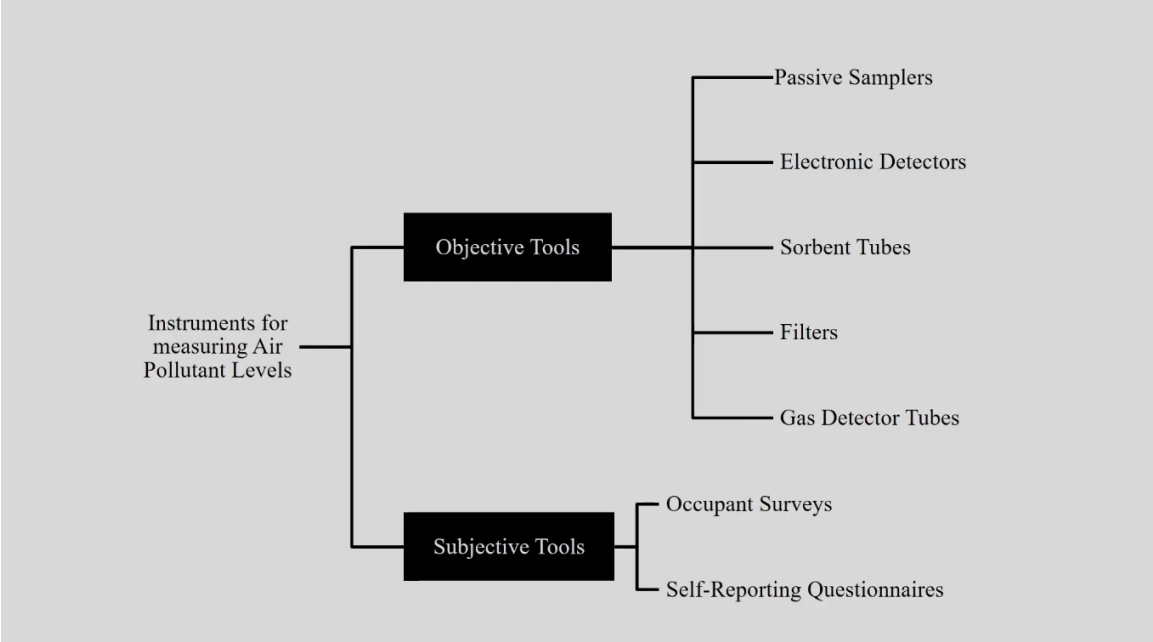
- Maximum pollutant concentration allowed for exposure (continuous or intermittent) without any critical health effects
- Defined via following:
  - Ceiling Values (VLG) – Pollutant exposure limits not to be exceeded at any time
  - Time-Weighted Average (TWA) – Pollutant exposure limit calculated for 8-hour shits

Okay so the maximum pollutant concentration allowed for the exposure without any critical health effects. So it is defined via like you know either ceiling value or time weighted average either the ceiling value that is the top maximum after that you are not going to allow or the time weighted. So within this time this much and if time increases then less if time lower down then exposure limit may increase so time weighted. So ceiling value we call it the pollutant exposure limits not to be exceeded at any point of time. Whatever time it is you should not exceed this much. Okay that is the ceiling whereas time is the pollutant exposure limit calculated for 8 hours shift because that is the allowed time of any kind of work shift.

