Ergonomics in the garment industry

Dr Gordana Colovic

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Preface

The crucial characteristic of the present time is rapid technological development, globalization of markets, enterprises that operate without regional and national boundaries, the diversity of views that must also be considered in making decisions, the individualization of business partners and the uncertainty and unpredictability of development, resulting in recent years in almost all areas in the changes that were not there before. New technologies and production processes are rapidly changing the familiar forms of work. Therefore, the work environment must be increasingly adapted to a man in order to perform a work task successfully without excessive fatigue.

When designing the work environment, it is necessary to align technology and technologicality of garment production, technique, ergonomics and work organization in order to obtain optimum work performance. Rational usage of working capacity of a man is a matter of not only being humane but also being economical. The value of ergonomics goes beyond health and safety. A good ergonomics strategy can add value to a company's business strategy and ultimately contribute to the business goals of higher profits.

The goal of ergonomics is to improve human's work activity. Ergonomics deals with the relationship between a man and his work, trying to find a way of better adapting to a man. Since it has an interdisciplinary character, ergonomics approaches the work with complexity: psychologically, physiologically, economically, organizationally, and societally. Today, ergonomics is a discipline that is evolving in new directions, because it cannot ignore the fact that the human's psychological and social constraints, needs and requirements may also be the limit when using an asset and that they should also be loaded while designing the technical means or the technical system.

Ergonomic disorders are the fastest growing category of all the occupational illnesses. They include 56% of all diseases. Ergonomic risk refers to the physical stress factors and workplace conditions that carry a risk of damage or muscle-bone disorders of the employees. The risk is always present when the job requirements exceed the ability of workers to perform the task. If the tasks or movements repeat frequently (e.g. every few seconds), the strain upon the muscles and tendons can accumulate, which can lead to permanent tissue

damage. Tendons and muscles can often recover from the effects of repetitive stress if there is enough time to rest between these repetitions. Unfavorable working postures increase the fatigue of workers and the time of performing technology operations.

The primary task of the manager should be the optimization of work. This is achieved by reducing the difficulty of human activity, which consists of adapting the physical conditions of work to the psycho-physiological and biomorphological human properties, as well as finding a technological process that largely suits a man.

I would like to thank Professor Dr. Danijela Paunovic for her professional support, Professor Sladjana Milojevic for editing, Company NexGen Ergonomics Inc., Laguna Clothing Company, and Ramax Company.

Dr Gordana Colovic

Foreword

The third book written by Gordana Colovic in an original way, with examples from the garment industry and with a detailed scientific analysis of ergonomics, points to the importance and necessity of this interdisciplinary science. Its application through the standardization of micro- and macro-environment in the garment industry provides an example of how to design the present and future processes. The author's analysis of ergonomics as a scientific discipline gives a very detailed explanation in Chapter 5 about how to provide the greatest long-term effectiveness through high impact and permanent ability to work in the garment industry.

Historical overview from Hammurabi, through Taylor and Chapanis to the IEA in the first chapter, describes designing the efficient system of work for the proper design of work, how the employees are motivated and how the division of responsibilities between management and work was carried out. Psychosocial factors of work in the scientific management system through the relationship ergonomically placed in the human–work system or Human–Machine System enable reducing monotonous and repetitive tasks to the ergonomically best designed system.

The second chapter analyzes the ergonomics through a series of modern scientific disciplines including biological anthropology, genetics, anatomy, physiology, biomechanics, psychology and design. Owing to its interdisciplinary character, the ergonomics gives a complex approach to work: psychological, physiological, economic, organizational, and sociological; hence, today in the age of high technical and technological development, it is necessary to adapt machines to human's bio-psycho-social constraints and requirements in order to use machines more efficiently, safely and reliably (Human–Machine System).

Employee satisfaction is a set of conditions that motivate employees to perform their tasks successfully and to respect ethical principles in their workplace. Simultaneous employee satisfaction can lead to larger support of the employees in achieving the goals of the organization, creating a larger market of fashion products and achieving higher profits. On the other hand, employee satisfaction can improve the relationships in PBS based on trust,

communication and coordination between functions. In the third chapter, the author discusses the importance of psycho-physiological components that affect humans directly. When the demands of work are such that a man can overcome them by putting an effort into it, the functional ability of his body and his health is not harmed and there is an ergonomic balance.

The analysis of anthropological and biomechanical characteristics of a man leads to the correlation with ergonomic principles set out in the fourth chapter. Unless the ergonomic principles are obeyed, a man is exposed to a number of risk factors: the action of force, repetitive movements, uncomfortable posture, poor posture, vibration, stress and cold. So authentic examples from the local and international garment industries are used to provide an analysis of a workplace (standing and sitting), movement analysis, the application of the principles in designing work processes, work time, the use of tools, as well as in the environment (light, noise, vibration, etc.).

The fifth chapter deals with the ergonomic design of the whole process of production, distribution and sale of apparel products.

Many apparel manufacturers in the world still operate in the conventional way, with technical and technological preparation being carried out in the offices without computers and the constructional preparation without using CAD systems. Traditional constructional production, preparation and the sale of garments are very difficult, both mentally and physically, and we believe that this original book will help those who take care of their employees, those who design machines in the garment industry as well as the processes and human relations in their companies.

Dr Danijela Paunovic

Author

Dr. Gordana Colovic was born in 1963. She graduated from the Department of Textile and Mechanical Engineering, Technical Faculty, B.Sc Textile Technology (2002), M.Sc. Technical Science (2004) and she holds a PhD in Industrial management (2007).

For 25 years she worked in The College of Textile – Design, Technology and Management in Belgrade, as a professor for Organization of manufacturing, Work study, Management of technology systems in garment industry, Marketing management for garment industry, Strategic management, Market research and Consumer behavior and Public relations.

She has published six books and paper works in around 100 publications and symposiums.

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Ergonomics development

Abstract: The task of ergonomics is to optimize the human–machine–environment system adjusting working conditions to physical, psycho-physical and physiological nature of a human, taking into account relevant differences that exist between humans in relation to their jobs and workplace. Ergonomics increases the efficiency and productivity of production or business system, and improves health, safety and comfort of a man in his working environment.

Key words: ergonomics, definition, history, development, standards

1.1 Definition of ergonomics

Ergonomics (Greek: *Ergon* = work + *Nomos* = custom, law) is an interdisciplinary scientific approach to problems of adjusting work to humans, aiming to increase productivity, i.e. working efficiency, work safety, and humanization of human labor.

The term *ergonomics* is used in most European countries, the term *human factors* or *human factors engineering* in the United States, and the term *engineering psychology* in the former Soviet Union. Ergonomics was first mentioned in 1949 when the Ergonomics Research Society was founded, and its authorship is attributed to Murrell, the society founder who, recognizing that the efforts of various experts in solving the problems of adaptation to humans are uncoordinated, had a group of different professionals (psychologists, physiologists, engineers, etc.) with the goal of mutual exchange of information.

The goal of ergonomics is to be studied and adapted to conditions of work, means of work, work process, and the product as a result of human work from the psychological, physiological and anatomical aspects, instead of adjusting a worker to the needs of a job. Adaptation of work to humans has the following three aspects:

(1) Adjustment of machines and tools, which should be designed, constructed and shaped, thus respecting human anatomical, physiological, psycho-physiological, and psychosocial characteristics, i.e. capabilities and limitations.

(2) Adjustment of working methods with respect to body positions and movements, allocation of work, i.e. work operations and their arrangement, organization of resources for work (work objects and tools) and, work organization (machine layout and synchronization of transport) so that the selected method of work with the least stress and fatigue should give the maximum effect.

(3) Adjustment of working environment, with regard to objective physical conditions, using their optimum arrangement, to provide a sense of comfort while performing work that affects the work efficiency.

Ergonomics is a multi- and interdisciplinary science that deals with human–machine system in order to adjust the machine to human's bio-psycho-social limitations and requirements, so as to use the machine more efficiently, safely, and reliably. It is the applied science that deals with the characteristics of people that are to be taken into account when constructing and structuring facilities used by the people, so that their mutual interactions in the system are maximally effective and safe.

According to different authors, there are several definitions of ergonomics:

- Ergonomics is a scientific discipline that examines the relationship between a human and his material environment, in order to optimally subordinate it to humans. Therefore, ergonomics is not a fully independent branch of science; it uses the results of many disciplines, which provide data about men and the outside factors that influence their behavior and work. (Keller, 1978)
- Ergonomics is the study of human abilities and characteristics that affect the design of equipment, systems and jobs, and its aims are to improve efficiency, safety, and well-being. (Clark and Corlett, 1984)
- According to Brown and Hendrick (1986), ergonomics is the relation between man and his occupation, equipment, and the environment in the widest sense, including work, play, leisure, home, and travel situations.
- Ergonomics attempts to optimize the fit between people and their environment. (Mark *et al*. 1987)
- According to James H. Stramler (1993), it is that field which is involved in conducting research regarding human psychological, social, physical, and biological characteristics, maintaining the information obtained from that research, and working to apply that information with respect to the design, operation, or use of products or systems for optimizing human performance, health, safety, and/or habitability.

- According to Alfons Chapanis (1995), it is a body of knowledge about human abilities, human limitations and other human characteristics that are relevant to design.
- Ergonomics is the branch of science that seeks to turn human–machine antagonism into human–machine synergy. (Henkok, 1997)
- According to Wickens *et al*. (1998), it is to apply knowledge in designing systems that work, accommodating the limits of human performance and exploiting the advantages of the human operator in the process.
- Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. (IEA, 2000)
- Ergonomics is now predominantly observed as an interdisciplinary part of science of work. According to R. Hackstein, the science of work is "a combination of theoretical, descriptive and experimental, natural and social sciences…about human labor as a conscious and planned, body and spiritual activity which aims to satisfy basic needs first, and then the other ones…"

According to Döring B. (1986), ergonomics has several areas of interest, which are as follows:

- Designing organization of a working system
- Organization of the flow of process
- Designing workplace
- Designing working areas
- Designing working environment
- Selecting and training employees

Put simply, the science of work deals with the parsing and designing of working systems and working environments, aiming to establish, on the basis of scientific knowledge, all the necessary measures that would improve and facilitate the work and life of a man in the industry. The main difference between the ergonomics and science of work is that the area of ergonomics is theoretical; hence, ergonomics should be viewed in its practical dimension – as technology.

The methodological approach in ergonomics consists mainly of applied researches and systematic application of relevant information on human

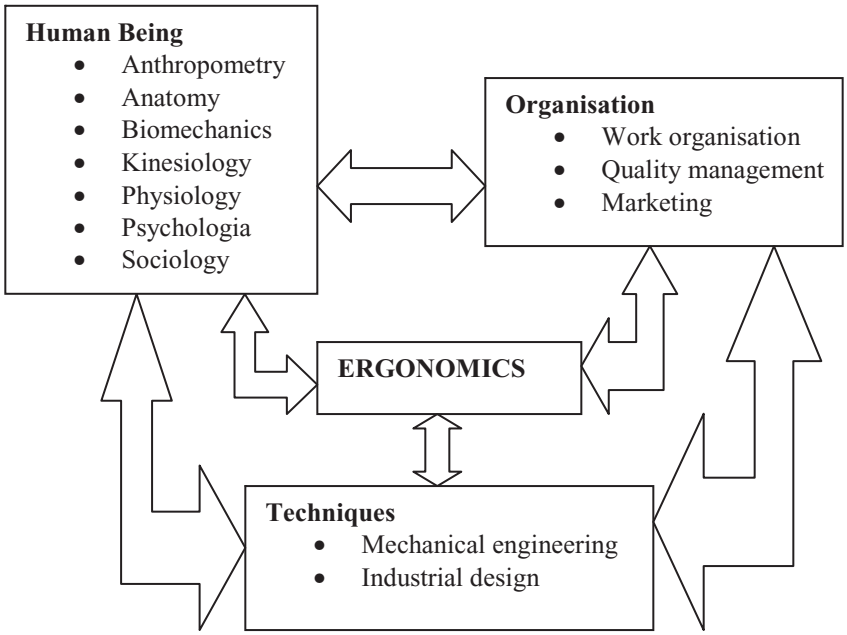

Figure 1.1 Sources or ergonomic knowledge

abilities, characteristics in behavior and motivation in carrying out the activities defined in ergonomics.

