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PHYSICAL ENVIRONMENT AND HEALTH

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1. Physical characteristics of air. Thermal environment

In order to study, describe, and understand the events that occur within the environment, researchers measure the physical characteristics of the air within which these events take place. Meteorologists describe the air primarily in terms of its composition, temperature, pressure, wind speed, wind direction, precipitation, and humidity.

Air temperature. Air molecules are in constant motion. The speed of air molecules corresponds to their kinetic energy, which in turn corresponds to the amount of heat energy in the air. Air temperature is a measure of the average speed at which air molecules are moving; high speeds correspond to higher temperatures. The temperature of a substance is measured by a thermometer.

Air t° is measured by the thermometer – mercurial or alcohol of the centigrade or Celsius scale. To measure air t°, the thermometer is placed where it is not under direct influence of the Sun’s rays. Exposition time should not be less than 10 minutes.
Temperature indoors should be taken in a place which is 1,5-2 m distance from the beating devices. More precise t° is acquired if the measurements are made in 3 different levels in the middle of the room.

1. 0,25 m distance from the floor;
2. 2 m distance from the floor;
3. 0,25 distance from the ceiling.

The acquired data are summed up, it is divided with the number of places measured and get the mean t° of the room air.

For systematic observation of air t° we use the thermograph. It contains a bimetal plate which is very sensitive to t° changes and it perceives all t° changes.

**Air pressure.** Air is held to the earth by gravity. The amount of force exerted on a unit surface area (a surface that is one unit in length and one unit in width) is called atmospheric pressure or air pressure. The air pressure at any level in the atmosphere can be expressed as the total weight of air above a unit surface area at that level in the atmosphere. Higher in the atmosphere, there are fewer air molecules pressing down from above. Consequently, air pressure always decreases with increasing height above the ground. Because air can be compressed, the density of the air (the mass of the air molecules in a given volume) normally is greatest at the ground and decreases at higher altitudes.

There are 2 types of instruments for measuring the pressure of atmosphere: the mercury barometer and the aneroid barometer. More common is the aneroid barometer. Aneroid consists of 2 metal boxes which upper pats are made of glass. Inside the instrument there is a small horseshoe – type metal box which is partially evacuated from air. A special mechanism connects the box with a pointer. Metal box is very sensitive to atmospheric pressure changes. When atmospheric pressure increases, it gets small, but, when it lowers – the box enlarges. The changes of the volume of the box are registered on the scale, which is graded in paskals and mercury column in millimetres. Continuous atmospheric pressure measurements can be done by barograph. It consists of several aneroid boxes, connected to a pointer.
A column of air 1 cm² in area, extending from the ocean surface (sea level) up to the top of the atmosphere would contain slightly more than 1 kg of air. If more air molecules are packed into the column, the total weight of air at the bottom of the column would increase, and the air pressure there would increase. If air is removed from the column, the total weight of the air at the bottom of the column would decrease, and the air pressure would decrease. The most common unit of pressure found on surface weather maps is the millibar (1 millibar equals 100 newtons/sq m, where newtons are the metric unit of force). Mm of mercury is a pressure unit commonly used in television and radio weather broadcasts. On average, at sea level, the standard value of the atmospheric pressure is 1013.25 millibars or 760 mmHg. Barometers are instruments that measure air pressure.

**Air movement.** Wind is air in motion. It is caused by horizontal variations in air pressure. The greater the difference in air pressure between any two places at the same altitude, the stronger the wind will be. The wind direction is the direction from which the wind is blowing. A north wind blows from the north and a south wind blows from the south. The prevailing wind is the wind direction most often observed during a given time period. Wind speed is the rate at which the air moves past a stationary object. A variety of instruments measure wind. A wind vane measures wind direction. Most wind vanes consist of a long arrow with a tail that moves freely on a vertical shaft. The arrow points into the wind and gives the wind direction. Anemometers measure wind speed. Most anemometers consist of three or more cups that spin horizontally on a vertical post. The rate at which the cups rotate is related to the speed of the wind.

**Air (wind) motion control.** Anemometer is applied for air motion (speed) control. Katathermometer is applied for control of slight air speed. The principle of anemometer is the following: under the influence of air flow, specially designed spades start rotating, which by means of special device are connected to a pointer. By rotation of spades the pointer moves on a scale. Air speed is measured per second is calculated according to the curves pointed out in the passport of the device.

4 bowls are used is hand (or bowel) anemometer, which are placed in the upper part of the device. The bowls are heavier than wings, therefore this device is used only in
those cases when the air speed is longer than 1 m/s (usually for meteorologic measurements outdoors).

Before air speed control is done, the state of scale put down. Then the device is switched on and by chronometer the interval of time is checked (exposition time 2-3 minutes). Then the state of scale is checked again, the difference is calculated and divided by interval of time in seconds. Thus the air speed is measured 1 meter per second.

If air speed is slight (small), it is controlled by thermoanemometer or katathermometer. It is liquid (alcohol) thermometer which has alcohol reservoir in the lower part of the instrument, there is a widening in the upper part of capillary. If katathermometer is heated and then it is allowed to cool, then the cooling rate is various, it depends on metereologic conditions in the given room.

Katathermometer scale is graded from 35° C to 38° C. The amount of heat which the surface of katathermometer of 1 cm² loses while cooling from 38° C till 35° C, is known as katathermometer factor, it is stated in the factory and it is written on each katathermometer.

To detect the air speed, the alcohol reservoir of katathermometer is dipped in warm water (+80° C) and heated as long as the alcohol fills up ½ of the capillary widening. Then katathermometer is dried, installed in the stand, and put in the place where air speed must be controlled, and then it is expected to cool down. As soon as the level of alcohol drops down to 38° C, chronometer must be switched on and the interval from 38° C till 35° C in sec. of katathermometer cooling time is calculated.