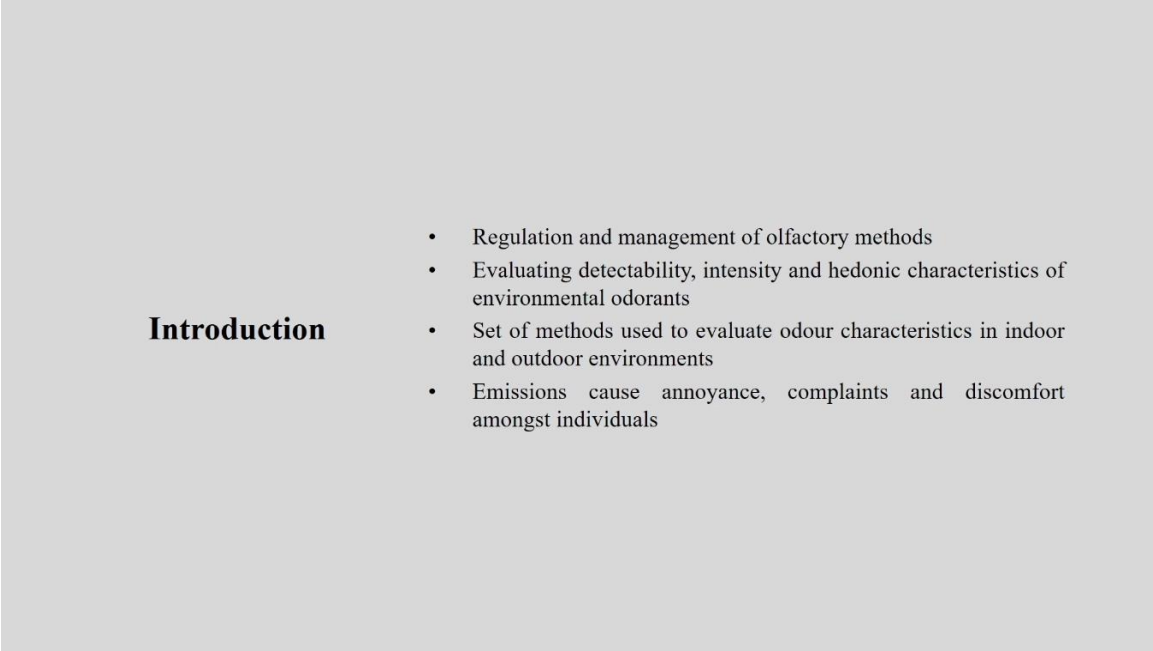
Threshold Limit Values (TLVs)

- Published by American Conference of Governmental Industrial Hygienists (ACGIH, 2003)
- Values available for more than 700 pollutants
- Guidelines indicating worker exposure allowed w/o unreasonable health risks – disease or injury
- Used for assistance in decision-making of workplace safety protocols dealing w/ exposure levels

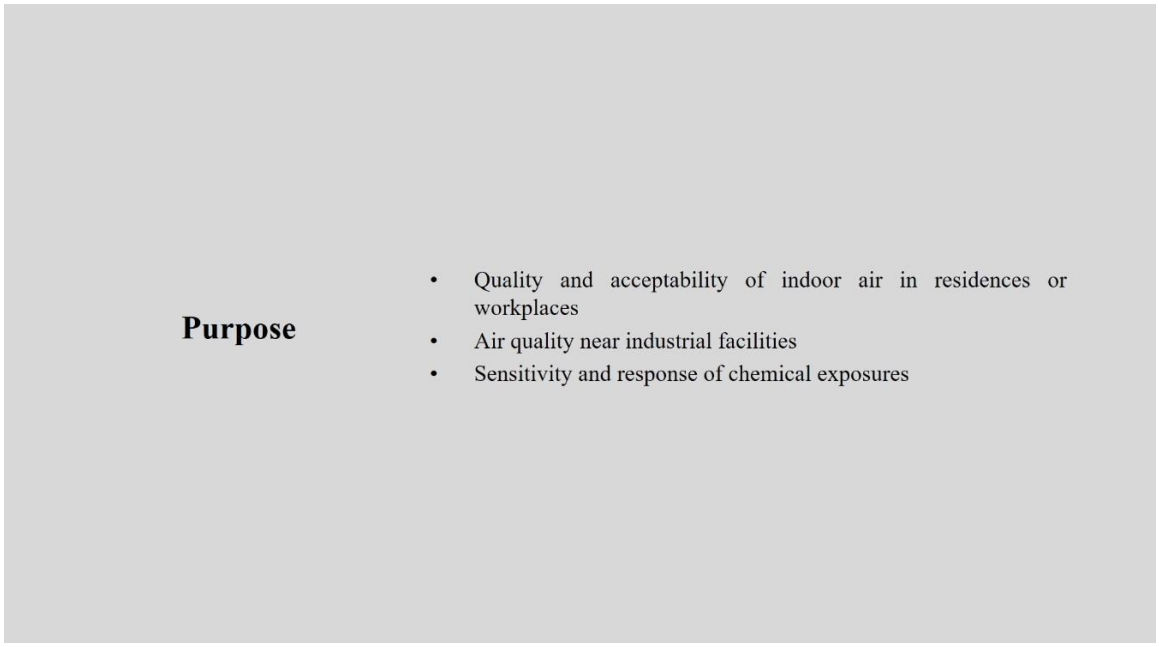
Threshold limit value this is very very important and what we can say that American conference of government and governmental industrial hygiene they publish it and values available for more than 700 pollutants. Okay so threshold value of more than 700 pollutants it is available and you can use that reference and you can use any one of the value according to your requirement. Okay so that is the threshold limit value. So it is used for assistance in decision making of workplace safety protocols dealing with the exposure level fine.