A large number of scientific disciplines contribute to the development of ergonomics: technique, anatomy, anthropometry, physiology, industrial psychology, medicine of work, sociology, industrial design, and others. Figure 1.1 shows the sources or ergonomic knowledge.

1.2 History of ergonomics

The relationship between a human and tools dates back to the earliest times of human labor. It was back in the primitive community that a human studied how to make a tool to make his work easier, i.e. how to adjust it to work.

Hammurabi, the king of Babylon (1728–1686 BC), introduced work planning, production control, calculation of required workers and working days and details of the required work hours. Xenophon (about 430–354 BC) left us a written statement of the division of work into operations when producing military shoes. The Ancient Greece (5th century BC) used ergonomic principles in the design of their tools, jobs, and workplaces. Hippocrates (c. 460 BC–c. 370 BC) described how a surgeon's workplace should be designed and how the tools he uses should be arranged.

Figure 1.2 Bernandino Ramazzini

Bernardino Ramazzini (1633–1714), known as the "father of medicine," was the first doctor who studied the diseases caused in the workplace. He noticed that many of his patients had symptoms related to their profession. He interviewed his patients about their work tasks and workplaces. He published his observations in 1713 in "De Morbis Artificum Diatriba" (Diseases of Workers), about the relationship between various injuries and occupations.

Ramazzini (Fig. 1.2) carefully described each task or occupation, paying particular attention to potential causes and consequences of long-term exposure to toxins, stressful tasks and positions in the workplace and other pathogens workers are faced with in 52 occupations. In 1982 the international society of scientists formed the organization in his honour, "Collegium Ramazzini," in order to improve the study of occupational and environmental health problems worldwide.

Wojciech Bogumil Jastrzebowski (1799–1882) was a Polish biologist who coined the term "ergonomics" in 1857. He defined ergonomics as the study of human capabilities in relation to the demands of work.

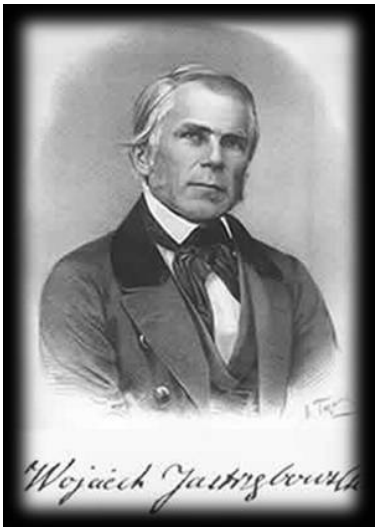

Figure 1.3 Wojciech Jastrzebowski

Jastrzebowski (Fig. 1.3) divides the work into two categories: useful work, which brings an improvement of the common good, and hazardous work, which brings aggravation. Useful work is classified as physical, aesthetic, rational and moral work, which requires the use of physical strength, sensory strength, the power of reason (thinking and reasoning), and spiritual strength.

He is the author of a pioneering ergonomics debate "An Outline of Ergonomics, or the Science of Work Based Upon the Truths from the Science of Nature" ("*Rys ergonomji, czyli nauki o pracy, opartej na prawach poczerpnitych z nauki przyrody*").

The Industrial Revolution occurred around 1875, together with the concept and method of mass production. The tendency was to increase productivity as well as profit, not for the reason of humanity. It took some time to realize that optimal results at work can be achieved not only by asking workers to put more effort and adapt to the conditions of the workplace, but also by adapting the work process, work environment and means of working to the worker.

In the 19th century, Frederick Winslow Taylor (1856–1915) (Fig. 1.4) made a pioneer method of "science management," who proposed a solution to find the optimal way to perform a task. This American engineer sought to improve industrial efficiency and is considered to be "the father of scientific management."

Taylor (1911), extending the principle of division of labor, designed an efficient work system for the proper design of job, the motivation of

Figure 1.4 Frederick Winslow Taylor

employees and the division of responsibility between management and labor. The analysis of psychosocial factors in scientific management system detects skills because workers have no control over the process of work and their job is monotonous and very repetitive.

He published many of his works, of which the most famous are: "Shop Management" (1903), "Principles of Scientific Management" (1911), and "Testimony before the Special House Committee" (1912), which were published in 1947 with the title "Scientific Management."

On the basis of his experiments, Taylor set the following principles of scientific management:

- The first principle is based on the assessment of daily performance of workers. "The knowledge of how much each type of worker can do in a day is obtained by employers either through their own experience, which eventually becomes foggy, or through occasional and unsystematic observation of their employees, or – at best – on the basis of data showing the shortest time required to have each job finished."
- The second principle of scientific management was given in Taylor's opinion in one of his first works, "Shop Management," in 1903 – that "all the spiritual work should be removed from the drive and performed in the planning department…"
- The third principle is the control of work and carrying out work tasks.

Figure 1.5 Frank Bunker Gilbreth and Lilian Gilbreth

In addition to these general principles, Taylor mapped out the methodology of implementation of scientific management in practice, as follows:

(1) Employees with the highest level of qualification for the specified work task should be chosen.

(2) Basic movements and operations that each worker should do in his job are to be studied in details.

(3) The time required for performing each movement or operation should be studied, using a stopwatch. On the basis of this knowledge, the shortest possible time required to make each movement should be established.

(4) All unnecessary and slow movements should be eliminated.

(5) After the removal of all unnecessary movements, a series of fastest and most effective movements are to be established.

Each of Taylor's principles might be subjected to criticism today. The first principle separates work from the skills of the worker. The second principle eliminates the concept (idea) from its performance. The third principle (although basically acceptable) gives the function of control exclusively to management and business structures, and eliminates it from direct production, to which it rightfully belongs.

After decades of oblivion, the Taylor theory has, in recent years, returned in various modified versions to the theory and practice of management.

Frank Bunker Gilbreth (1868–1924) and Lilian Gilbreth (1878–1972) (Fig. 1.5) are well-known worldwide for their pioneering work in Time and Motion study and ergonomics.

Therblig	Color	Symbol/Icon	Therblig	Color	Symbol/Icon
Therblig	Black		Use	Purple	
Find	Gray		Disassemble	Violet Light	
Select	Light Gray		Inspect	Burnt Orange	
Grasp	Light Red		Pre-Position	Sky Blue	
*Hold	Gold Ochre		Release Load	Carmine Red	
Transport Loaded	Green		Unvoidable Delay	Yellow Ochre	
Transport Empty	Olive Green		Avoidable Delay	Lemon Yellow	
Position	Blue		Plan	Brown	
Assemble	Violet Heavy		Rest for overcomming fatigue	Orange	

Figure 1.6 Therblig's list

Gilbreth met Taylor in 1907 and became an admirer of his system of studying. In 1914 Lilian and Frank made their own form of scientific management, which was dedicated to the human factor as well. They saw the need to improve the satisfaction of employees, which in turn would improve the overall job performance and efficiency of workers. Frank devised a system to relieve the fatigue of workers and increase productivity by studying each worker's movement, and the process was called a micro-movement study. The Gilbreths used photographs and film strips for the study of movement of workers, in order to design methods to perform the task in the best possible way. They also saw the need to improve the physical comfort of employees, and their innovations in the design of office furniture were well ahead of their time, the leading way to study ergonomics.

Gilbreth made a table (table list) of 18 basic movements, which he named "Therblig" by the anagram of his surname (Fig. 1.6), with graphic signs that occur during each work, and those movements are good enough to show different jobs at different positions. This allowed the analysis of time and introducing time standards for performing certain tasks.

Kenneth Frank Hywel Murrell (1908–1984), a British chemist and psychologist, was among the first ones who studied ergonomics. In 1949, with a small group of the like-minded, he established the Ergonomics Research Society – later to become known as the Ergonomics Society, and is today the Institute of Ergonomics and Human Factors (IEHF).

Murrell was particularly interested in the development and usage of knowledge and skills for the analysis of ageing and fatigue, as well as the application of psychology and ergonomics to practical questions. He wrote the first ergonomics textbook ("Fitting the Job to the Worker," 1960). In the UK, he worked with anthropologists, unions and managers in the dissemination of ergonomics.

Alfons Chapanis (1917–2002) was the founder of ergonomics, the branch of engineering that observes the production and design of the workplace. In 1943, as an officer in World War II, he found out that pilots made fewer errors if the aircraft control panel layout was simplified.

During his 50 years career, Chapanis helped find the field of ergonomics. His contributions included:

- Writing the ergonomics textbook "Applied Experimental Psychology: Human Factors in Engineering Design."
- Improving the safety of aircraft cockpits to prevent accidents.
- Conducting research that led to the design of the standard telephone touchtone keypad.
- Conducting pioneering work in the design of teleconferencing and videoconferencing systems.
- Conducting studies into the intelligibility of digitized speech (a precursor to satellite-based telephony and digital wireless telephony).
- Championing the importance of the user in human–computer interaction.
- Working to improve safety labels.

Alfons Chapanis (Fig. 1.7) was also the president of the Society of Engineering Psychologists and the Human Factors Society (now the Human Factors and Ergonomics Society).

Based on this brief historical review, the development of ergonomics can be divided into the following two stages:

(1) Classic or corrective ergonomics (from the industrial revolution to the 1950s).

(2) System or project ergonomics (from the 1950s to present time).

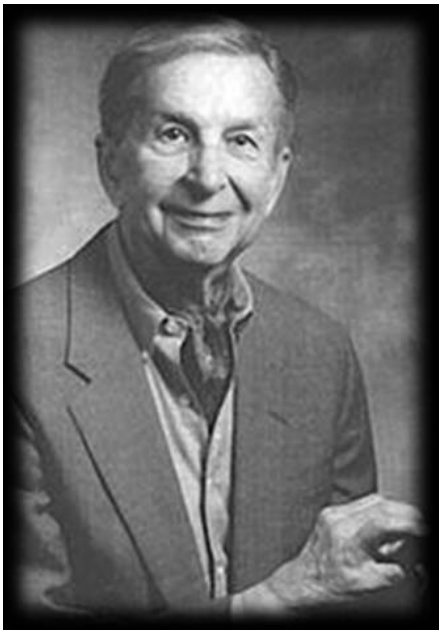

Figure 1.7 Alfons Chapanis

At the beginning of this science, immediately after World War II, the emphasis was put on the adjustment of machine to human body and its limitations. In 1963 Barnes extended Gilbreth's basic principles of rationalization to 22 principles for the rationalization of movement. These cover the principles of the usage of human body, which are still applied in practice when we want to shape the workplace optimally:

- Eight principles are related to the economy of movement.
- Eight principles are related to the regulation of workplace.
- Six principles are related to methods and principles of designing tools and equipment.