**Air humidity.** Humidity refers to the air’s water vapor content. Hygrometers are instruments that measures humidity. The maximum amount of water vapor that the air can hold depends on the air temperature; warm air is capable of holding more water vapor than cold air. Relative humidity is the ratio of the amount of water vapor in the air compared to the maximum amount of water vapor that the air could hold at that particular temperature. When the air is holding all of the moisture possible at a particular temperature, the air is said to be saturated. Relative humidity and dew-point temperature (the temperature to which air would have to be cooled for saturation to occur) are often obtained with a device called a psychrometer. The most common type of psychrometer is...
Augustus psychrometer. Augustus psychrometer consists of 2 mercurial or alcohol thermometers. Reservoir of mercury of one thermometer is wrapped by muslin, the end of which is dipped in a small vessel containing distilled water. When water evaporates from muslin, the t° lowers and the corresponding thermometer registers the t°. By looking up the dry and wet bulb temperatures in a set of tables, known as humidity tables, it is possible to find the corresponding relative humidity and dew-point temperature.

![Picture 1. Augustus psychrometer](image)

When air humidity is lower, the water evaporates quicker, and correspondingly the t° of the wet thermometer lowers quicker, too. The rate of evaporation of water depends not only on the air humidity but also on the rate of air t° and air motion. To detect air humidity, one must know air t°, the rate of air motion in the given place and the difference between the t° of dry and moist thermometers. First of all the absolute air humidity is measured according to Renjo formula:

\[
A = M - a ( T - T_1 ) H,
\]
where \( A \) – absolute air humidity;
\( M \) – maximum air humidity (pressure of saturated water vapours) according to the moist thermometer \( t^\circ \) (see table);
\( a \) – psychrometer coefficient, which depends on the rate of air motion (table);
\( T \) - \( t^\circ \) of dry thermometer;
\( T_1 \) - \( t^\circ \) of moist thermometer;
\( H \) – atmospheric pressure (mmHg) during the time of measuring. Then the relative air humidity is calculated to the formula:
\[
R = \frac{A \times 100}{M}
\]
where \( M \) – maximum air humidity according to the \( t^\circ \) of dry thermometer (table).

2. Determination of human thermal comfort

Weather or climatic conditions in which we are everywhere and everytime may effect for us very various – the effect may be heating, freezing, slight discomfort and comfort.

It depends upon the combination of all physical factors of the air, hardness of work, energy consumption, etc.

All these factors may be in various combinations, and no one separate factor don’t may characterise the human thermal comfort.

Katathermometry

One of the methods for determination of human thermal comfort may be katathermometery. The katathermometer consists of glasswork tube with reservoir of alcohol or quicksilver, the scale of temperatures from 35\( ^\circ \) C to 38\( ^\circ \) C or from 33 to 40 \( ^\circ \) C and a little reservoir for broadening of liquid. The mean/average temperature of this scale – 36,5\( ^\circ \) C –it is equivalent to mean humans body temperature.

In the place of measuring we heat the katathermometer while the liquid comes to the broadening reservoir. Than we hang up it and dry up him with a rag paper, and left
him to cool down. We measure the time in seconds, which is need to cool the liquid in limit of the scale.

Everyone katathermometer have it’s own factor quality as constanta, which characterises the quality of calories from one while the katathermometer cool down in limit of the scale.

![Picture 2. Katathermometer](image)

The cooling size calculation:

\[ H = \frac{C}{t} \]

\( C \) – constanta of instrument

\( t \) – time in seconds, which was used to cool the liquid in limit of the scale.

It show, how many calories was loosed from 1 cm\(^2\) per second in measurement environment.

The more calories was losed – the more human suffer from cold, and in the other way – the too little calories from 1 cm\(^2\) per second – the more human suffer from warmth. The comfortable environment to human in rest for our people – when cooling size is
between 5.5 and 7 cal/cm$^2$/sec. For working persons with high energy expenditure the cooling size is comfortable between 8 and 10 cal/cm$^2$/sec.

The katathermometer may be used to exact measure of the air movement from 0 to 5 m per second. The cooling effect of dry instrument depends upon temperature we may detect by thermometer, and air movement we calculate by formula:

1. $V = \left( \frac{H}{Q} - 0.20 \right) \div 0.40)^2$

2. $V = \left( \frac{H}{Q} - 0.13 \right) \div 0.47)^2$

where $V$ – speed of air movement in m/sec,
$H$ – cooling size in cal/cm$^2$/sec,
$Q$ – difference between the mean temperature of katathermometer – 36.5 and the temperature of environment in moment of measure.

The first formula is used when the speed of air movement is less than 1 m/sec (the ratio $H/Q$ will be less then 0.6) and the other formula – to air movement more then 1 m/sec (the ratio $H/Q$ will be 0.6 or more).

**The effective temperatures**

How do you feel in every environment depends upon complex action of air temperature, humidity and movement at the same time.

These factors may be in very different combinations. Because all these factors may be in variable quantity’s, the characteristic of climatic conditions may be made when two of these factors are in constant value – from all possible combinations, which take the same thermal effect to human organism, we take the combination when are no air movement and air humidity is maximal. The air temperature of this combination will be equal to effective temperature.

The scale of effective temperatures is made as a graphic, where in vertical we have two scales of temperature of psychrometer – the left scale of dry thermometer data, the right one for wet thermometer data. The diagonal lines shows the data of detected by anemometer or katathermometer air movement.
In accordance with results of measuring we draw straight line between the dry and wet thermometers data and look the place of this line where it cross with the diagonal of speed of air movement. This point of intersection upon the scale of effective temperatures show the instant human feelings of thermal conditions.