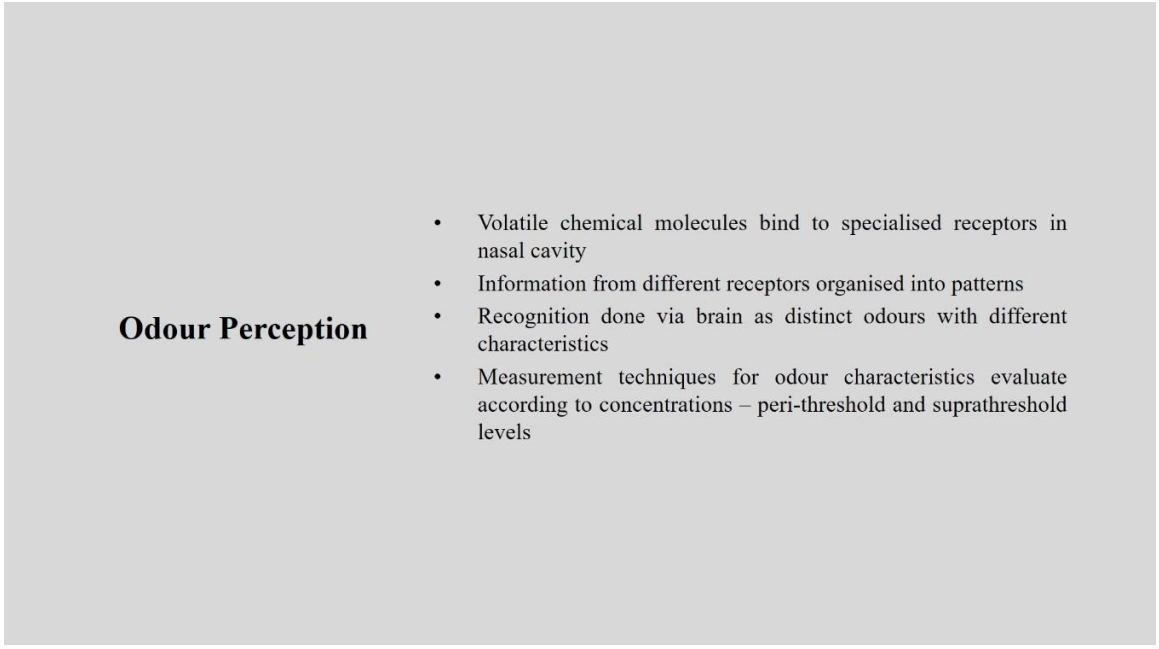
Now instruments whatever is required for the measuring the air pollutant level. So there are something called objective tools there are something called subjective tools. So when we are talking about objective tools we have passive sampler, electronic detectors, sorbent tubes, filters, gas detectors. Whereas we are talking about subjective we have occupant survey and self reporting questionnaire. All are easily available tool you can pick any one of them according to your best fit in your situation. Okay all those things when we are talking about air quality indoor air quality then it is very important for us to know the olfactory also. It is not about the amount of gaseous or biochemical elements are present how it is affecting your olfactory system. This is also very important that is why I want to introduce you to the olfactory.



