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ANALYSIS OF WORKING CONDITIONS IN DESIGNING SPECIAL CLOTHING FOR WORKERS IN MANUFACTURING ENTERPRISES

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Workers of manufacturing enterprises encounter hazardous and harmful production factors during their work process. The classification of harmful and hazardous production factors by professions is carried out in accordance with State Standard 12.0.003-2015 [1].

When developing special clothing with ergonomic, aesthetic, and protective properties for workers of manufacturing enterprises, it is important to enhance the effectiveness of personal protection, meet occupational safety requirements, and ensure comfortable movement of the worker under operational conditions. This, in turn, helps achieve high labor productivity.

Among the hazardous and harmful factors negatively affecting the health of workers in automotive plant workshops are:

- the level of noise and vibration in the working area,
- dustiness of the air,
- the presence of harmful substances in the workplace air (carbon monoxide, nitrogen oxides),
- microclimate conditions (intensity of heat radiation from heated parts),
- sparks generated during the welding of metals,
- exposure to toxic substances in paints,
- and the physical strain of the work process.

The analysis of working conditions in this study was conducted in the workshops of the “SamAuto” automobile plant, where the system of physical-mechanical and chemical hazardous and harmful production factors was determined (Figure 1).

According to the requirements of State Standard 12.0.003-2015, working conditions are classified into four classes [1]. Based on this classification, the factors of the production environment and their impact on the health and performance of workers in the automobile plant can be categorized as follows:

- in the preparation workshop, where mainly fitters, turners, and milling machine operators work, workers are exposed to factors such as dust generated during cutting of raw materials (metal sheets), high temperature on the surface of metal and equipment, and the heaviness of the labor process. High temperatures on material or equipment surfaces can cause heat shock and burns, lead to significant heat loads on the body, disturb water balance, and increase blood pressure.

- in the welding workshop, where primarily welders work, workers are affected by high noise levels from welding equipment, elevated temperature of the equipment and materials being welded, flying sparks, as well as the risks of heat shock and burns.

