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PHYSICAL FACTORS IN ENVIRONMENT

Distribution of physical factors

Waves	Mechanical waves	Noise	
		Vibrations	
	Electro-magnetic waves	Non-ionizing radiation	Radio waves, Microwaves, Radar waves, Infrared radiation, Visible light, Ultraviolet radiation
		Ionizing radiation	alpha, beta, gamma, X-rays
Thermal comfort	Climatic factors	Air temperature, Air humidity, Speed of air flow, Intensity of heat radiation	
	Individual factors	Activity, Thermal resistance of clothes	

Sound waves

Noise

- **Noise = Any sound having disturbing or troubling character, or having damaging effects**
- The range of usual noise level values is 0-140 dB.
- The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect.
- Frequencies that may be perceived by the human ear vary from 20 to 20 000 Hz.
- The range of frequencies below than 20 Hz is called infrasound, the range above 20 kHz, is called ultrasound.

Types of noise

- **Steady state** – noise the level of which does not change more than 5 dB at given place and during given time period, such as the sound of a waterfall.
- **Fluctuating noise** – noise the level of which changes by more than 5 dB at given place and during given time period.
- **High-frequency noise** – noise with expressive components in frequencies higher than 8 kHz.
- **Noise with tone components** – noise, the spectrum of which contains tone (discrete) components with levels of acoustic pressure higher by more than 5 dB than surrounding frequency areas.
- **Impulsive noise** – noise produced by individual sound impulses in duration up to 200 ms or by series of such impulses following each other in intervals longer than 10 ms.

Noise – influence on humans

- Some sounds are noises only at certain times, in certain places, to certain people, e.g. some types of music.
- An important factor of disturbance is also the informative content of the sound. Usually, the conversation is more disturbing that an indifferent sound (music, humming).
- On the contrary, indifferent sounds are used in many cases to mask sounds with disturbing information.

Noise – influence on humans

The damaging effect of noise:

- a direct damage to hearing;
- acoustic trauma caused by levels of noise over than 140 dB;
- a rustle in ears;
- system changes or symptoms as an increase of blood pressure or some immunological changes;
- permanent functional changes, changes in work effectiveness, the extent of fatigue after working hours or the quality of sleep.

Noise – influence on humans

- The severity of damaging effects is given by the dose of energy received.
- Strong intermittent sounds with tone components and/or with impulses are biologically more effective than soft and steady sounds. The intensity of noise:
  - above 120 dB can damage cells and tissues;
  - above 90 dB are dangerous for the organ of hearing;
  - above 60-65 dB for the vegetative system;
  - above 30 dB for nervous system and psychic state.

Noise – influence on humans

- Repeated exposure to excessive noise levels results in a noise-induced hearing loss.
- Its effects on the hearing apparatus appear usually after a long period of time (for levels about 80 dB even after 10 – 15 and more years) when the damage is usually irreversible.
- Another important thing is that a man is usually unable to find out the changes in his hearing because here the objective comparison is missing.
- We don’t know what we have to hear, and what we don’t have.

Examples of noise levels

Source of a noise	Noise level [dB]
Leaf noise in low wind	10
Whisper (a very quiet apartment and a very quiet street)	30
Muffled speech	40
Loud speech	60
Heavily busy street	70
Subway tunnel	80
Train (moving)	90
Pneumatic hammer	100
Airplane (at start)	120
Petards	170

Noise – measuring and evaluation

- For the steady-state noise, we measure the **average noise level** L_A.
- This means that we measure repeatedly the noise level using the weight filter A (The weight filter A respects different audibility for the different frequencies).
- From results we count the arithmetical average.
- When measured noise contains high frequencies, the usage of the weight filter A is not suitable because this filter will undervalue dangerous effects of higher frequencies. In this case, we have to use a special zone (octave) filter.

Noise – measuring and evaluation

- For the variable noise, we use the **equivalent noise level**, which means that we measure repeatedly the noise level using the weight filter A which is suitable for a long time, so we measure all of the incident noise levels.
- From results, we count an energy average of noise levels.
- An energy average is not an arithmetical average of dB values, but an average of p/p_0 value subsequently expressed in dB.
- *As an example, we can count an arithmetic average from values 40 dB and 80 dB which gives 60 dB. But the energetic average is 74 dB which means a mistake of 14 dB. In fact, this means more than 4 times higher noise energy.*

Noise – evaluation

- For **evaluation** of noise, we use the limit value L_L which is given as a sum of the basic value L_B and correction K_i.
- The correction K_i increase or decrease the resulting limit value L_L according to the existing situation, e.g. the type of room or time.
- The limit value <u>for the occupational environment</u> is given in accordance with the complicacy of work, type of noise, a period of noise etc.
- The basic value L_B of noise <u>for inside protected rooms</u> (apartment houses and civil constructions) is 40 dB and 50 dB in outdoor space.