There are two diapasons of effective temperatures.

The first one, called the **zone of comfort**, consists of the effective temperatures, in which environment more than 50 % of human feel themselves in comfort. The zone of comfort for Lithuanians is between 17,2 and 21,2 degrees of effective temperature.

The second diapason – called the **line of comfort** – consists of the effective temperatures in which environments more than 95% of human feel themselves comfortability. The line of comfort for our population is between 18,1 and 18,9 degrees of effective temperature.

The more effective temperature is different these diapasons – the more discomfort will be climatic environment to the population.

In the other hand this graphic may be as good adviser how we may improve climatic conditions. There we may see how changes of everyone to human thermal feelings and comfortability.
3. Determination of effectiveness of indoor air heating

Indoor air temperature must be measured in distance of 20cm from the external and internal wall and in the middle of the room. The thermometers may be protected from the sun or various heating equipment influence. After 10-15 min. we count the data of instruments and determine the horizontal fluctuation of the temperature. It may be not more than 2°C. on the data of this index may affect air movement in the room, the system of heating equipment and the parameters of the room.

Air temperature must be measured in three points in vertical too: about 30cm above the floor, 20 cm below ceiling and in high about 150 cm above the floor. The vertical fluctuation of the temperature may be not more than 2°C but it depend on the same factors as mentioned above.

Indoor air temperature must be measured many times per day and may found the fluctuation of the temperature per twenty four hours. This fluctuation depends on the
outdoor climatic situation, the system of heating equipment and should be not more than 30° C.

**Lighting**

Light is the visible portion of the electromagnetic spectrum of radiant energy. The visible portion of the total spectrum includes those wavelengths to which the retina of the eye is sensitive. Light comes to the eye in two ways:

1. directly from some luminous body, such as the sun or light bulb,
2. indirectly, by being reflected from some object.

The sensitivity of the eye to differences in wavelengths of light gives rise to colour perception. Surfaces of objects absorb depends on the wavelengths reflected from it.

**Glare** can cause visual discomfort and can affect the visual performance of people. There are two types of glare: a) direct glare, which is caused by light sources in the line of vision and b) reflected glare, which is caused by light being reflected from a surface to the eye.

Direct glare can be reduced by reducing of the brightness of light sources, by placing the light sources out of the line of vision, by increasing the brightness of areas around the glare sources, and by using shields, hoods and other such devices. Reflected glare can be reduced by keeping the brightness of individual light sources reasonably low, by providing good general illumination, by diffusing light, by proper positioning of light sources, and by avoiding the use of glossy surfaces.

**Candle** – unit measure of the intensity (strength) of a source of light. One candle – power was originally the power of a wax candle of a certain fixed size; special lamps are now used. The candle is 1/60 of the radiating power of 1 square centimetre of a black body at the temperature of melting platinum. A 40 watt lamp gives about 30 candle-power. An electric lamp makes light by heating a tiny wire white hot and about 10% of energy produce light.

A luminescence lamp makes the production of light in a substance without the use of heat.
Lumen - unit for measuring the flow of light from a source (e.g. a lamp) or the flow of light on to a surface. The lumen (symbol: lm) is the SI derived unit of luminous flux, a measure of the total "amount" of visible light emitted by a source.

An illumination of 1 lumen per square metre – one lux.

A 40 watt lamp gives about 450 lumens.

The measurement of natural lighting

Illumination measured in lux with a light meter show amount of light falling on a surface. Natural lighting may be evaluated by such indicators:

Coefficient of natural lighting show relation between horizontal lighting measured in luxes in the middle of the room and natural illumination outdoor in percent expressed. For living rooms this coefficient may be more than 1% and for clinical laboratory – not less 3% outdoor light.

Light coefficient show relation between square areas of windows – glass and floor space of the room in m². This coefficient for living rooms may be as relation 1:6 or 1:8, for school classes – 1:3, 1:4, for operating rooms in hospitals – 1:2, 1:3.

Natural lighting at workplaces may be measured by determination of angle of the open air, which is found between two straight lines drewed from the workplace surface – one to the upper part of window glass, and another – to the upper object outdoor before the window. This angle must be not less than 5°.

The angle of fall of rays of light which is found between two straight lines drewed from the workplace surface – one to the upper part of window glass, and other – to the lower part of windows glass. This angle must be not less than 27°.

Albedo – measure of the power of a surface to reflect light and is expressed in percentage of reflected rays from the surface. The white painted surface of ceiling or the wall reflect about 80% of light rays, white marble surfaces – about 60%, bright furniture – about 40%, and dark furniture – no more than 10% of rays falled.

The measurement of artificial lighting

The general lighting of room or the amount of lighting falling on a work surface may be measured with a light meter (luxmeter) in luxes or may be counted by quantity of
energy used to produce light in \( \text{w/m}^2 \). the powerty of all light sources are added divided to floor space. For general tasks of room lighting this powerty must be as 40 watt per square meter \( (\text{w/m})^2 \).

Lighting may be done by electric bulb lamp, which is very simple for use, but is not right to use for lighting of wards and doctors cabinets, because the spectrum of light is more yellow and may simulate icterus. Light productivity of these lamps is very low – only 8-10% of energy used produces light.

**Luminescent lamps** produces 2-3 times more light than electric bulb lamps, and the spectrum of lighting is more as natural.

In investigation of local lighting in the workplaces we must estimate the protective angle of the light source. It is between two straight lines drawed from the light source – one to the lower part of lampshade, and other – to the projection of workers eye. This angle may be about 30\(^\circ\) and defence workers eyes from the straight glare.