Classical or corrective ergonomics is based on these principles.

Today, ergonomics is a discipline that is evolving in new directions, because it cannot ignore the fact that the human's psychological and social constraints, needs and requirements may also be the limit when using an asset and that they should also be loaded while designing the technical means or the technical system.

The corpus of knowledge of ergonomics is in literature, textbooks, manuals, instructions, standards, journals, and electronic databases. Ergonomics is integrated by the knowledge about human functions, the structure and

behavior of practical use in the designing process. Formal courses and the degree of human factor can be obtained at universities and colleges worldwide, as well as at professional associations that has existed for the education and information exchange since 1957.

The analysis of recent experience suggests that in the future the development of ergonomics will be moving towards adjustments to socio-economic needs, thus causing further diversification. Tendencies in the development of ergonomics are as follows:

- The focus of ergonomic researches is shifting from the ergonomics of production systems to the ergonomics of products.
- In the process of planning and establishing manufacturing processes/systems, workplaces and products, the standpoints related to safety and environmental protection are becoming more important.
- Special requirements will be largely increasing, i.e. the requirements of the individual layers in the planning process.
- There is a growing percentage of users of products in the process of ergonomic planning and evaluation.
- Wide usage of information technology raises complex requirements in the field of ergonomic researches and practical application of ergonomics.
- There is a growing interest of engineers in the area that has until recently been dominated by psychologists.

1.3 Standards

The first International Organisation for Standardisation (ISO) standard based on ergonomic design of work systems ISO 6385 (1981), i.e. ergonomic principles of work system design, was developed on the basis of the German standard DIN 33 400 (1975), designing systems according to the ergonomic guidelines.

International Ergonomics Association (IEA) established a standard ISO/TC 159 in 1975. The scope of ISO/TC 159 standard in the field of ergonomics includes terminology, methodology, and data on human factors. In the context of scope, the board, through standardization and coordination of activities, promotes the adaptation of working and life conditions so as to adjust the anatomical, physiological, and psychological characteristics of humans to the physical, sociological and technological environment.

The requirements for ISO/TC 159 to achieve its goals are as follows:

- To collect and make a critical review of ergonomic data relevant to international standardization and which are related to designing and manufacturing of machinery, design and organization of work processes, as well as the layout of work equipment and the control of physical environment in the work rooms.
- To identify those branches of industry, services and trade where the ergonomic needs will expand or develop with new technologies.
- To recognize the inevitable delay time in manufacturing, as well as its performing.
- To set and implement comprehensive subprograms for standardization of activities in different areas of ergonomics.
- To create, within the framework of ISO/TC 159, the function responsible for strategic planning implementation and updating of this strategic policy statement.

The organizational structure of ISO/TC 159, ergonomics (January 2000):

(1) ISO/TC 159/SC 1 General ergonomic principles:

TC 159/SC 1/WG 1 Principles of ergonomics and ergonomic design.

TC 159/SC 1/WG 2 Ergonomic principles related to mental work.

(2) ISO/TC 159/SC 3, Anthropometry and biomechanics:

TC 159/SC 3/WG 1 Anthropometry.

TC 159/SC 3/WG 4 Human physical strength: manual handling and force limits.

(3) ISO/TC 159/SC 4, Ergonomics of human–system interaction:

TC 159/SC 4/WG 1 Fundamentals of controls and signalling methods.

TC 159/SC 4/WG 2 Visual display requirements.

TC 159/SC 4/WG 3 Controls, workplace and environmental requirements.

TC 159/SC 4/WG 5 Software ergonomics of human–computer interaction.

TC 159/SC 4/WG 6 Human-centerd design processes for interactive systems.

TC 159/SC 4/WG 8 Ergonomic design of control centers.

TC 159/SC 4/WG 9 Tactile and haptic interaction.

TC 159/SC 4/WG 10 Accessible Design for Consumer Products.

TC 159/SC 4/WG 11 Ease of operation of everyday products.

TC 159/SC 4/WG 12 Image safety.

(4) ISO/TC 159/SC 5, Ergonomics of the physical environment:

TC 159/SC 5/WG 1 Thermal environments.

TC 159/SC 5/WG 4 Integrated environments.

TC 159/SC 5/WG 5 Physical environments for people with special requirements.

TC 159/SC 5/WG 6 Perceived air quality.

The standards were developed at different levels within the following structure:

- Basic standards relating to the basic characteristics of humans.
- Functional standards related to human factors in work and use of equipment, processes, products and systems.
- Ecological standards related to the effects of physical factors of environment on human qualities, ranging from convenience, health and risk.
- Standards for testing of procedures and processing ergonomic data will be applied in developing standards in the above three categories or assessment in accordance with the already-accepted standards.

One of the criteria for assessing the quality of ergonomic design of each workplace is a component that needs to be individual, depending on human work. For example, mental workload is becoming increasingly important as a result of mechanization and automation, which is why the ISO/TC 159 developed its own standard (ISO 10075:1991), which deals with the principles of ergonomics related to decreasing of mental workload.

Standards will not specify the design of the workplace, but may provide a useful "starting point" for a successful design. Therefore, further ergonomic ISO standardization has to promote humanity, as opposed to technology, product development and work system. The standard ISO/TC 159 continues to contribute significantly to this process and to ensure that people do not have to adjust to the machine, but machines are to be adjusted to people.

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2

Divisions of ergonomics

Abstract: Owing to the interdisciplinary character, the approach of ergonomics to work is a complex one: psychological, physiological, economic, organizational, and sociological. Ergonomics integrates a number of disciplines, including biological anthropology, genetics, anatomy, physiology, biomechanics, psychology, and design.

Ergonomics is both a multi- and interdisciplinary scientific discipline concerned with the human–machine system in order to adjust machines to man bio-psycho-social limitations and requirements, aiming to use the machine more efficiently, safely, and reliably.

Key words: categories of ergonomics, types of ergonomics, macro-ergonomics, micro-ergonomics

2.1 Categories of ergonomics

According to the specific human traits and characteristics of human interaction with the environment, ergonomics is divided into physical ergonomics, cognitive ergonomics, and organizational ergonomics.

2.1.1 Physical ergonomics

Physical ergonomics is concerned with how the human body responds to physical work activity (work physiology) and how the physical dimensions of the human body affect the capabilities of a worker (anthropometry).

The main objective of physical ergonomics is to increase comfort, to reduce pain, and the occurrence of muscle-bone disorders (MBD). That is why it deals with designing a system that minimizes physical exertion and defines human capacities, human logics, and reasoning.

Physical ergonomics deals with anatomical, anthropometrical, psychological and biomechanical characteristics of human beings in their relationship with physical activity, such as the following: attitudes toward work, handling with materials, frequent injuries due to movement, MBD, organization of working space and safety and health.

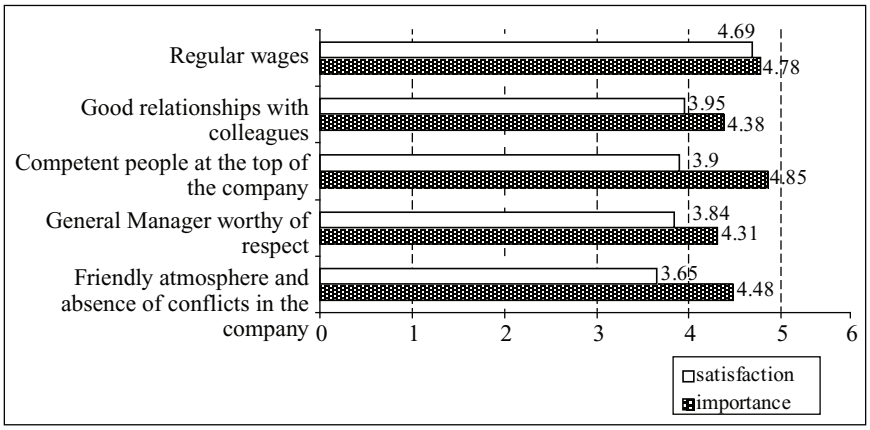

Figure 2.1 Sources of satisfaction

(1) Attitudes towards work

Attitudes toward work are affected by a very large number of factors, many of which are not influenced by management (e.g. life satisfaction). Attitudes are very stable and difficult to change. Attitudes are affected by perceptions of employees, so even a small change in work affects a great change in the attitude toward work.

Employees' attitudes toward changes, organization and work can affect the changes in the concept of human resource management (HRM) either positively or negatively. A positive attitude is when the process of change is accepted as the basis for successful business and organizational development, when changes are initiated, when there is an interest of employees to be involved in the process of creating changes and when the proposed changes are consistently applied. A negative attitude is the resistance against changes, which is in practice manifested in different ways.

Satisfaction in work, preoccupation with work and commitment to production–business system (PBS) represent some of the most important attitudes toward work and PBS that affect the motivation of workers, and thus indirectly the outcomes of some forms of work behavior. Some of the sources of satisfaction at work are shown in Fig. 2.1.

(2) Handling with materials

Handling with materials includes handling materials in warehouses and plants. There is often the risk of possible injuries during work. Manual Material Handling (MMH) refers to any manual task of the human body as "a source of strength." MMH includes raising, lowering, pushing, pulling, carrying, and storage (see Chapter 4).

(3) Frequent injuries due to movement

Diseases associated with work belong to the group of non-specific diseases of work. In some occupational groups particular diseases occur with greater frequency, which is why they are referred to as profession diseases. These are, for example, occupations in which doing a job requires performing rapid complex movements or repetition of monotonous ones (sewing, computer work, etc.).

Constant and continuous action of long-term performance of the same movements, repetition on the same part of the body over a long period of time, constant pressures and body stretchings, weight of the work tool and lack of proper rest may result in loading the bones, joints, and muscles as well as result in degenerative diseases of their structure (see Chapter 4).

(4) Muscle–bone disorders

The International Commission on Occupational Health (ICOH) defines MSD associated with work as such disorders and diseases of the musculoskeletal system that have a causal determinant, which is associated with work. Damages and degenerative changes of the musculoskeletal system are the consequence of mismatch between the requirements for the load on the body and the abilities of the body to respond to those requests.

Repetitive Strain Injury (RSI) or Cumulative Trauma Disorder (CTD) is a group of musculoskeletal disorders in the joints of the upper part of the body (hand, elbow, shoulder, neck) and less frequently in the lower part of the body (knee, foot). Body position during work depends on the type of work and the conditions of working space. Non-physiological and forced posture at work, permanent standing or sitting, bending or squatting, kneeling and lying are very unfavorable because they lead to static muscle strain.

Musculoskeletal symptoms and disorders are damaged muscles, joints, tendons, ligaments, nerves, bones and local circulation, which often appear in inappropriate, non-ergonomic positions. The symptoms of this disorder are as follows:

- Local muscle and joint symptoms: swelling, pain or sensitivity, redness, numbness, pallor, tension or stiffness.
- General symptoms: fatigue, pain, limited movement.
- Overuse syndrome of the musculoskeletal system by cumulation of chronic micro-traumatic damages.
- Injuries of the musculoskeletal system.