Noise – prevention and protection

- Hearing damage can be prevented in following three steps:

1) <u>by technical arrangement</u>:
   - Remove the source of noise or lower it substantially. Innovation of noise equipment by the less noisy one is the best way.
   - Encase the source of noise in a suitable covering, e.g. bricks wall around a compressor, constructing a partition etc.

Noise – prevention and protection

2) by organizational arrangement:

- Separate exposed workers from the source of noise, e.g. by establishment of a control room.
- Limit the time of exposure to noise by arranging breaks rest in environment without noise or alternation of workers in noise and calm environment.
- Increase the distance of noise sources as the energy of noise decreases with a square of distance.

Noise – prevention and protection

3) by using the personal protection aids:

- Use of suitable personal protection aids, e.g. glass wool, cotton wool safeguards, resonance safeguards, earphone safeguards, masks and helmets against noise.
- The entrance into an environment with maximum noise level above 140 dB (A) should be not allowed even with use of personal protective aids.

Vibrations

- **Vibrations = A mechanical phenomenon whereby oscillations occur about an equilibrium point.**
- Any vibration has two measurable quantities: How far (amplitude or intensity), and how fast (frequency) the object moves helps determine its vibrational characteristics.
- The terms used to describe this movement are frequency, amplitude and acceleration.

Influence of vibrations on humans

- The effects of vibration on the body manifest themselves both mechanically and psychologically. The overall effect of vibration depends on:
  1) the characteristics of the vibration: amplitude and acceleration of vibrations, magnitude, frequency, direction;
  2) the exposure type: whole-body or hand-transmitted;
  3) the factors related to the worker, including his/her exposure duration, the posture used during the exposure, location of the body contacts, applied forces, and the amount of training with the tool.

Whole-body vibration exposure

- **When a worker sits or stands on a vibrating floor or seat, the vibration exposure affects almost the entire body.**
- The typical general effect of vibrations is caused by total horizontal or vertical vibrations usually associated with driving the vehicles and mobile machinery.
- Vibrations cause mostly the general effects as tiredness and worsening of reactions to outside stimuli after a long-term exposure.
- Another risk is the combination of forced operating position and exposure to whole-body vibration – the most vulnerable segment in the case of a vertical direction of vibration is the lumbar spine.

Hand-arm vibration exposure

- **When a worker operates hand-held equipment, vibration affects hands and arms.**
- Hand-arm vibration causes damage to hands and fingers.
- The main risk here is vascular disease or nerve and musculoskeletal disease of the upper limb. Mostly it appears as damage to blood vessels and nerves in the fingers.
- The resulting condition is known as white finger disease, Raynaud's phenomenon and is caused by vibrations transmitted to hands at frequency 20 – 40 Hz.

Influence of vibrations on humans

- The sensoric effects: e.g. the vision is affected by whole-body vibration, which may lead to motion sickness.
- In buildings we can find a small vibration from external (e.g. trains, subways or industrial facilities) or internal sources (elevator systems or exercise rooms).
- Beside the human annoyance these vibrations can also disturb sensitive medical and industrial equipment.

Vibrations – measuring and evaluation

- The physical quantities typically measured in the case of evaluating the influence of vibration to the human body is acceleration effective value expressed in [ms^{-2}] and acceleration level in decibels [dB] relative to the reference acceleration.

Vibrations – measuring and evaluation

1) Vibrations at working places.
   - The setting up of the highest admissible limit is done in a similar way as for noise.
2) Vibrations in dwellings and other buildings for activities not related to work.
   - The highest admissible level of acceleration of vibrations in building structure is set up as a sum total of the basic level of acceleration, of vibrations, and corrections for the utilization of premises, daytime and character of vibrations.
3) Vibrations of the frequency lower than 1 Hz.
   - The limitation of incidence of kinetosis should be taken into consideration when setting up admissible values for vibrations with the frequency lower than 1 Hz.