**Table. General minimal artificial lighting in the middle of the room in luxes**

<table>
<thead>
<tr>
<th>Room</th>
<th>Types of lighting lamps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electric bulbs</td>
</tr>
<tr>
<td>Living room</td>
<td>50</td>
</tr>
<tr>
<td>Washing room, WC</td>
<td>30</td>
</tr>
<tr>
<td>Operating rooms</td>
<td>200</td>
</tr>
<tr>
<td>Doctors cabinets</td>
<td>100</td>
</tr>
<tr>
<td>Boxes, isolators</td>
<td>75</td>
</tr>
<tr>
<td>Laboratories</td>
<td>150</td>
</tr>
<tr>
<td>Wards</td>
<td>30</td>
</tr>
<tr>
<td>Classrooms, library</td>
<td>200</td>
</tr>
<tr>
<td>Teacher’s room</td>
<td>100</td>
</tr>
<tr>
<td>Recreation rooms</td>
<td>100</td>
</tr>
<tr>
<td>Staircase</td>
<td>30</td>
</tr>
</tbody>
</table>

Commonly called 'light bulbs', lamps are the removable and replaceable part of a light fixture, which converts electrical energy into electromagnetic radiation. While
Lamps have traditionally been rated and marketed primarily in terms of their power consumption, expressed in watts, proliferation of lighting technology beyond the incandescent light bulb has eliminated the correspondence of wattage to the amount of light produced. For example, a 60 W incandescent light bulb produces about the same amount of light as a 13 W compact fluorescent lamp. Each of these technologies has a different efficacy in converting electrical energy to visible light.

Lamp types include:

- **Light bulb lamp.** Is designed to produce light from electricity. These components usually have a base of ceramic, metal, glass or plastic, which makes an electrical connection in the socket of a light fixture.

- **Fluorescent light:** A tube coated with phosphor containing low pressure mercury vapor that produces white light.

- **Halogen:** High pressure incandescent lamps containing halogen gases such as iodine or bromine, increasing the efficacy of the lamp versus a plain incandescent lamp.

- **Neon:** A low pressure gas contained within a glass tube; the color emitted depends on the gas.

- **Light emitting diodes:** Light emitting diodes (LED) are solid state devices that emit light by dint of the movement of electrons in a semiconductor material.

- **Compact fluorescent lamps:** CFLs are designed to replace incandescent lamps in existing and new installations.

5. **Noise, its properties and health effects**

Noise is described as unwanted sound. It disturbs the human being and cause an adverse effect on the mental and psychological well being. The source of most outdoor noise worldwide is mainly transport and industry, including motor vehicle noise, aircraft noise, and rail noise. The extent of the noise problem is large. In the European Union countries about 40 % of the population are exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dB(A) daytime and 20 % are exposed to
levels exceeding 65 dB(A). Taking all exposure to transportation noise together about half of the European Union citizens are estimated to live in zones which do not ensure acoustical comfort to residents. More than 30% are exposed at night to equivalent sound pressure levels exceeding 55 dB(A) which are disturbing to sleep. The noise pollution problem is also severe in cities of developing countries and caused mainly by traffic.

Sound is characterized by frequency and intensity. Frequency refers to the number of vibrations per second. It is measured in Hertz (Hz). The audible frequency range is normally considered to be 20–20 000 Hz for listeners with unimpaired hearing. The audible range is divided to low, medium and high frequency ranges.

Sound intensity is a pressure as a basic measure of the vibrations of air that make up sound. Because the range of sound pressures that human listeners can detect is very wide, these levels are measured on a logarithmic scale with units of decibels (dB). So intensity is measured in decibels.

The ear can tolerate low tones more easily than high tones. Consequently, if the ear is damaged, it is the perception of high tones disappears at first. We must not notice this because we can hear normal speech. It takes several years before the damage becomes so apparent that we have difficulty in understanding what other people say.

Sound intensity in the environment you can see in table 1.

Table 1. Sound levels in the environment

<table>
<thead>
<tr>
<th>Source of sound</th>
<th>Human feeling</th>
<th>Sound level dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light rain</td>
<td>Very quiet</td>
<td>15</td>
</tr>
<tr>
<td>Rusting of leaves</td>
<td>Very quiet</td>
<td>20</td>
</tr>
<tr>
<td>Singing birds</td>
<td>Quiet</td>
<td>50</td>
</tr>
<tr>
<td>Conversation</td>
<td>Quiet</td>
<td>60</td>
</tr>
<tr>
<td>Air conditioner in the room</td>
<td>Moderately loud</td>
<td>80</td>
</tr>
<tr>
<td>Crowded restaurant</td>
<td>Moderately loud</td>
<td>80</td>
</tr>
<tr>
<td>Truck Traffic</td>
<td>Moderately loud</td>
<td>80</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>Extremely loud</td>
<td>100</td>
</tr>
<tr>
<td>Tractor</td>
<td>Extremely loud</td>
<td>100</td>
</tr>
<tr>
<td>Subway</td>
<td>Extremely loud</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Uncomfortably loud</td>
<td>120</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Rock music amplified</td>
<td>Uncomfortably loud</td>
<td>120</td>
</tr>
<tr>
<td>Thunder severe</td>
<td>Uncomfortably loud</td>
<td>120</td>
</tr>
<tr>
<td>Pneumatic jackhammer</td>
<td>Uncomfortably loud</td>
<td>120</td>
</tr>
<tr>
<td>Jet plane</td>
<td>Human ear pain threshold</td>
<td>140</td>
</tr>
<tr>
<td>Shotgun blast</td>
<td>Human ear pain threshold</td>
<td>140</td>
</tr>
</tbody>
</table>

The health significance of noise pollution is evaluated according to the specific effects:

- noise-induced hearing impairment;
- interference with speech;
- communication;
- disturbance of rest and sleep;
- psychophysiological, mental-health and performance effects;
- effects on residential behaviour and annoyance;
- interference with intended activities.
- cardiovascular effects;

**Hearing impairment** is typically defined as an increase in the threshold of hearing. If hearing is damaged, the perception of high tones disappears at first. Hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3 000–6 000 Hz, with the largest effect at 4 000 Hz. But with increasing noise intensity and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2 000 Hz.