So the regulation and management of the olfactory methods are available so you can pick any one of them according to your requirement and evaluating the detectability, intensity and hedonic characteristics of the environmental ordinance. It is very important because if the olfactory is not really convenient for you however you have good air quality indoor air quality you will not be able to work. So that is very important so set of methods used to evaluate the any kind of order characteristics in any indoor or outdoor environment and emissions causes annoyance because definitely if it is it is a very bad smell definitely you will not be able to stay there. So it cause annoyance, it cause complaints, it cause discomfort. So understanding the olfactory of a particular working environment is very important.

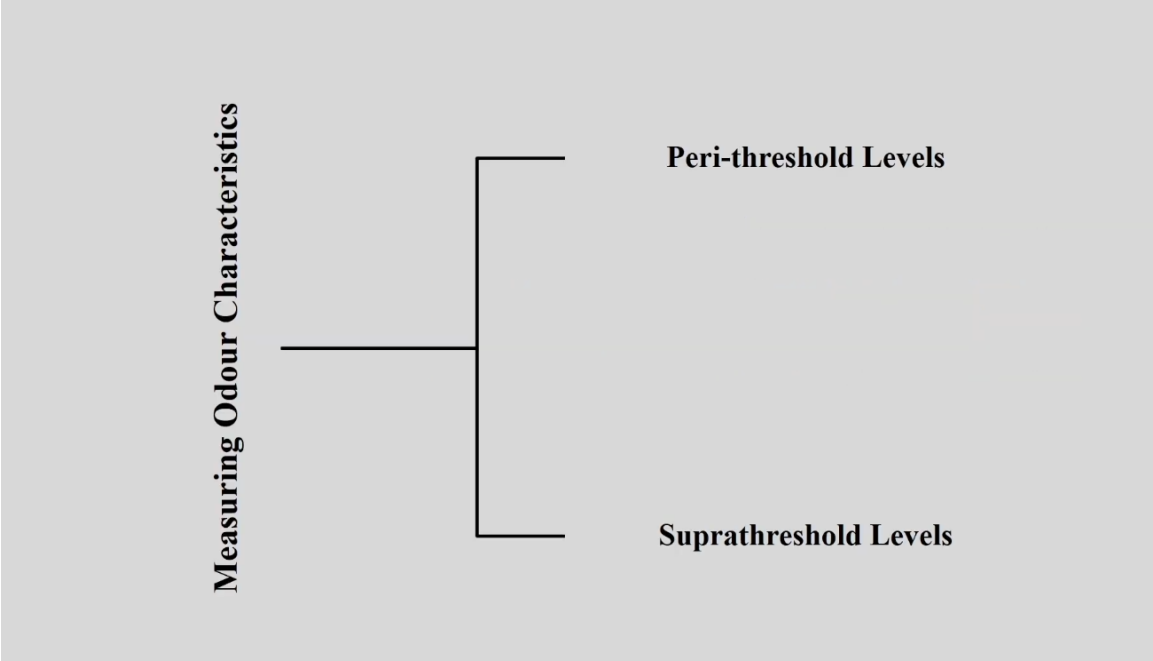


So what is the purpose of doing it? So quality and acceptability very important terminology that is the acceptability. However we can ensure the indoor air quality through thermal you know through kind of wind speed it has and all other factor. However if there is any very odd order is present then that is not acceptable by the worker. So acceptability of the indoor air in a particular workplace. So air quality near the industrial facilities and sensitivity and responses of the chemical exposure.