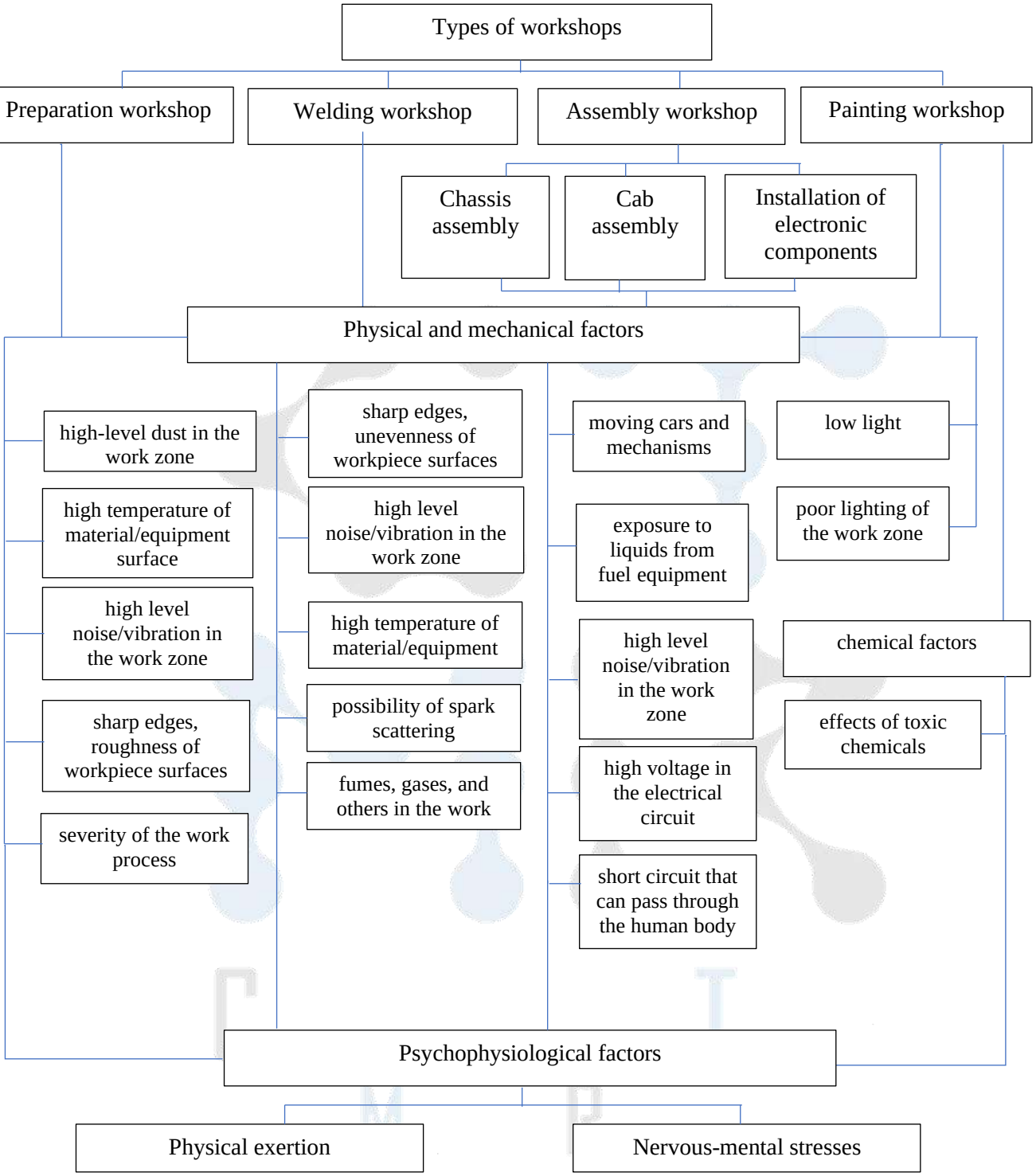

Figure 1. Classification of Hazardous and Harmful Production Factors in the Automotive Industry Production Environment

- in the chassis and cab assembly workshops, fitters performing mechanical operations are engaged. They are exposed to hazards from moving machines and mechanisms, high noise levels from equipment, and elevated surface temperatures of the equipment. In addition, factors such as the heaviness of labor-lifting or pushing heavy objects, prolonged standing and bending during the shift-are significant.

- in the workshop for installing automotive electrical and electronic components, workers of the electrician profession are mainly employed. They are exposed to risks such as high voltage in the electric circuit, possible short circuits passing through the human body, and moving machine parts.

- in the automobile body painting workshop, painters work under exposure to hazardous chemicals, such as dimethylbenzene and butyl acetate contained in paints, aggressive environments, acids, toxic gases, organic compounds, as well as insufficient lighting conditions in the workplace.

In all of the above workshops, factors such as high surface temperatures of equipment and materials and the heaviness of the work process lead to overheating of the worker's body, resulting in intensive perspiration. Therefore, these factors highlight the importance of the hygienic indicators of special clothing.

One of the most significant factors influencing the worker's body and performance is the microclimate (meteorological conditions) in the production facilities, which refers to the internal environmental conditions affecting heat exchange between workers and their surroundings. These conditions are determined by the combination of temperature, relative humidity, air velocity, surface temperatures of surrounding objects, and the intensity of heat radiation (infrared). Although the parameters of the microclimate in production facilities can fluctuate, the human body temperature remains constant (36.6 °C) due to its thermoregulatory capability to maintain heat balance with the environment [2].

The lower the air temperature and its velocity, the more heat is transferred from the human body through radiation. At higher temperatures, a significant portion of body heat is lost through evaporation of sweat [3].

When designing special clothing for high-temperature environments, it is essential to quantitatively assess the intensity of sweat secretion. Under the same conditions, a person perspires more easily and more intensely in summer than in winter. Moreover, the intensity of perspiration depends on the body's adaptation to climatic conditions. For instance, at an ambient temperature of 35 °C, the amount of sweat secreted from the skin surface can reach $52 \cdot 10^{-6}$ kg/sec·m², whereas at 45 °C, it can reach up to $101.8 \cdot 10^{-6}$ kg/sec·m² [4].

Microclimate parameters are interrelated. For example, at high air temperatures, air velocity tends to increase, whereas at high relative humidity, air temperature tends to decrease. Under conditions of no air movement, the following temperature-relative humidity ratios affect the human body similarly:

- 17.7 °C – 100%
- 18.3 °C – 90%
- 20.7 °C – 50%
- 22 °C – 0%

The body's adaptability to meteorological conditions is significant but not unlimited. The upper threshold of thermoregulation for a resting person is considered to be 30-31 °C. Under heavy work, heat balance is maintained by thermoregulatory functions of the body at 25-26 °C (relative humidity 40-60%) [5].

Thus, for a person to feel thermally comfortable, temperature, relative humidity, and air velocity must be in certain proportion.

In production facilities, at an air temperature of 35 °C, air movement facilitates increased heat transfer from the body. As the temperature rises, moving hot air begins to transfer its heat to the

human body, causing heating. At low temperatures, moving air causes body cooling. Sudden changes in indoor temperature, such as drafts of cold air, significantly disrupt thermoregulation in winter and lead to colds [4].

The analysis of labor activity in production facilities primarily indicates the need for special clothing that meets hygiene requirements [6-7-8]. When designing special clothing for workers in production facilities, it is advisable to take into account factors such as relative humidity and air temperature and to use fabrics with high hygienic properties. Additionally, modifying the clothing design to suit climatic conditions serves as an effective solution to the problem [9-10-11].

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