Worldwide, noise-induced hearing impairment is the most prevalent irreversible occupational hazard and it is estimated that 120 million people worldwide have disabling hearing difficulties. In developing countries, not only occupational noise but also environmental noise is an increasing risk factor for hearing impairment. Hearing damage can also be caused by certain diseases, some industrial chemicals, ototoxic drugs, accidents. Hearing weakness is also associated with ageing.

The main social consequence of hearing impairment is the inability to understand speech in daily living conditions, and this is considered to be a severe social handicap.
Even small values of hearing impairment (10 dB averaged over 2 000 and 4 000 Hz and over both ears) may adversely affect speech comprehension.

Sleep disturbance is related to environmental noise. It may cause primary effects during sleep, and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a essential for good physiological and mental state, and the primary effects of sleep disturbance are:

- difficulty in falling asleep;
- awakenings and alterations of sleep stages or depth;
- increased blood pressure and heart rate;
- vasoconstriction;
- changes in respiration;
- cardiac arrhythmia;
- and increased body movements.

The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability. The probability of being awakened increases with the number of noise events per night. The secondary, or after-effects, the following morning or day(s) are: reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.

For a good night’s sleep, the equivalent sound level should not exceed 30 dB for continuous background noise, and individual noise events exceeding 45 dB should be avoided. At table 1 you can see guideline values of community noise in environment.

Table 2: Guideline values for community noise in specific environments.

<table>
<thead>
<tr>
<th>Specific environment</th>
<th>Critical health effect(s)</th>
<th>L(\text{Aeq} ) [dB(A)]</th>
<th>Time base [hours]</th>
<th>L(\text{Amax} ) fast [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor living area</td>
<td>Serious annoyance, daytime and evening</td>
<td>55 50</td>
<td>16 16</td>
<td>--</td>
</tr>
<tr>
<td>Dwelling, indoors Inside beds</td>
<td>Speech intelligibility &amp; moderate annoyance, daytime &amp; evening Sleep disturbance, night-time</td>
<td>35 30</td>
<td>16 8</td>
<td>45</td>
</tr>
<tr>
<td>Location</td>
<td>Noise Impact and Intensity</td>
<td>LAF</td>
<td>CAF</td>
<td>Peak Sound Pressure</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Outside bedrooms, Sleep disturbance, window open (outdoor values)</td>
<td>45</td>
<td>8</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>School class rooms &amp; pre-schools, indoors</td>
<td>Speech intelligibility, disturbance of information extraction, message communication</td>
<td>35</td>
<td>during class</td>
<td>-</td>
</tr>
<tr>
<td>Pre-school bedrooms, indoor</td>
<td>Sleep disturbance</td>
<td>30</td>
<td>sleepin g-time</td>
<td>45</td>
</tr>
<tr>
<td>School, playground outdoor</td>
<td>Annoyance (external source)</td>
<td>55</td>
<td>during play</td>
<td>-</td>
</tr>
<tr>
<td>Hospital, ward rooms, indoors</td>
<td>Sleep disturbance, night-time Sleep disturbance, daytime and evenings</td>
<td>30</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Hospitals, treatment rooms, indoors</td>
<td>Interference with rest and recovery</td>
<td>#1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial, commercial shopping and traffic areas, indoors and outdoors</td>
<td>Hearing impairment</td>
<td>70</td>
<td>24</td>
<td>110</td>
</tr>
<tr>
<td>Ceremonies, festivals and entertainment events</td>
<td>Hearing impairment (patrons:&lt;5 times/year)</td>
<td>100</td>
<td>4</td>
<td>110</td>
</tr>
<tr>
<td>Public addresses, indoors and outdoors</td>
<td>Hearing impairment</td>
<td>85</td>
<td>1</td>
<td>110</td>
</tr>
<tr>
<td>Music and other sounds through headphones/ earphones</td>
<td>Hearing impairment (free-field value)</td>
<td>85 #4</td>
<td>1</td>
<td>110</td>
</tr>
<tr>
<td>Impulse sounds from toys, fireworks and firearms</td>
<td>Hearing impairment (adults) Hearing impairment (children)</td>
<td>--</td>
<td>--</td>
<td>140 #2 120 #2</td>
</tr>
<tr>
<td>Outdoors in parkland and conservations areas</td>
<td>Disruption of tranquillity</td>
<td>#3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#1: As low as possible.
#2: Peak sound pressure (not LAF, max) measured 100 mm from the ear.
#3: Existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low.
#4: Under headphones, adapted to free-field values.
**Cardiovascular effects**

Among other non-auditory health endpoints, short-term changes in circulation including blood pressure, heart rate, cardiac output and vasoconstriction, as well as stress hormones have been studied in experimental settings for many years. Classical biological risk factors have been shown to be elevated in subjects that were exposed to high levels of noise. Epidemiological evidence was accumulated supporting the hypothesis that persistent noise stress increases the risk of cardiovascular disorders including hypertension and ischaemic heart disease.