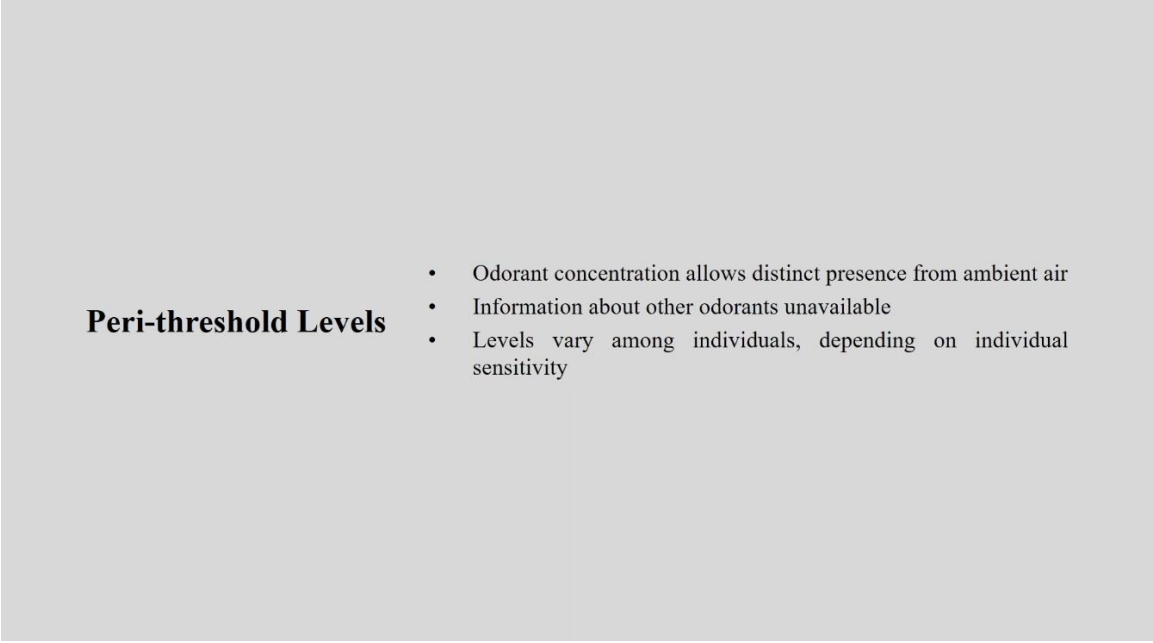


So order perception because we are talking about order so we need to understand it is a perception by the person. So it is a volatile chemical molecules bind to specialized

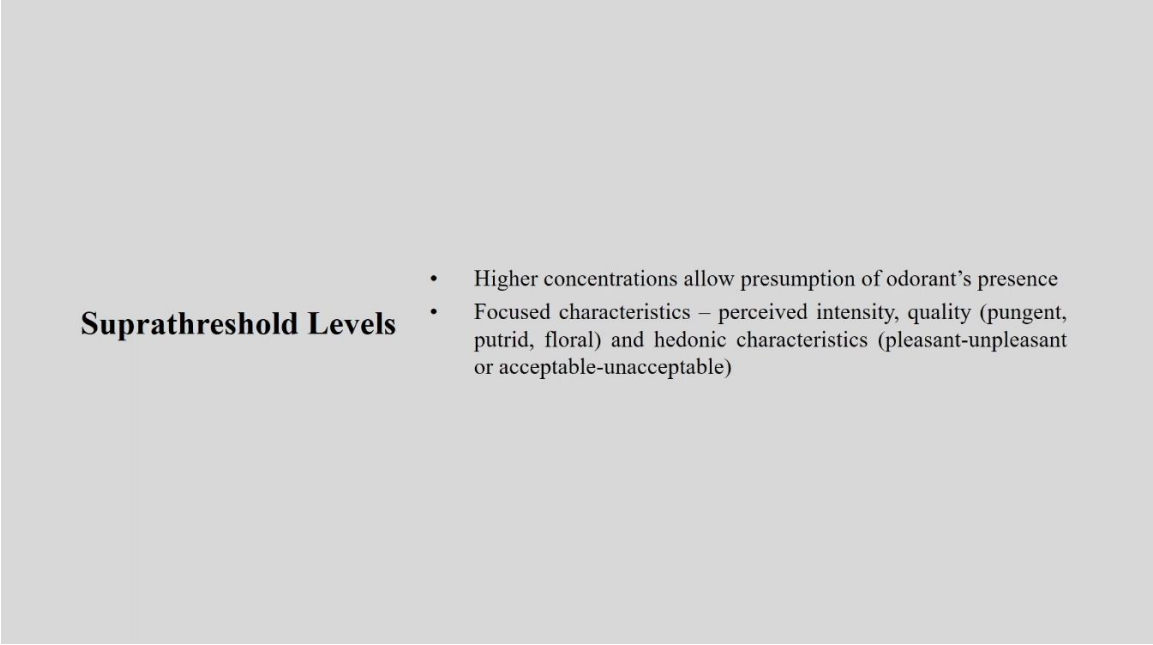
receptors in a nasal cavity and it gives you the perception. So information from different receptors organized in a particular pattern and recognition done by a brain as distinct order with different characteristics.