Vibrations – prevention and protection

- There are a number of ways that exposure to vibration can be minimized, we can divide them into following three categories:

1) <u>technical/engineering solution:</u>
   - Anti-vibration handle or grip of tools and maintenance of the tool.
   - Special operator's seat with elastic construction.

Vibrations – prevention and protection

2) <u>organizational arrangement:</u>
   - A reduction in exposure time e.g. by using job rotation schedule and providing adequate rest (e.g. working with certain types of vibrating tools is limited to two hours per work shift).
   - Informing the workers about early symptoms and how to avoid factors enhancing the risk of disease caused by vibrations (drinking coffee or smoking).

Vibrations – prevention and protection

3) <u>using the personal protection equipment</u>:
   - “Anti-vibrating” gloves help to some extent by impeding some vibration.
   - However, with the gloves, it is often necessary to exert more force than would be exerted without a glove.
   - It is important to keep warm the worker or his/her hands exposed to the detrimental effects of vibrations, they must be also protected against cold and dampness (warm working clothing and footwear, gloves with the limited transmission of vibrations, heated machine cabins, warming rooms).

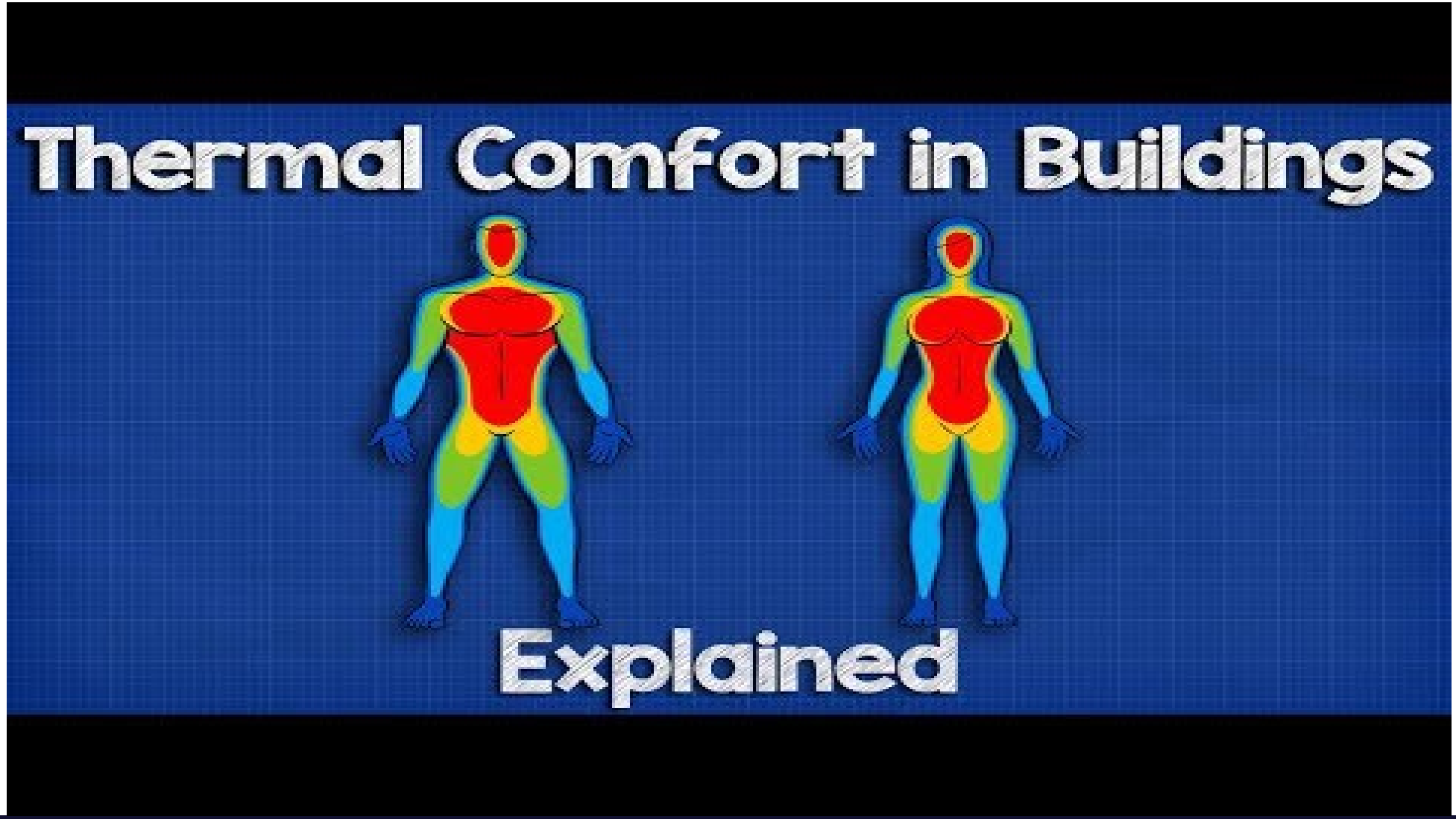
Time for a break

Thermal Comfort

- **Thermal comfort is the condition of mind, which expresses the satisfaction with the thermal environment.**

- **Environmental (climatic) factors**: air temperature, air humidity, the speed of air flow and the intensity of heat radiation.