**Loss of productivity in adults**

Noise has negative impacts on cognitive performance:

- For recall and reading, a reduction of the day and night noise level by 5 dB within the range of 65–80 dB was shown to improve performance by almost 10%.
- For attention and memory, a 5 dB reduction in average noise level results in approximately 2–3% improvement of performance.

These adverse impacts of noise on cognitive performance can lead to a reduction in the productivity at work and the learning performance at school.

**Learning impairment in children**

Children chronically exposed to loud noise show impairments in attention, memory, problem-solving ability and learning to read.

**Hearing impairment**

Studies and data are not sufficient to derive relationships between community or social specific noise exposure and hearing impairment in adults and children. Nevertheless, assuming that social noise is not significantly different from occupational noise and that the equal energy principle is applicable, exposure–response curves can be established on the basis of International Organization for Standardization (ISO) standard
1999 (on determination of occupational noise exposure and estimation of noise-induced hearing impairment), which uses an audiometric threshold shift at 4 kHz.

**Noise pollution prevention**

There are many methods which help to control the noise pollution. The source of noise must be reduced. The path of transmission of sound must be stopped and the receiver of noise must be safeguarded. The amount of traffic must be reduced near the residential homes, educational institutes and hospitals. The machinery must be redesigned and the vehicles must be properly maintained. The acoustical furnishing must be done so that the sound can be absorbed. The industries must be built away from the residential areas and the legal laws must be established and observed to protect the humans from noise pollution.

Roadway noise can be reduced by the use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. An important factor in applying these strategies is a computer model for roadway noise, that is capable of addressing local topography, meteorology traffic operations and hypothetical mitigation. Costs of building-in mitigation can be modest, provided these solutions are sought in the planning stage of a roadway project.

Aircraft noise can be reduced by using quieter jet engines. Altering flight paths and time of day runway has benefitted residents near airports.

Industrial noise has been addressed since the 1930s via redesign of industrial equipment, shock mounted assemblies and physical barriers in the workplace.


Nonionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy per quantum to ionize atoms or molecules. This radiation consists from electric and magnetic fields. All spectrum of electromagnetic radiation consists from radiowaves – non-thermal radiation, microwaves – thermal radiation and visible (optical) radiation. Picture 4 shows all electromagnetic spectrum, which starts from wavelengths shorter than $10^{-10}$ meter to longer than 1 meter (100 km) waves.
Radio waves

Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light. Like all other electromagnetic waves, they travel at the speed of light. Naturally occurring radio waves are made by lightning, or by astronomical objects. Artificially generated radio waves are used for fixed and mobile radio communication, broadcasting, radar and other navigation systems, satellite communication, computer networks and innumerable other applications. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere; long waves may cover a part of the Earth very consistently, shorter waves can reflect off the ionosphere and travel around the world, and much shorter wavelengths bend or reflect very little and travel on a line of sight.
**Very low frequency (VLF)**

Very low frequency or VLF refers to radio frequencies (RF) in the range of 3 to 30 kHz. Since there is not much bandwidth in this band of the radio spectrum, only the very simplest signals are used, such as for radio navigation.

**Extremely low frequency (ELF)**

Extremely low frequency (ELF) is a term used to describe radiation frequencies from 3 to 30 Hz. In atmosphere science, an alternative definition is usually given, from 3 Hz to 3 kHz. In the related magnetosphere science, the lower frequency electromagnetic oscillations (pulsations occurring below ~3 Hz) are considered to lie in the ULF range, which is thus also defined differently from the ITU Radio Bands.

**Microwave**

Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. This broad definition includes both UHF and EHF (millimeter waves), and various sources use different boundaries.

**Health effects from nonionizing radiation**

Electric and magnetic fields are complex physical agents whose potential health effects are the subject of much research. Particularly controversial are the biophysical mechanisms by which these RF fields may affect biological systems. General health effects reviews explore possible

- carcinogenic,
- reproductive
- neurological effects.

Health effects by exposure source are noted in radar traffic devices, wireless communications with cellular phones, radio transmission, and magnetic resonance imaging (MRI).
**Low frequency fields**

Scientific knowledge about the health effects of EMF is substantial and is based on a large number of epidemiological, animal and in vitro studies. Many health outcomes ranging from reproductive defects to cardiovascular and neurodegenerative diseases have been examined, but the most consistent evidence to date concerns childhood leukemia. In 2001, an expert scientific working group of WHO’s International Agency for Research on Cancer (IARC) reviewed studies related to the carcinogenicity of static and extremely low frequency (ELF) electric and magnetic fields. Using the standard IARC classification that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans in the group 2 based on epidemiological studies of childhood leukemia. “Possibly carcinogenic to humans” is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. Evidence for all other cancers in children and adults, as well as other types of exposures (i.e. static fields and ELF electric fields) was considered inadequate to classify either due to insufficient or inconsistent scientific information. While the classification of ELF magnetic fields as possibly carcinogenic to humans has been made by IARC, it remains possible that there are other explanations for the observed association between exposure to ELF magnetic fields and childhood leukemia.

**High frequency fields**

Concerning radiofrequency fields, the balance of evidence to date suggests that exposure to low level RF fields (such as those emitted by mobile phones and their base stations) does not cause adverse health effects. Some scientists have reported minor effects of mobile phone use, including changes in brain activity, reaction times, and sleep patterns. In so far as these effects have been confirmed, they appear to lie within the normal bounds of human variation. Presently, research efforts are concentrated on whether long-term, low level RF exposure, even at levels too low to cause significant temperature elevation, can cause adverse health effects. Several recent epidemiological studies of mobile phone users found no convincing evidence of increased brain cancer risk. However, the technology is too recent to rule out possible long-term effects. Mobile
phone handsets and base stations present quite different exposure situations. Radio frequency exposure is far higher for mobile phone users than for those living near cellular base stations. Apart from infrequent signals used to maintain links with nearby base stations, handsets transmit RF energy only while a call is being made. However, base stations are continuously transmitting signals, although the levels to which the public are exposed are extremely small, even if they live nearby.