It is estimated that two-third of the total number of cases of sick workers suffer from one form of RSI, i.e. about 7% of the world's population suffers

from a form of RSI. Epidemiological studies show that 25% of the working population suffers from the disorder of system of movement, and individual complaints of back pain were reported by 90% of the people questioned. Every year from 11% to 14% of workers are limited in activity due to musculoskeletal disorders. Therefore, the initial health problems should not be ignored, because the majority can be prevented, eliminated, or reduced by protective measures.

Some examples of risk factors that may lead to the occurrence of musculoskeletal and other disorders are as follows:

- Unnatural and static positions: Bending or lowering the body due to holding or lifting heavy objects; pulling out or pushing objects into blocked areas; frequently repeated tasks, which include leaning, bending forward, kneeling, or squatting, working with arms bent or distorted, using hands below the waist or above the shoulders; standing or sitting most of the shifts; working with arms or hands in the same position over a longer period of time without changing posture or resting.
- Putting a lot of force into the movement: Lifting (lifting heavy loads with one hand or without the help of mechanical devices; lifting heavy loads by bending, reaching above shoulders or leaning); pushing, pulling, carrying (manual cranes for pallets or other carts that are difficult to move; uneven surfaces and cracks in the floor or panels with low edges that can catch wheels while pushing; pulling objects instead of pushing them; manual transport of heavy objects to big distances) and using tools that are too small or too large for the hands of workers.
- Repetitive movements: Rapid movements of hands; movements that are performed for several hours without rest; jobs that require a repeating force of the fingers – packaging, putting labels on products.
- Contact stress: Contact with sharp or hard edges, working with machines for cutting – knives.
- Vibrations: Using tools on the electric drive – vibrations of hands and arms, driving forklifts, trucks and other vehicles – whole-body vibration.
- Coldness: Working in a cold environment without proper clothing.

Many of the musculoskeletal injuries can be prevented. Employers must reduce any risks identified in the process to the lowest possible level by introducing control measures. Here, it is important to consult the workers, because they know most about the job. This means that the job should be adjusted to the worker, and not the worker to the job.

(5) Organization of working space

Workplace is the least technological and organizational encirclement within which there is a precisely defined part of a process. Workspace can be defined as an area in which a worker can perform the intended actions. Viewed from the standpoint of workers, workspace is a part of space in which there is the possibility of performing given actions, i.e. the set of items worth being reached by his extremities.

Workplace layout is intended to provide stimulating working conditions and improve the creativity of workers. In designing the working space, we can count on the adaptability of man. Therefore, when designing the workspace anthropometric measures and dimensions of people who will work in specific work areas must be taken into account, together with a large number of other measures. For example, when designing a desk and a chair, which seems to be a simple task, one should consider the following dimensions:

- worktop width (not to exceed the arm's length)
- worktop height
- height of space under the table
- seat height
- seat depth (not to be less than the width of the thigh)
- support in the lumbar area of the hull
- sufficient space for leg

Optimal: Appropriate designing of workspace leads to increased work performance and greater safety and sense of comfort for workers, thus reducing damage to tools, machinery and equipment, injuries or accidents at work.

(6) Safety and health

Safety and health protection at work includes a set of (collective and individual) measures and means aimed at providing safe working conditions and a set of measures and means to create comfort in places of work, a humane working environment, preserving the privacy, human dignity and integrity of the employee at work. The concept of health and safety protection at work in a broader sense should create better physical and mental health for all the employees, protect the integrity and dignity of workers, and provide comfort and satisfaction at work.

Safety and health at work, as defined by the International Labour Office (ILO), is a discipline concerned with the improvement of working conditions and working environment, prevention of injuries, occupational diseases, and illnesses related to work, as well as protecting and improving the health of employees.

Safety at work includes a set of modern technical, medical, social, and other measures and means with the purpose of preventing and eliminating the causes of injuries and damages to health of the people at work, or at least to minimize their harmful effects. The term "dangers at work" involves the set of adverse effects on the health of workers. A danger does not happen permanently (mechanical hazards, electrical currents, etc.) but currently, and only in the case of accidents. The hazards at work include a set of influences on a worker's body, which causes long-term health damage (harmful and toxic substances, noise, vibration, etc.). According to the source they are divided into chemical and physical. They can be classified into the following 12 types:

- physical effort (non-physiological position of workers): any activity that requires more dynamic or static effort
- mechanical hazards: everything resulting from the mechanical action of the means of work in a state of rest or movement on the worker's body
- dangers of electricity: when working on electrical devices or using electricity, the danger of voltage
- hazards: when caused by dust, fumes, and aromas, harmful effects are evident in damaged respiratory organs, eyes, and skin of workers
- chemical hazards: a worker comes into contact with hazardous substances when doing his job, which may be hazardous to his health and life
- dangers of noise, vibration and shock loads: hearing loss, heart disorders, balance disorders, insomnia, etc.
- poor lighting: eyesight loss, which increases the number of errors and reduces the possibility of perception
- harmful radiation: consequences can be observed after a shorter or longer period of time, and some consequences are transmitted to descendants
- unfavourable microclimatic conditions: temperature, humidity, air velocity
- biological hazards: viruses, bacteria, parasites, insects, fungi, etc. – of organic origin, depending on the type of hazards, which may be small or large
- risk of falling and working at heights (more than 3 m) on all surfaces
- risk of fire or explosion: they are particularly seen in cases where security measures have not been applied

There are 50 million injuries in the industry per year, or 160,000 per day. Most of the injuries occur with:

- fingers – 19%

- eye – 9.44%
- ankle – 6.81%
- neck and throat – 5.57%
- knee – 5.42%

The most common causes of accidents at work are as follows:

1. lack of applying rules of safety at work and lack of conditions to be met by employees, and
2. passages and areas for work being improper.

According to DeCenzo and Robbins (1996), there are 45,000 deaths in the US per year due to accidents at work and 6.6 million injuries and occupational diseases, besides 90 million lost workdays, for which the US companies pay more than 111 billion dollars. In the UK, 30 million working days per year are lost due to diseases and injuries at the work place (Stephen Pilbeam and Marjorie Corbridge, 2002). Two million people complain about deterioration of health caused by their work. Another 17,500 people per year were forced to leave their jobs, while 90,000 people change their jobs annually because of injuries or illnesses. It is estimated that the total loss caused by reduced productivity due to illnesses, hospital treatments and administrative reasons amounts to more than 10 billion pounds a year. The consequences of injuries observed in terms of human factors and economic losses for just one injury are shown in Table 2.1.

Table 2.1 The consequences of injuries observed in terms of human factors and economic losses (for one injury).

	The human factor	**The economic loss**
Injured worker	physical pain psychological suffering	reduction of income special expenses decrease in efficiency
Family workers	psychological suffering reduction of other activities	financial difficulties
Plant	discomfort worry panic	reduction of income overwork teaching a new employee
Production–business system	decline in the working atmosphere loss of reputation	reduction of production damage to the machine medical costs compensation costs

	The human factor	The economic loss
Society	decline in human resources	reduction of production increased insurance costs reduction in purchasing power increased costs for the standard and education

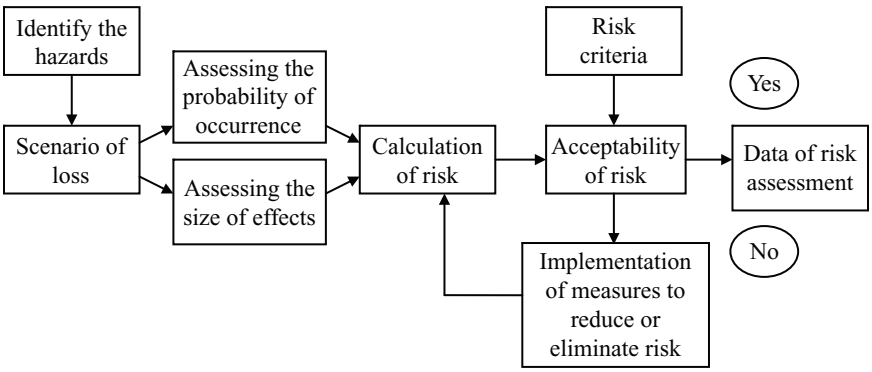

Figure 2.2 A logical framework for risk assessment

Analysis of the causes of accidents shows that the occurrence of an accident is mostly affected by behavior (70%), followed by skills (20%) and, finally, knowledge (10%). Prevention of accidents at work can be achieved primarily by influencing the behavior and motivation of employees.

The system of safety and health at work in each PBS should be based on applying the principles of prevention from occupational injuries, illnesses, or damages to the health of an employee, which are carried out before starting work at the workplace and in the working environment. A prerequisite for successful application and implementation of measures for safe and healthy work in the workplace and working environment is risk assessment. Risk is the probability of injury, disease, or impairment of health of the employee due to hazards.

Risk assessment is a systematic recording and assessing of all factors in the work process that can result in accidents, illness or damages of health and determine options, i.e. how to prevent, eliminate, or reduce risks at the workplace and in the working environment. Figure 2.2 shows the logical framework for risk assessment. From the standpoint of the interest of fashion companies, taking care of health and safety contributes to increased productivity and efficiency in a way that:

1. directly affects the maintenance of working capacity

2. reduces the cost for replacement of absent workers due to disability
3. eliminates the costs of any fines for violating the legal safety norms at work
4. eliminates the possible costs of compensation for occupational injury and disability
5. has a positive effect on the company's image in the public and the labor market
6. reduces employee dissatisfaction with unacceptable conditions, etc.

The Seoul Declaration on Safety and Health at Work was adopted in 2008. It emphasizes the principle that the right to a safe and healthy working environment should be acknowledged as a fundamental human right, because only a safe work and healthy working environment can provide a productive work and life.

Safe Work Program International Labour Office promotes an integrated approach to health and safety at work, considering the physical, mental, and social well-being of men and women in the workplace.

2.1.2 Cognitive ergonomics

Cognitive ergonomics deals with mental processes such as perception, memory, thinking and mobility and the way they are affected by interaction with the elements of the observed system. The most important aspects include mental effort, decision making, interaction with computers, human reliability, and work stress.

Cognitive ergonomics concentrates on the analysis of thought processes: mental workload, decision making, and planning that are required from knowledge workers (Marmaras and Kontogiannis, 2001).

The process by which a human is orientated among phenomena and things of the outside world is called the cognitive process; it consists of feeling, perception, learning, thinking, and memory.

Senses are reflections of certain features of objects and phenomena of the outside world in our minds.

Perception is a process that gives meaning to sensory information, connects previous experience and current experience, and establishes and maintains internal cohesion and unity of knowledge about the relevant parts of the outside world, or reality in general. Important objects of perception in organizations are:

- The perception of work performance
- The perception of organizational roles
- The perception of personality

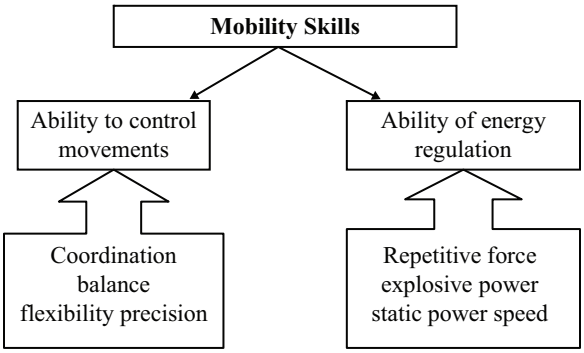

Figure 2.3 The division of mobility skills

- The perception of certain groups or categories of members of the organization

Perception involves searching, obtaining and processing information. People receive stimulants from the environment through their five senses: taste, smell, hearing, sight, and touch. The way people interpret stimulants will lead to the response (open, concealed, or both).