Thermal comfort factors



Thermal Comfort

- **Objective individual factors**: activity (transformation of chemical energy into thermal energy, e.g. intensity of work) and thermal resistance of clothes (clothing insulation between an organism and environment).
- **Subjective individual factors**: adaptation and thermoregulation mechanisms (sensitive resistant), health state (healthy sick), mental condition (comfort stress), conditions of an organism (rested exhausted, satiety hunger).

Climatic factors

- **Air temperature** is one of the important parameters to evaluate the thermal comfort.
  - The recommended range for internal air temperature in apartment houses is between 19 °C and 23 °C (grades of Celsius) in winter, and less than 27 °C (grades of Celsius) in summer.
  - But, for example, 21 °C may be considered too warm for housework or exercising, but perhaps a bit cold for a sedentary work. Comfortable air temperature requirements also vary from day to day for the same person.
  - For the air temperature measuring, we use any type of thermometers.

Climatic factors

- **Absolute air humidity** is the concentration of water vapours in air at a given temperature expressed in gram per cubic meter (g/m3).
- **Relative air humidity** is a ratio of the partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature. Relative air humidity is usually expressed as a percentage.
  - For humans, the comfortable relative humidity range is between 30 % and 60 %.
  - For the measuring of the relative air humidity, we use different types of hygrometers or psychrometers.