7. Solar radiation

Solar radiation is the light and heat that we perceive from the sun. The sun is a star and it produces energy in many forms, from perceptible heat, visible and invisible spectrums of light, radiation, and more. About half of the radiation is in the visible radiation as short-wave part of the electromagnetic spectrum. The other half is mostly in the near is infrared part and ultraviolet part of the spectrum.

Infrared Radiation (IR)

The skin and eyes absorb infrared radiation (IR) as heat. People normally notice excessive exposure through heat sensation and pain. Sources of IR radiation include furnaces, heat lamps, and IR lasers.

Health effects: Heating of tissues in the human body is the principal effect of infrared radiation. Excessive infrared radiation can result in heat strokes and other similar reactions particularly in elderly, infirm or very young individuals. At moderate levels of exposure, the warmth experienced from being in the sun is relaxing and restorative.

Visible Radiation

The different visible frequencies of the electromagnetic (EM) spectrum are "seen" by our eyes as different colors. Good lighting is conducive to increased production, and can help prevent incidents related to poor lighting conditions. Excessive visible radiation can damage the eyes and skin. Lack of visible radiation usually in winter time is related with seasonal depression. This condition sometimes associated with lack of sunlight (seasonal affective disorder). Visible radiation influence metabolism and stimulate central
nervous system. Lack of visible light at autumn-winter time can determine asthenia or depressive state, changes in hormonal system.

**Ultraviolet Radiation (UV)**

Ultraviolet radiation (UV) has a high photon energy range and is particularly hazardous because there are usually no immediate symptoms of excessive exposure. Sources of UV radiation include the sun, black lights, welding arcs, and UV lasers. UV radiation is classified according wavelength frequency to A, B, C zones.

Stratospheric Oxygen and Ozone molecules absorb 97-99% of the sun's high frequency Ultraviolet light, light with wavelengths between 150 and 300nm. Ultraviolet-B(UV-B) is a section of the UV spectrum, with wavelengths between 270 and 320nm.

The amount of UV-B light received by a location is strongly dependent on:

- **Time of day.** About 20-30% of total daily UV is received one hour either side of midday in summer, with 75% between 9 am and 3 pm.
- **Surface reflection.** Reflection of UVR from ground surfaces, including the sea, is normally low (<7%). However gypsum sand reflects about 25% of incident UVB and fresh snow about 50% - 80%.
- **Latitude and elevation** of the location. At the high-latitude polar regions the sun is always low in the sky; because the sunlight passes through more atmosphere so more of the UV-B is absorbed. For this reason average UV-B exposure at the poles is over a thousand times lower than at the equator.
- **Cloud cover;** the reduction in UV-B exposure depends the cover's thickness.
- **Proximity to an industrial area** because of the protection offered by photochemical smog. Industrial processes produce ozone, one of the more irritating components of smog, which absorbs UV-B. This is thought to be one of the main reasons that significant ozone losses in the southern hemisphere have not been mirrored in the northern hemisphere.
**Health effects of UV light**

1. **Genetic damage.** DNA absorbs UV-B light and the absorbed energy can break bonds in the DNA. Most of the DNA breakages are repaired by proteins present in the cells nucleus but unrepaired genetic damage of the DNA can lead to skin cancers. In fact one method that scientists use to analyze amounts of ‘genetically-damaging UV-B is to expose samples of DNA to the light and then count the number of breaks in the DNA.

2. **The Cancer link.** The principle danger of skin cancer is to light-skinned peoples. A 1% decrease in the ozone layer will cause a estimated 2% increase in UV-B irradiation; it is estimated that this will lead to a 4% increase in basal carcinomas and 6% increase in squamous-cell carcinomas. 90% of the skin carcinomas are attributed to UV-B exposure and the chemical mechanism by which it causes skin cancer has been identified. The above named carcinomas are relatively easy to treat, if detected in time, and are rarely fatal. But the much more dangerous malignant melanoma is not as well understood. There appears to be a correlation between brief, high intensity exposures to UV and eventual appearance (as long as 10-20yrs!) of melanoma. Twice as many deaths due to melanomas are seen in the southern states of Texas and Florida, as in the northern states of Wisconsin and Montana, but there could be many other factors involved. One undisputed effect of long-term sun exposure is the premature aging of the skin due to both UV-A, UV-B and UV-C. Even careful tanning kills skin cells, damages DNA and causes permanent changes in skin connective tissue which leads to wrinkle formation in later life. There is no such thing as a safe tan.

3. **Possible eye damage** can result from high doses of UV light, particularly to the cornea which is a good absorber of UV light. High doses of UV light can causes a temporary clouding of the cornea, called ‘snow-blindness’, and chronic doses has been tentatively linked to the formation of cataracts. Higher incidences of cataracts are found at high elevations, Tibet and Bolivia; and higher incidences are seen at lower latitudes (approaching the equator).

4. **Skin burns.** Sunburn, or erythema, is an acute injury following excessive exposure to solar UVR. The redness of the skin which results is due to an
increased blood content of the skin by dilatation of the superficial blood vessels in the dermis, mainly the subpapillary venules. Skin colour is an important factor in determining the ease with which the skin will sunburn. Whereas fair-skinned people require only about 15-30 min of midday summer sunshine to induce an erythremal reaction, people with moderately pigmented skin may require 1-2 h exposure and those with darkly pigmented skin (i.e. Negroes) will not normally sunburn. Other phenotype characteristics that may influence the susceptibility to sunburn are hair colour, eye colour and freckles.