When employees learn, they gain explicit knowledge and knowledge acquired by observation. Explicit knowledge is organized and can be transferred from one person to another. The knowledge acquired by observation is not documented; it is directed toward action and is known below the level of awareness. Learning should cause permanent changes in the behavior of an individual. In organizations, managers want employees to learn and apply productive work behavior. Learning a new work behavior depends on environmental factors. The goal of managers is to create such a working environment that will develop the behavior of employees the organization wants.

Memory is learning through which new habits, knowledge and experience are acquired. It is the possibility of acquiring, retaining and using information. It is important for a man, for his development and his identity. Thinking (or the flow of thoughts) is a mental process that is characterized by reasoning and inference, i.e. by understanding of cause–effect relationships between different concepts.

Mobility has an important role in initiating the entire body. Movements are performed by using smooth, large and small cross-striped muscles that allow static and dynamic body movements, such as head posture, sitting, standing, walking, climbing, and similar movements.

Mobility skills are skills of performing mobility activities in relation to physical parameters (space, time, force) and they can be (Fig. 2.3):

(a) primary mobility skills: coordination, speed, precision, balance, strength, flexibility, and

(b) secondary mobility skills: the ability to control movements (performing movements in space and time) and the ability to regulate energy (for optimum use of energy during the activity).

These skills are measurable and they are influenced by all the physiological and anatomical factors, such as genetic potential, the level of mobility awareness (knowledge), morphological characteristics, energy potentials, cognitive ability, conative characteristics, etc.

Aspects of cognitive ergonomics

Aspects of cognitive ergonomics are mental effort (workload), decision making, interaction with computers, human reliability, and work stress (see Chapter 3).

(1) Mental effort

Mental work is a mental activity in which the brain processes information it receives from the environment. There are two categories of mental work:

(i) Mental work in a narrow sense: a process that requires creativity in a bigger or smaller sense depending on the knowledge, experience, and mental abilities.

(ii) The processing of information, as a part of the human–machine system (HMS): combining new information with what was previously known and decision making. Information processing in any business involves perception through sensory organs (sight, hearing), the interpretation and processing of received information.

Mental workload in the workplace is increased if:

- there is a need to maintain concentration for a long period of time
- there is a need to make a decision that involves big responsibility for product quality and safety of workers and equipment
- the workplace is isolated (no contact with others) and
- occasional lack of concentration because of monotony

Therefore it is important to determine the required effort the worker can really put into 8 hours of work during the day. Different jobs require different efforts, and how much effort an individual will make depends on the level of his work motivation. Thus, by measuring the effort (the highest possible performance for a specific work task and its variations), the level of work motivation of individuals can be measured as well.

Designing the structure of the task by a specific person, sufficient rest periods during working hours, and adequate rest, sleep, and recreation are some ways of reducing symptoms of mental fatigue, in order to avoid permanent damage.

(2) Decision making

The essence of management is the ability to achieve goals through or with other people. Hence, decision making is one of the most important tasks for managers. Many factors such as information, knowledge, experience, data, etc. affect the quality of selected decisions because managers make decisions in the present, to solve problems in the future.

Decision making is a process of identifying problems in the work situation and the choice between the existing alternative courses of action (reorganization, acquisition of new sewing machines, analysis of work places, etc.). Decision making is a complex process of making a number of different decisions at different organizational levels and the places of decision making. Decisions can be classified on different basis and according to different criteria: related and free-will decisions; routine, adaptive, and innovative; strategic, tactical, and operational; programed and unprogramed; individual and collective, long-term, medium term, and current.

Decisions can be classified based on leadership, management, and executive. Leadership decisions set the goals of PBS, their parts and units, and the relationships with functional environment. These decisions are determined by the strategy and policy of PBS. Leadership decisions are global, strategic, and political. The PBS concept implies decisions being brought by the owners, their representatives, and management bodies. The goals included in the leadership decisions are worked out through managerial decisions, on different organizational and managerial levels.

Management decisions determine organizational procedures, methods, results, and tasks to be achieved in order to achieve the goals and plans. These decisions ensure the unity of the work process and business, or effective performing group and individual tasks and jobs. Management decisions have an internal hierarchy, the order of making and carrying them out. They result from management decisions, and management decisions can be realized only by further elaboration and transforming into a number of operational and executive decisions.

By executive decisions, on the basis of set and delegated tasks, the results of functioning of employees are achieved in workplaces, groups, and teams. The workplace is a basic organizational unit of executive function.

Organizational behavior theorists identify two alternatives, i.e. two approaches to the decision-making process: classical and behavioral (Fig. 2.4).

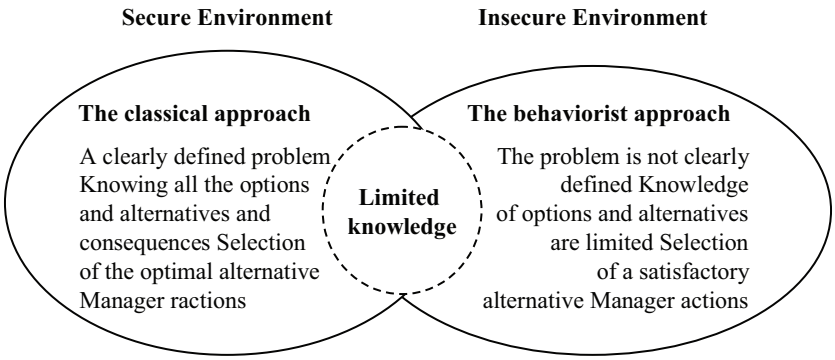

Figure 2.4 The classical and behaviorist approach to decision-making process

The decision-making process consists of several stages. There are different methods for their identification. The researcher and theorist James Stoner indicates different phases of the basic process of rational decision making:

(a) The phase of stating a problem is the first phase, which consists of a number of activities: identifying problems, analyzing problems, defining problems, and a diagnosis. In order to gain knowledge about the problem, the analysis of the current situation is performed and then compared with the desired situation. The difference between these situations is a potential problem, and it creates the need for a decision. At this phase the action is directed, the thing to be changed is specified and the degree of change is defined.

(b) The phase of analyzing variants is a complex phase consisting of various activities: developing possible options, designing alternatives, estimating costs, and so on. Variations are possible changes aiming to solve the problem. Developing variants is suggesting ways to change the current situation in the desired direction. Each variant is followed by the risk, uncertainty, and limitations. Limitations are of various natures: time, resource, and expertise limitations. This phase requires creativity, and it is the most important dimensions of decision making. The ability of management is dealing with new and changeable conditions, and considering a change as a new opportunity and chance. The process of decision making is better if you have several options for a problem; however, it becomes more complicated if we have too many options. Each option is analyzed from the point of the missed benefits. In the process of achieving goals, a good manager will choose the option that will give best results.

(c) The phase of choosing a decision is the third phase of the decision-making process. It means choosing the most favourable and attainable option and providing conditions for its implementation. Choosing the

best option means deciding upon the option that has the least cost and most benefit when applying it. Therefore, the choice of option depends on the assessment of its effectiveness. When choosing an option the subjective data of a manager might have a vital role.

(d) Carrying out decisions is the fourth and the last phase of the decision-making process. When a chosen option is implemented, it should be monitored and controlled. This completes the process of decision making.

Making a decision means choosing the right decision in a variety of alternatives (garment manufacturing strategy, choosing textile materials, choosing suppliers, placement on the market – domestic and/or foreign). When there is the possibility of choosing between two or more alternatives it is necessary to make a choice, or make a decision (e.g. the choice of fashion collection, style, colors, etc.). Where there is no choice, there isn't any decision making. This is not an easy process. The decision-making process is influenced by several factors.

Decision making is the process of evaluating alternatives and choosing the best way to solve the problem. The problem is the deviation from the current to the planned situation, and is reflected in deviations from the intended plan and previous experience. Decision making is not an isolated process and it is influenced by many factors, with different intensities.

The degree of environment stability significantly affects decision making. In a stable environment it is easier to acquire necessary information, they are more reliable and less changeable. In an unstable environment it is necessary to make decisions faster, detect the problem on time and guide decision making directly to problem solving. Many studies have shown that successful garment manufacturers are those who continuously analyze their environment (dynamic fashion market, the market of textile materials). The environment affects the PBS, but PBS affects the environment too, trying to change it, reduce its influence, and so on. Not only is PBS an object of the market, but it is also its creator. A fashion company is expected to play an active role, to make things happen and not to be caught unprepared by events, thus reacting hastily.

Interaction with computers:

The area of interaction in the human–computer interaction (HCI) includes a variety of aspects, which are in the narrow context related to hardware and software and their relation to the user.

HCI is the alternative to man–machine interaction (MMI). This study discusses interactions between people (users) and computers. HCI is a discipline

related to the design, evaluation, and implementation of interactive computer systems used by people, together with the study of the main phenomena that surround them.

HCI also studies the performances of tasks that are carried out by both humans and computers, the structure of the human–computer communication, sociological and organizational interaction in system designing, human ability to use computers (including the ability to learn), algorithms and programing of the interface itself, engineering problems that arise during the design and construction of the interface and the processes of specifying, designing, and implementing interface.

The main goal of this scientific discipline is to improve the interaction between users and computers by making computers more convenient and easier to use.

(3) Human reliability

Analogous to definitions of reliability of technical systems in which the main subject of interest is the failure of technical systems, the center of attention in the theory of human reliability is human error. A human error means understanding his actions, which are not proper or which deviate from given norms. A man, as a part of the system, can increase overall system reliability, but it can also diminish it if its reliability is low. When an employee starts working, the number of errors is usually large (Fig. 2.5). After some time, the number of errors, due to his fatigue, begins to increase.

Human error can also be systematic, for example, when a person has been taught wrongly or if he always gets the information that leads to the same error (e.g. faulty topstitch, bad seam fixing, wrong position of the pocket and the like). Wrongly made belt loop is shown in Fig. 2.6.

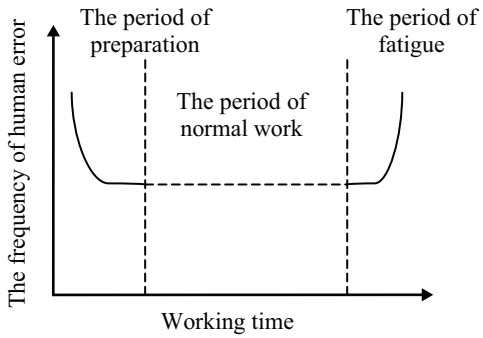

Figure 2.5 The function of the intensity of human errors

Figure 2.6 Wrongly made belt loop

2.1.3 Organizational ergonomics

Organizational ergonomics studies the optimization of socio-technical systems, including their organizational structure, rules, and processes. This ergonomics includes communication, organization of work, teams and work teams, cooperative work management, organizational culture, quality management, virtual organizations, and community ergonomics.

The organizational structure of PBS consists of the schedule and relations of a company's components: funds for the work, subjects of work, and employees. The components of the organization coordinate within the process and perform work processes and tasks of PBS. In that process, broader and more complex tasks are divided into a number of special and individual tasks and jobs. The foundation and pillars of the organizational structure of PBS are obtained by the process of a split-up, i.e. division of total jobs and tasks into a number of individual and group tasks. Splitting-up involves the division of jobs and tasks of a workflow into individuals, groups and teams, as well as the division of jobs and management tasks into more specific organizational parts of PBS.