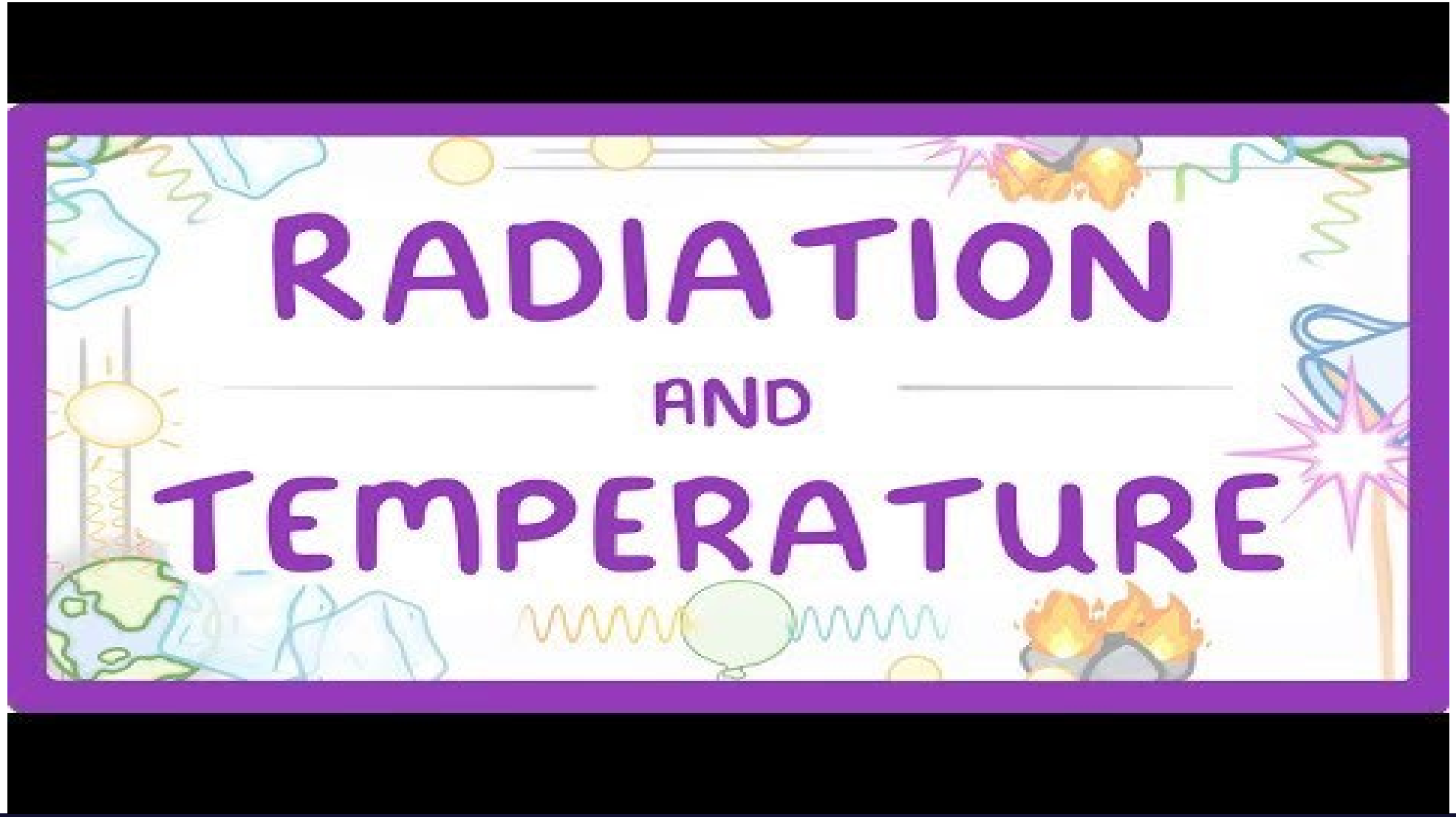
Climatic factors

- The **speed of air flow** is a measure of the movement of air in a space.
  - The recommended values for the work environment are 0.1-0.3 ms-1, for administrative buildings depending on the type of activity and the used clothing it is for winter period of maximum 0.15 ms-1 and for the summer period, not more than 0.25 ms-1.
  - For the measuring the speed of air flow, we usually use different types of anemometers or the kata-thermometer for the low velocity of the air flow.

Climatic factors

- The principle of **heat radiation** is infrared energy exchange between a human body and surrounding surfaces.
  - Thermal load of an organism is an issue mainly at hot workplaces (glassworks, blasts furnaces).
  - For measuring the heat radiation we use a globe thermometer.

Thermal comfort factors



Objective individual factors

- The **activity** is usually measured as the energy output of an individual.
  - The total (gross) energy output we count as the sum of nett (clear) energy output and the basal metabolism.
  - The net energy issue is measured as the heart activity by Holter apparatus or we use the orientation estimate done by pulse rate or by spreadsheet method.
  - An energetic value of the basal metabolism depends on the sex and falls with the age. For measuring, we can use the direct calorimetry or – what is more used – the graphic findings.

Objective individual factors

- The **thermal resistance of clothes** depends on the number of clothes layers and the speed of air flow.
  - The higher is the number of cloth layers, the higher is the number of thermal insulation layers among these layers.
  - The graphical findings show a strongly decreasing of protective ability of clothes against the cold by an increase of air streaming speed.

Subjective individual factors

- From **subjective individual factors**, the most important are the adaptation and thermoregulation mechanisms of an organism, the health state, the mental condition and current state of the organism.

- The thermoregulation mechanisms of the human body are:
  - the direct heat loss – convection, conduction, heat radiation and
  - the indirect heat loss – evaporation and respiration.

Thermal Comfort factors

These changes, as well as a new approach to energy use, will require buildings to be capable of evolving over time in order to be both comfortable and energy efficient.

Evaluation

- For **evaluation of thermal comfort**, the tables or graphs are used to determine the suitability of climatic factors combination according to the individual factors, e.g. the energy load.
  - The optimal thermal load is used in apartment houses or in workplaces where only moderately heavy work is performed.
  - The long-term feasible thermal load is used in workplaces where heavier work is performed (energy load, temperature).
  - The short-term feasible thermal load is used in workplaces with the heaviest work (high energy load, high temperature).

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THANK YOU FOR YOUR ATTENTION

QUESTIONS?

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