So measurement techniques for order characteristics evaluate according to the concentration. So pre-threshold and supra-threshold level. Now when we are talking about sorry peri-threshold and supra-threshold. So measuring the order characteristic we need to follow these two separately.



Now when we are talking about peri-threshold we know that is the ordinate concentration allows the distinct presence from the ambient air. Information about other odorants unavailable because if this is specific one is available then maybe other things are not available. So levels vary among the individual depending on the individual sensitivity. It is not same for everyone. I may be very much sensitive to a particular fragrance, however my colleague may not be sensitive towards that fragrance. So if that fragrance is present that may not affect him or her, but it may affect me. So how these things are being taken care you should know beforehand you set up the workplace.



And supra-threshold that is the higher concentration allows the presumption of odorant present and focused characteristic that is the perceived intensity, quality and hedonic characteristics.

Measuring Odour Characteristics

Exposure Level	Odour Characteristics	Index	Method
Peri-threshold	Detectability	Odour Detection Threshold	• Statis Olfactometry • Dynamic Olfactometry
Suprathreshold	• Intensity • Hedonics • Quality	• Intensity Rating • Acceptability and Annoyance Ratings • Descriptive Labels	• Scaling Methods • Qualitative Descriptive Analysis

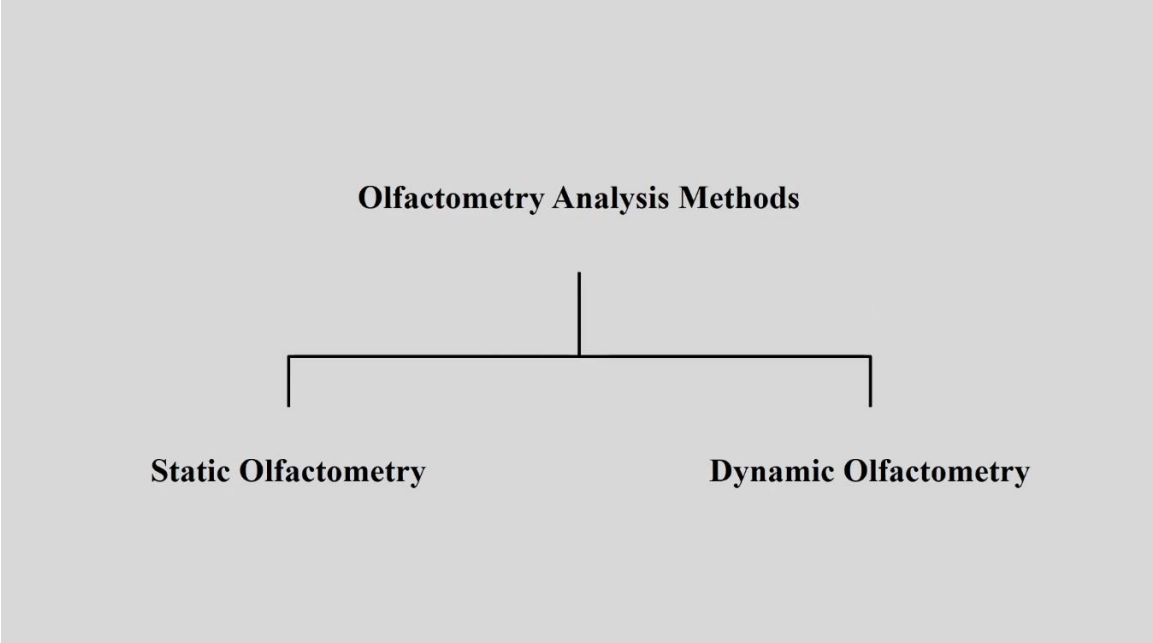
Relevant Odour Characteristics and Assessment Methods