The organizational structure should be viewed as a dynamic category, in which relations are established between the individual components, people and their activities or functions in the PBS in order to achieve its goals.

The organizational structure defines the way of an information flow between different levels: in the centralized structure from top to bottom and vice versa in different directions.

Modern organization points out the importance of the process approach and teams as a key performance of the future company. A key element, except for the definition of a process itself, is the approach to a whole organization based

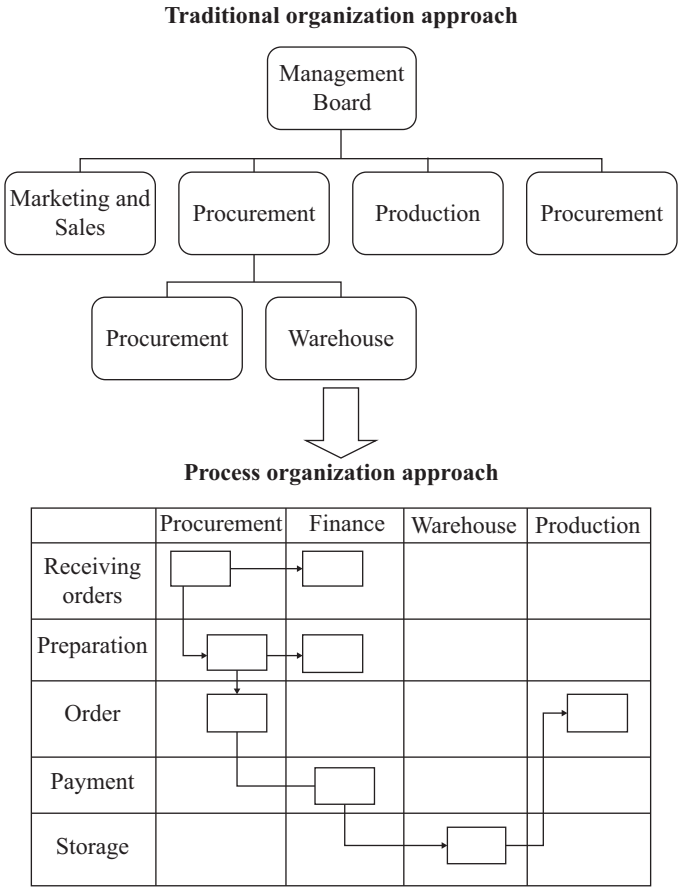

Figure 2.7 The traditional and process organization approach

on the support of information technology and continuous investment into developing and improving of processes (Business Continuity Management). Future organizational design requires more flexible organizational structures allowed by the command and control hierarchy, which mainly dominates organizations of the 20th century. It is, therefore, necessary to reorganize business conducted on the process approach (Fig. 2.7).

(1) Communication

Constant changes in world economy force organizations to keep on finding new ways to be singled out from the competition. It is no longer enough to interact with the environment; it is also important to know how to perform this communication within the organization. Communication implies the following: who says, what does he say, how does he say (in what way, by which

channel, in what kind of a voice, by which technical means), who does he say to, why does he say (informing, gaining knowledge).

Communication (Latin: *communis* – common, together) is the process of exchanging information, physical (material and energy) and social (the message) structure in interactions that are conducted with mental, verbal, nonverbal, technological and combined models, in the intrapersonal, interpersonal, organizational and technological levels in the appropriate context (Banjanin, 2007). Communication is one of the most basic functions in any PBS and its importance cannot be stressed enough. This is the process of transfer of information, ideas, thoughts, opinions, and plans amongst various parts of an organization. Relationships between people are not possible without communication; hence, a good and effective communication is an essential part in human relationships and successful businesses.

According to some researches, the time employees spend in various forms of communication are as follows:

i. Listening – 45%
ii. Talking – 30%
iii. Reading – 16%
iv. Writing – 9%

Communication has four main functions: control, motivation, emotional expression, and information. The role of communication is to control behavior in several possible ways. The achievement of organizational communication is measured by the degree of success in directing the activities or motivation of all participants to behave in a certain way. In order to make the organization function, individuals and groups need to conduct their activities in line, and that compliance would be impossible without communication, because without it people would not know how and what to do. Communication encourages motivation by explaining what to do, how do they do things and what needs to be done to improve performance.

By applying the concept of "total communication" in different conditions a man, within the dimensions of his own personality, expresses his own subjective experience, levels of value, quality of professional education, adaptation, and accommodation. The concept is a generalized idea by which a set of abstract and real objects is used as the basis for the development of a theory.

"Total communication" has many forms of communication and ways they are expressed, and includes not only speech, conversation, negotiation, listening, writing, reading, thinking, reasoning, and decision making, but also every look, movement, gesture, facial expressions, paralinguistic tones, contact, sight, thought, desire, feeling, attitude, spatial position, understanding,

expression of anger or hatred, pleasure or joy, indifference or interest, absence or mobility, etc.

The concept of "total communication" is implemented on the principles of spatial continuity (anywhere and everywhere) and the permanence time (24 hours a day) with an abundance of forms of communication that a man performs on four levels:

i. Biological-physical level: the parallel activity of multiple receptors – sight, hearing, touch, smell, and taste in a given situation (in order to see the point of view, hear the listened, register the touched, feel, recognize, experience it and respond adequately, and so on).

ii. The mental level: we communicate with ourselves by thinking, gaining knowledge and memorizing, remembering and discovering, creating, making concepts, developing ideas, arousing emotions, determining intentions, and forming attitudes.

iii. The emotional level: it enables a man as a rational, intelligent, and healthy human being to behave proactively in all kinds of contacts with people and things, i.e. events and systems or processes in all situations.

iv. Organizational process and technologically interactive level: with a complete integration of previous three dimensions of human communication-specific interaction between people and systems, between systems and processes and between processes and processes that operate in the surrounding area.

To ensure coordination and integration in the fashion industry, information has to move from the base to the top, from down and upwards, but for better precision of the work to be done communication goes from the top to the base. The top needs to know the quality of life of those who work, especially those in the base. To ensure a partnership, involvement, loyalty, and commitment, lower-level staff must know what is going on at higher levels of the company.

For the organization of work and management, formal and informal communications are of particular importance. Formal communication is based on the hierarchy that exists in the organization. This form of communication should be based on the openness of managers to employees establishing such conditions and relationships in which employees can express their needs and obtain the desired information from the management. Formal communication is often done in writing. This form of communication with employees includes letters, notices, reports, manuals, newsletters, internal newspapers, internal magazines, audio-visual aids, electronic mail and boxes for suggestions. Formal communication can take place directly, through meetings of managers and employees, various meetings, visits and other forms of communication.

Informal communication is the communication that is not defined by the structural hierarchy of the organization and is carried out apart from "official roads." It allows employees to satisfy their need for social interaction and improves the performance of the organization by creating alternative, often faster and more efficient communication channels (e-mail, face-to-face conversations, telephone calls, etc.). Information flowing through informal channels are the product of personal impulses of participants and are colored by personal interests, emotions, values, and preferences. As such, they have less credibility because they operate with partial truths or untruths (prejudice, gossip, etc.).

(2) Organization of work

The task of the organization is large and very complex. Thus, managers, when performing the function of the organization, take the necessary actions in order to divide the overall task, or work, into a number of less-complex tasks and their allocation to individuals. Organization of work is arranging work processes and work environment in which there is a minimum spending of a worker's bioenergy. It is the reduction of various mental and physical workloads with the help of physiology, psychology, sociology, pedagogy, technology, and implementation of ergonomic measures.

Organization of work in the production process should improve the quality and quantity of work performance and the quality of life and work.

Poor work organization leads to a range of psychosomatic symptoms of workers, thereby causing sleep disorders, depression due to exhaustion, and so on. It leads to many work disruptions that cause incalculable damage. If depersonalization, formalization and disintellectualization of work, as well as improper construction of machinery, tools and devices, and poor work environment (e.g. noise pollution) are added to poor work organization, we certainly have a "first alert." It grows, becomes stable and leads to activity declines.

Work organization is closely associated with the occurrence of accidents. The issue of working time and rest is very important, because these two issues are related to the phenomenon of fatigue at work. It has been proved that long working hours, due to the fatigue that it causes, reduce labor productivity and increase the number of injuries at work. Over time, more intensive work and monotonous work are work organization factors that could cause accidents. Technical organization of work is a very important factor that can cause accidents, too (delivery of textile materials and shipment of garments, congestion of the passage between sewing machines, scrap materials on the floors, slippery floors, etc.).

To improve the organization of work it is necessary to do the following:

i. design a working place ergonomically

ii. eliminate extra tasks and operations
iii. "beat" the monotony
iv. construct responsible and flexible jobs
v. reduce the number of management levels
vi. establish efficient delegation and supervision of work and
vii. ensure that the organization of production corresponds to business goals

(3) Teams and work teams

Team is a form of formal organization of a joint working or business process that connects the goals and interests of its members, a joint mission and tasks.

The work teams deal with specific tasks within the work process and business conducted by PBS or its organizational unit. Such teams perform jobs with existing components and resources of PBS, achieving their goals as parts of broader goals of PBS. The main objective of work teams is the effective usage of available resources to achieve results in the form of products or profits of companies.

Teams for improving business perform specific tasks or solve problems related to quality, improvement of technology, development and business processes, the increase of productivity, the increase of sales, safety at work, etc. These teams are primarily oriented toward increasing the effectiveness of work processes and operations of a company or a part of a company. The task of a manager is to apply solutions and results of these teams within the PBS.

The choice and designing of teams are a complex management activity. Available human resources of a broader organization are used to form a team of complementary personalities, various professions and roles divided to perform certain tasks. Turning a group into a team requires skill and ability to coordinate, and maintaining a team and its development requires constant attention of the management. The group cannot become a team if the management or a group leader does not provide the environment and conditions for different personalities to have constant and quality relationships with other members, to work with them complementarily, communicate effectively and appreciate their contributions. Each working group that has a need to increase the impact and scope of its own business is a potential team. A potential team becomes a real team when it receives their specific tasks and authorities.

To create a successful team, the following conditions must be provided:

1. a common goal
2. mutual trust and good relationships

3. clear division of roles
4. communication
5. respect for diversity and
2. maintaining balance between tasks and relationships in the group

In theory and practice of the organization, there is also a division into functional teams and cross-functional teams.

Functional teams are formed within a broader organizational unit. They are a component and a part of the functional organization of PBS. Functional teams are formed in various business areas of PBS, and they consist of employees and experts in various disciplines from different organizational units of PBS (and outside PBS).

Cross-functional teams (or teams with more functions) consist of members who belong to different organizational units and functions of PBS (marketing, finance, personnel, etc.). They can be formed as temporary or permanent teams. These teams bring people from different parts of PBS together.

Cross-functional teams lead to so-called process teams, which are established in organizations whose functioning and business are based on processes. Process teams are responsible for conducting the business or work processes of PBS from their beginning to their end.

Special types of teams in PBS are top management teams (TMT). These teams consist of managers and executives of different organizational levels: top management, divisional, or functional managers. TMT are formed for specific strategic and development projects. They consist of fewer members than other types of teams.

Business cases of numerous teams in various companies confirm their high degree of impact and effectiveness of work. The most important indicators of team success are the following: quality, timeliness, efficiency, and rationality.