5. **Production of vitamin D.** The only thoroughly established beneficial effect of solar ultraviolet radiation on the skin is the synthesis of vitamin D3. Solar radiation in the UV waveband photochemically converts 7-dehydrocholesterol in the epidermis to previtamin D3. Only short exposures to sunlight are required to synthesize vitamin D3 in the skin; from spring until autumn 15 min exposure to the hands, arms and face between 9 am and 4 pm is adequate to provide our vitamin D3 requirement. It is not surprising, therefore, that the seasonal variation of solar UVR, and hence plasma 25-hydroxyvitamin D3 levels can led to calcium imbalance in the elderly and rachitis in children.

6. **Photo-aging.** The clinical signs of a photo-aged skin are dryness, deep wrinkles, accentuated skin furrows, sagging, loss of elasticity, mottled pigmentation and telangiectasia. These characteristics reflect profound structural changes in the dermis.

7. An increase in UV-B will cause increased amounts of Ozone to be produced at lower levels in the atmosphere. While some have hailed the protection offered by this ‘pollution-shield’ many plants have shown themselves to be very sensitive to photochemical smog.

**Protective measures from solar radiation**

Methods for personal protection from solar radiation exposure include adequate clothing, hats and the proper use of sunscreens to protect exposed skin. For eye protection, UV absorbing sunglasses are needed. Changes in behavior could minimize
solar UV exposure. These include staying out of the sun, either indoors or in shaded areas, during the four-hour period around solar noon when UV levels are at their highest. During summer, when daylight saving time is in effect, solar noon in most of Europe is at 14.00 hours (2 p.m.); in the UK and countries with a similar longitude, it is at 13.00 hours (1 p.m.).

Broad-spectrum sunscreens should be used when other means of protection are not feasible, and then to reduce exposure rather than lengthen the period of exposure. While topical applications of sunscreen are preferred for absorbing UVR, some preparations do not absorb the longer wavelength UVA effectively. Moreover, some preparations have been found to contain ingredients that are mutagenic in sunlight. People using sunscreens should use those with a high sun protection factor (SPF) and be aware that they are to protect from the sun and not for tanning purposes.

The reflective properties of the ground have an influence on UV exposure. Most natural surfaces such as grass, soil and water reflect less than 10% of incident UV. However, fresh snow reflects nearly 80% while sand reflects 10-25%, significantly increasing UV exposure for skiers and bathers.

**Global Solar UV Index**

The Global Solar UV Index is an important tool developed through the work of the *WHO INTERSUN Project* to assist local authorities in giving guidance on the degree of protection to be used on any given day. The values of the Index range from zero upward and the higher the Index number, the greater the likelihood of skin and eye damaging exposure to UV, and the less time it takes for damage to occur.

In the most extreme environments close to the equator, summer-time values can range up to 20. During a European summer the Index is generally not more than about 8, but can be higher, especially at beach resorts. The following descriptions are usually associated with various values of the Index: Low UV exposure - 1 and 2; Moderate exposure - 3 and 4; High exposure - 5 and 6; Very high exposure - 7 and 8; Extreme exposure - greater than 9.

The Global Solar UV Index should be used as a vehicle to raise public awareness of the potential harm of excessive UV exposure and to alert people about the
need to adopt protective measures. This is especially important given the continuing
decrease in stratospheric ozone and subsequent increase in UV intensities that cause
increasingly severe UV-induced health effects;

National governments should be encouraged to use the Global Solar UV Index
as part of their public awareness and educational programmes. The news media should be
couraged to report the Global Solar UV Index with their daily weather information, so
that people begin to accept this as something they need to know in addition to the news
and weather.

Table 4. Recommendations for protection in relation with UV Index

<table>
<thead>
<tr>
<th>UV Index</th>
<th>Description</th>
<th>Recommended Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2</td>
<td>Low danger from the sun's UV rays for the average person</td>
<td>Wear sunglasses on bright days; use sunscreen if there is snow on the ground, which reflects UV radiation, or if you have particularly fair skin.</td>
</tr>
<tr>
<td>3–5</td>
<td>Moderate risk of harm from unprotected sun exposure</td>
<td>Take precautions, such as covering up, if you will be outside.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stay in shade near midday when the sun is strongest.</td>
</tr>
<tr>
<td>6–7</td>
<td>High risk of harm from unprotected sun exposure</td>
<td>Wear sunglasses and use SPF 30+ sunscreen, cover the body with sun protective clothing and a wide-brim hat, and reduce time in the sun from three hours before to three hours after solar noon (roughly 10:00 to 16:00 during summer in zones that observe daylight saving time).</td>
</tr>
<tr>
<td>8–10</td>
<td>Very high risk of harm from unprotected sun exposure</td>
<td>Wear SPF 30+ sunscreen, a shirt, sunglasses, and a hat. Do not stay out in the sun for too long.</td>
</tr>
<tr>
<td>11+</td>
<td>Extreme risk of harm from unprotected sun exposure</td>
<td>Take all precautions, including: wear sunglasses and use SPF 30+ sunscreen, cover the body with a long-sleeve shirt and trousers, wear a very broad hat, and avoid the sun from three hours before until three hours after solar noon (roughly 10:00 to 16:00 in zones that observe daylight saving time).</td>
</tr>
</tbody>
</table>
Literature:

7. [www.pavesis.lt](http://www.pavesis.lt)