Now how do we measure? Here also we have if we talk about the peri-threshold, we have detectability, how do we detect it, order detection threshold, static olfactory and dynamic olfactory. And if we talk about the supra-threshold, we have intensity, we have hedonics and we have quality. So these three things you can characterize and intensity rating, acceptability and annoyance rating because you have scale you see that what is the acceptability and what is the annoyance and the descriptive level. The kind of method we use for that that is the may be scaling as I mentioned and qualitative descriptive analysis. So you just ask people about this thing. So these are the method or tool you can use for the peri-threshold and supra-threshold. Now when we are talking about olfactory, we should know what are the modalities available.

Olfactometry Analysis

- Standardised methodology for determining concentration of odours, along with instruments – olfactometers, used in the presence of human panellists

So standardized methodology for determining the concentration of odors along with the instruments that is the olfactrometer and used in the presence of any human panelist so that you can do it. It is very important some cases because in some chemical industries these are very very sensitive issues and you should take care of them.



So when we are talking about olfactory analysis, we have static, we have dynamic.

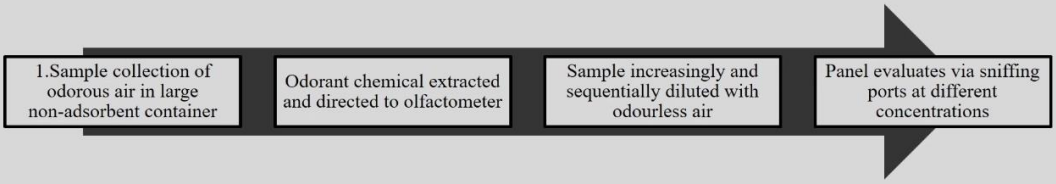
Static Olfactometry

- Fixed concentration of odour presented as liquid chemical in closed container
- Stimulus – Odourised air or headspace over liquid
- Different concentrations dissolved in odourless diluent according to predetermined sequence – binary/tertiary/logarithmic series
- Stimulus of interest
- Amount of odorant available to the subject's nose
- Concentration of odorant in vapour phase i.e., headspace
- Vapour-phase concentration assesses via gas chromatography
- Concentrations expressed in parts per million (ppm) or parts per billion (ppb)

So what is static? We are talking about fixed concentration of a particular odor present as a liquid chemical in a closed container. So it is a fixed. It also talks about the amount of odorant available in a subject's nose because if it is there in the environment how it is coming to your nose and the vapor because it may vaporize. So that is all about the static.

Dynamic Olfactometry

- Continuous & regulated gas flow containing odourised air delivered w/ varying proportions of odourless carrier gas
- Used to determine presence/ odour response of particular chemicals
- Unknown compositions of gaseous mixtures sampled from environments can be determined –alternative for laboratory reproduction



Now coming to dynamic how do we do? First we sample collect from the odors in a large non-absorbent container, then odorant chemical extracted and directed to the olfactrometer because you have an instrument named olfactrometer you direct it to them

and then sample increasingly and sequentially diluted with the odorless air. Because you have a component which is having odor and you are slowly diluting it. So it is a dynamic process that is why it is dynamic olfactrometer and panel evaluates via sniffing the ports at different concentration, because you have slowly diluting. So here the concentration is this, concentration is this, concentration and slowly when something comes which is odorless. So how it is happening? So how long it is taking? So that process is the dynamic olfactrometry. So that is all about the indoor air quality environment and how do we take care of them in a particular workplace. In the next class probably we will be talking about some component in the noise, vibration and illumination and then we will be finishing our course. Thank you.