The questionnaire to measure the effectiveness of teams is shown in Tables 2.2–2.5 where the offered answers are: 1 – strongly disagree; 2 – disagree; 3 – undecided; 4 – agree; 5 – strongly agree.

Table 2.2 The synergy in a team (the sense of belonging to a team).

Questions	**Answers**
Belonging to a team is clearly defined	1 2 3 4 5
Team goal is clearly set	1 2 3 4 5
Each member has a clear role to play in a team	1 2 3 4 5
Communication within a team is good	1 2 3 4 5

Questions	Answers
I feel worthy of being a member of my team	1 2 3 4 5
Other employees in PBS respect this team	1 2 3 4 5
I am proud to belong to this team	1 2 3 4 5
Each member does his best in a team	1 2 3 4 5
The leadership team is effective and adequate	1 2 3 4 5
All members provide a maximum in their work	1 2 3 4 5

Table 2.3 Skills (knowledge and expertise of team members).

Questions	Answers
All team members are properly trained and competent to do their job professionally	1 2 3 4 5
Team members are competent to carry out a variety of jobs within a team	1 2 3 4 5
Team members are flexible and willing to perform other tasks within a team	1 2 3 4 5
Team members highly respect further education	1 2 3 4 5

Table 2.4 Innovation (searching for ways to improve productivity and work methods).

Questions	Answers
Team members are encouraged to try new work methods	1 2 3 4 5
Every innovation in the work of a team is respected and rewarded	1 2 3 4 5
Work problems are detected quickly	1 2 3 4 5
Detected problems are resolved quickly	1 2 3 4 5
Problem solving is seen as a learning and team development	1 2 3 4 5

Table 2.5 Using the working material (all materials, including buildings and equipment are used to increase the maximum effect).

Questions	Answers
Team members feel that their ability are adequately exploited	1 2 3 4 5
Maximum usage of facilities and equipment	1 2 3 4 5
Unnecessary costs are reduced to a minimum	1 2 3 4 5
A team is fully equipped to achieve its goals	1 2 3 4 5
The system of control of equipment is well organized	1 2 3 4 5

(4) Cooperative work

Cooperation is a form of joint working, in the same or related production processes on schedule, and it can be:

1. simple cooperation, if each worker performs all the operations required to make a product (a tailor);
2. complex cooperation, if there is division of work (garment production).

The purpose of the division of work is providing prerequisites for effective and efficient performance of each job or task. Division of work simplifies tasks so one can learn relatively quickly how to perform and complete tasks in a short period of time. In this way proper organizational prerequisites for successful performance of each work are created, as well as of the total job or the task of organization.

Division of work is often based on specialization. The objective is breaking work on individual tasks and specializing employees to perform each of them successfully. Specialization means that each employee performs those activities for which he has been trained and qualified the most (designer clothes, sewer, controller, etc.). It can be carried out in different ways, from simple – where an employee performs one work or a simple operation, to complex forms of specialization, which include more specific knowledge, skills, and operations.

Job specialization enables every man to become an expert in performing certain types of work. In this way, the prerequisites for increased productivity of not only each employee but also of the organization as a whole are created. Specialization has some drawbacks, too. The most notable among them are dehumanization of work, boredom, monotony, stress and various frustrations. The disadvantages of specialization have a negative impact on motivation, responsibility at work and fluctuations, which have a negative impact on productivity. To prevent these phenomena and create prerequisites for increasing productivity in a well-organized PBS, various measures and activities that essentially represent an alternative specialization are undertaken. Among them, the most important are job rotation, increased work, and work team.

When defining the tasks that are logically grouped and influence the motivation of employees, it is necessary to provide:

1. Simplification of work, where employees are given a small number of activities to be performed, and routine repetitive operations that are easy to learn.
2. Rotation of work, where employees sometimes change places (it reduces boredom and increases interest). Dissatisfaction, frequent unjustified absences and fluctuation were partly the consequence

of a monotonous and routine performing of a job. These are the consequences of a narrowly specialized work. Rotation of jobs is the organization of the work process by which workers periodically change places in performing certain tasks that are integral to a work process. Jobs are similar in nature and require the same level of qualification. The goal of this method is not to increase the motivation to work, but mostly to help managers solve problems related to frequent absences and fluctuation of employees. Rotation of jobs provides employees with flexible options, who can perform a number of related tasks equally well. Rotation of jobs proved to be useful in the training of workers with no work experience and in developing operational management. Unfortunately, it's only effective as a short-term solution.

3. Extending of work that expands the scope of activities for employees and increases their interest. The goal of expanding the scope of work is allowing a worker to perform as many different working operations as possible. Extending work does not deepen the work – the work does not become more complex, because the expansion of work is carried out through the horizontal dimension, merging the operations that require the same level of qualifications, but it now requires a new rhythm of work. There are no changes in terms of business planning, decision making, and the control of operator performance.

(5) Management

Management refers to the main activities of a leader and basic functions of leadership. It is an integrated set of connected activities and tasks that can be related to planning, managing, organizing, and control.

Tasks of a manager are to plan, organize, manage and control his own work behavior and the behavior of his associates. The main characteristics of a manager are to achieve goals through other people. Besides having technical and conceptual skills, a manager is expected to be a psychologist-practitioner and to be successful with people (interpersonal relationships). Three unavoidable problems of a manager are: problems of work motivation, problems of communication and behavior in conflict situations.

Leadership implies the processes and possibilities of the influence some people have on the behavior of others. It is a special relationship between two or more persons in which there is mutual influence, with one person dominating the other. The leader is a special person who occupies the appropriate position. He has a dominant influence in a group, thus significantly influencing its functions and objectives. The leader realizes this position in a group, thanks to possessing certain skills and knowledge.

Coordination ensures the unity of management and executive action in PBS and adjusts the system of decision making and performing to existing conditions and limitations. Time, space and operational coordination of all activities, processes and parts of an organization are important features of the content of management. Coordination task connects all the actions into an effective system of work and business. Coordination includes technical and interest aspects. The technical aspect of coordination ensures the unity of the process, phases of work and parts of the organization, its technical subsystems. Interest aspects of coordination ensure the alignment of narrow interests, goals, within more complex management structures of PBS and its environment. This coordination sets and dissolves human relations and controls employees' organizational behavior.

For production functioning of PBS and its business, it is important to have internal coordination, which controls:

- coordination of individual activities, tasks and operations in the work process
- coordination of organizational units
- coordination of carrying out management decisions
- coordination of common activities and functions of PBS

HRM is also an important part of management today. The main subsystems of human resource function can be reduced to employment, professional development, encouraging success at work, discovering management resources and informing in the field of human resources. The main processes and human resource functions are shown in Fig. 2.8.

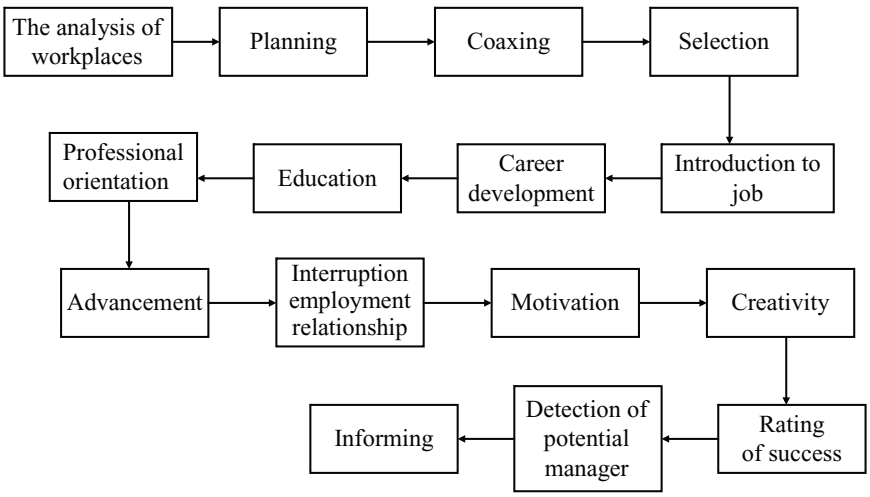

Figure 2.8 Main processes and functions of human resources

(6) Organizational culture

Organizational culture is a system of values and behaviors that make a unique social-psychological unit of an organization. A unit is the total of the following elements: the past and the present of an organization, experience, philosophy and other values that keep an organization together, the image, internal organization and public relations, plans and expectations. Organizational culture is manifested in the conduct, relationship with employees, customers, and the public.

According to Schein (1992), organizational culture is a model of common fundamental premises. Culture of an organization consists of common values, attitudes, assumptions, and beliefs of managers and employees in the organization, which shape their behavior and actions. It dictates the way people think they should do. Successful organizations typically have a culture that emphasizes excellence, quality, and service to customers. Culture is connected to the vision and mission of the organization.

There are two main approaches to defining organizational culture – the invisible and the visible approaches:

- The invisible approach includes the influence, understanding, ethics, lifestyle, personality, and character of employees in an organization.
- he visible approach includes what has been a long-lasting and always the same behavior of employees in an organization.

The culture of PBS exists on two levels in the organization (visible and invisible):

(i) Values, norms, attitudes, and beliefs belong to invisible signs of culture. Values represent the basic framework and guide for behavior, and compliance with values is a prerequisite for survival in the organization, is rewarding and so on. Standards are conceptions of desirable behaviors, or to be more precise, standards for work behavior and the expected effects, and are their converting into rules of everyday behavior. Attitudes and beliefs are considered to be the most elusive part of an organizational culture and relate to basic ideals and principles of behavior.

(ii) Status symbols are very recognizable and visible signs of corporate culture. They are about social positions of individuals, groups, or entire organization in relation to others (position, salary, company car brand, location of parking areas, etc.).

(iii) Tradition and history are the symbols of corporate culture, precisely because they last long and make a company unique from its very beginning.

(iv) Rituals, ceremonies and games are some of the most striking symbols of corporate culture. According to Deal and Kennedy (1988), rituals are the rules that determine behavior in the life of a company. They bring order into disorder and hence they are, like habits, quite usual and considered to be something quite normal. Contrary to rituals, ceremonies are always something special and remembered by employees for a long time. For example, a show program is prepared together with the promotion of a new product.

(v) Language and jargon (which is largely determined by the type of activity that PBS deals with) are important symbols of organizational culture.

(vi) The physical environment (macro- and micro-location, plant).

It is a way of group thinking and collective actions of individuals within the organization. It was built into all aspects of organizational activity through which it can be seen how the organization changes, grows and develops. The top management of PBS does that in the best possible way with their viewpoints, policies, and strategies. Management styles are very important for the organizational climate. Everybody desires a pleasant working environment with a positive atmosphere and good cooperation among employees. A positive environment influences the flow of information, knowledge, and ideas among employees. Organizational climate is reflected in the satisfaction with the work environment, innovation, initiative, attitude toward the quality, motivation, knowledge about the mission and vision, internal communication and information, education, membership organization, and lesser numbers of absences and staff fluctuation. Organizational climate is affected by the environment in which the organization operates (e.g. a country with its laws and taxes, business and economic trends).

The ideal organizational climate is characterized by trust, credibility, openness, security, satisfaction, expectations, and high involvement of employees (Baskin and Aronoff, 1988).

Culture plays a large role in an organization; it determines the behavior of people and their beliefs and provides a general impression of the organization. Organizational culture is, actually, the invisible and informal awareness of the organization that directs the behavior of individuals.

The development and condition of the organizational culture of a PBS are of great importance for safety at work, which is one of the functions of organizational culture. Many PBS, through defining their vision and mission, choose to create safe working conditions and safety at work, implementing them into the organizational culture. Safe work environment is becoming a common

pattern of behavior and value and is one of the measures for assessing the value of organizational culture of PBS.

(7) Quality management

Quality (Latin: *qualis*, *qualitas* – how to perform) is the measure of satisfying the needs of individuals and the society as a whole. According to ISO the definition of quality is: "Quality is the set of all the properties and characteristics of products or services related to the ability to meet the established or indirectly expressed needs." According to the American Society for Quality, the control quality is the totality of features and characteristics of products or services that are reported through the ability to express or satisfy specified requirements.

The role of management in establishing a quality system is indispensable. This role is reflected not only in determining the approach to establishing a quality system but also in showing commitment to the development and improvement of a quality management system, as well as in the realization of the project for establishing a quality system.

Total Quality Management (TQM) is applied in order to improve effectiveness, efficiency, flexibility, and competitiveness. It requires the entire PBS to be organized and committed to quality in all its segments, in each activity and production unit, so that every employee understands its importance and its commitment.

There are five key components that every PBS must constantly examine and measure in order to realize the level of weakness and productivity. Each of these components is of strategic importance for the functioning of TQM, and they are connected and dependent on each other. These are as follows:

- Product: Meets the requirements of the management, all the employees, customers or consumers.
- Process: Ensures the product quality. Processes must be evaluated to understand whether they meet specific standards and expectations of a PBS. Otherwise, the process must be corrected to ensure that the product is of satisfactory quality.
- Management team: To ensure the success of TQM, it is necessary to have a trained team and the division of responsibilities.
- Commitment: Researches show that TQM is successfully implemented in the PBS, which has a high degree of commitment of workers and the management. By participating in the implementation process, managers can see if the improved processes result in the

desired results. On the other hand, workers by their assessment in problem solving become motivated to work because their results are recognized.

- Organization: An organization can be successful only if there is a work team. Their creativity, enthusiasm, objectivity and motivation enable functioning of TQM.

(8) Virtual organizations

Virtual organizations are geographically deployed organizations connected by common interests, which collaborate through information and telecommunication technologies.

Organizations can be temporary or permanent virtual ones. Temporary virtual organizational structures are a broader form of virtual organizational structures that usually connect organizations of related activities in order to gain greater flexibility and benefit for each participant, thus connecting garment manufacturers, suppliers of fabrics, suppliers of thread, buttons, fashion apparel vendors, distributors, customers, etc.

Permanent virtual organizational structures are based on connecting different organizations where each organization tries to externalize (outsourcing) the activities for which it is not the leader on the market, i.e. to outsource them to other organizations. In this way, the replacement of key skills leads to achieving competitive advantages.

The fashion company Benetton is an example of virtual organization with a network organizational structure that covers the whole chain of creating values: from producers of raw materials to final customers. Production operations are carried out externally in a number of partnership companies throughout the world. Benetton, as a leading company, designs new products, organizes and optimizes the chain of creating values and guarantees product quality and market placement of goods produced all around Europe.

(9) Community ergonomics

Community ergonomics improves human interactions, evolution, law and planning for positive organization of groups for self-regulation and control of community resources and work. According to Vink *et al*. (1998) community ergonomics deals with very complex systems and tries to improve the fit between the different subsystems of the community and the community's environment. The people or entities affected and whose health, safety and performance are to be improved can play a key role in the process of designing or redesigning the community to which they belong.

2.2 Types of ergonomics

There are several divisions of ergonomics according to the types and specific human traits and characteristics of human interaction with the environment: conceptual ergonomics, system ergonomics, corrective ergonomics, software ergonomics and hardware ergonomics.

2.2.1 Conceptual ergonomics

Conceptual ergonomics deals with the designing of ergonomic measures in the very beginning of construction of a working system and therefore is the cheapest one. This ergonomics includes the tasks of improving the conditions of life and work in two areas:

- the area of humanity and
- the area of economy

In the area of humanity, the ergonomics must reduce the strain of workers, reduce the risks at work, allow a holiday, increase the satisfaction and interest in work and make work pleasant. It is important to reduce health problems at work, improve protection while working, reduce the harmful influence of the environment and perform the work easily.

The tasks of ergonomics from the perspective of economy are increase the accuracy of work, speed up the rhythm, ensure the feasibility of labor, reduce the work requirements, reduce costs, facilitate decision making, improve information flow, and utilize time.

Ergonomics must increase motivation, and the quantity and quality of work. To meet the specified requirements, they must shape the ergonomic measures that arise as a general result of system ergonomics.

2.2.2 System ergonomics

Besides system sciences, ergonomic researches introduce a systematic methodological approach (Singleton, 1982; Munipov and Zinchenko, 1989). Ergonomics must enable an increase in personal motivation and the quantity and quality of work in the production process. In order to fulfil that, ergonomic measures that arise as a result of system ergonomics must be designed.

The task of system ergonomics is to take care of the coordination functions of a manufacturing system. It takes care of personal and mechanical functions in which the worker in the production system must not be under any kind of strain. System ergonomics pays attention not only to some parts of the system (man, machine, environment, etc.) but also to the whole system.

The base of system ergonomics is conceptual ergonomics. After the situation is established conceptually, system ergonomics decides about the steps to be taken. System ergonomics is a sort of methodical, technological procedure that is performed when developing a workplace. During the implementation of the functions of system ergonomics, human psychophysical capabilities must always be taken care.

In designing HMS, various questions are being actively resolved, such as:

(a) Which functions or specific tasks will be performed by a machine and which by a man?

(b) How many people are needed in the system?

(c) What are the information that the operator will need, and how will they be presented?

(d) How to select and train people to work in the system?

System ergonomics, with its approach, reduces the gap that arose between personnel psychology (according to Hugo Münsterberg, the founder of psychology, it has the task to adapt the work to a man and his tasks) and classical ergonomics.

2.2.3 Corrective ergonomics

At the beginning of its development as a science, ergonomics was mainly engaged in partial relationships of man–machine relationships. The contribution of these researches was to create a solid database for the analysis of work activities. This phase in the development of ergonomics is called classical or corrective ergonomics.

Corrective ergonomics occurs in the later period of realization or utilization of the working system. It implies meeting the ergonomic requirements subsequently, so it is less successful and more expensive than the previously mentioned types of ergonomics. It is subjected to many limitations because the ergonomic principles are neglected in its development phase. Corrective measures are therefore based on reliable experiences. Corrective ergonomics is based on the principle: "You see – you look – you improve." The representative of this ergonomics is Barnes (1968), who defined 22 principles for the rationalization of work.

The essence of corrective ergonomics consists of identifying gaps or mismatches in order to improve the existing systems based on reliable experience; however, since this is a subsequent meeting of the ergonomic requirements, it is less successful and at the same time quite expensive and subjected to many limitations.

2.2.4 Software ergonomics

Software ergonomics is an interdisciplinary part of the science of work that deals with direct or indirect effects of software products in the human–machine–environment system. It includes biological, psychological, and social aspects of interaction between a man and software. The following are the objectives of software ergonomics:

- improvement of adopting information technology
- improvement of work motivation
- increase in work competence
- development of personality and
- optimization of strain in introducing new technologies

By introducing computers, a man no longer manages the machine directly but indirectly, because of which he must dispose of all the components that will allow him a certain level of freedom when coping with work tasks and goals within the cores of software ergonomics.

The usage of information technology allows the increase of production with the help of new technologies; it enables the increase of efficiency of processing information by introducing better methods and procedures.

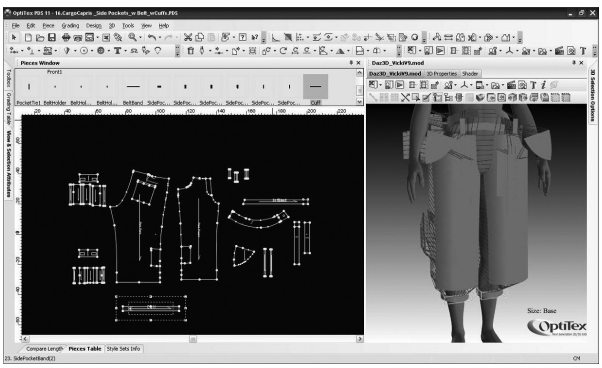

Figure 2.9 Computer screen of Optitex

In order to improve software products they must be mutually comparable and their quality assessed. Software ergonomics develops the methods and criteria for performing such evaluations. It includes the following types of interaction of a man and software:

1. biological
2. psychological and
3. social aspects

The central goals of software ergonomics are improving:

- acceptance of new technologies
- work motivation
- work competencies
- personal development and
- load optimization when introducing new technologies

Software ergonomics is also concerned that, because of the strain transfer from physical to mental side of man, a worker shouldn't be under too big or too small a strain. Hence, while working at the computer (a sitting workplace), it is important to know the following:

(1) Feet must be laid flat on the floor.

(2) The knee joint must be bent to 90º, i.e. set from 20º to 45º below the hips.

(3) Elbows must be laid parallel on the table or with minor deviations.

(4) Shoulders must be flat and straight, but also relaxed.

(5) The screen must be at least 50 cm away from the head and must be in the eyesight without moving the head.

(6) Wrists must be flat and under no strain.

(7) Keys on the keyboard must be pressed very lightly without using much force.

In countries with developed industries, the concern about adjusting the workplace to the worker gradually becomes a subject of interest because of physiological (health), psychological (selection and satisfaction), and economic reasons (production quantity and quality). The ergonomic position while working on a computer, according to the European Union Council Directives 90/270/EEC, is shown in Fig. 2.10.

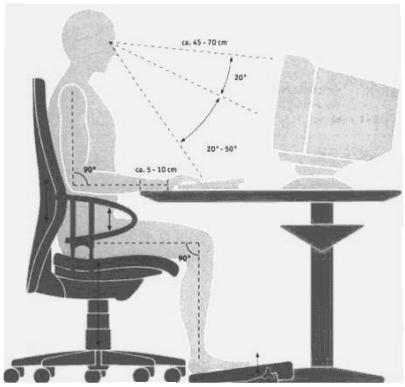

Figure 2.10 Ergonomic position while working on computer

2.2.5 Hardware ergonomics

Classical ergonomics actually means this type of ergonomics. A narrow framework for the study of hardware ergonomics includes technical-physical components of a computer system and a broader framework includes direct and indirect environments of the system, such as appropriate structure of a workplace with computer equipment, physical characteristics of the workplace, a desk and a chair and their properties, microclimate, lighting, etc. (see Chapter 4). Figure 2.11 shows a workplace with computer equipment.

Figure 2.11 Workplace with the computer equipment

2.3 Micro-ergonomics and macro-ergonomics

The German School of ergonomics defines macro-ergonomics as more orientated to sociology, and micro-ergonomics as more orientated to improving performances of the whole system and reducing stress caused by work.

The main goal of micro-ergonomics is to improve the performance of the work system and reduce stress analysis: task, working environment, and MMI. The concept of stress–strain is the traditional approach to assessing the working system. The basic concept is that every workplace is characterized by external factors, which are the same for all individuals who react differently depending on individual characteristics and abilities. Stress is different from the parameters of stress (defined by numbers), stress factors (given only descriptively), and the time of stress exposure. In order to understand the factors

that influence work, the structure of HMS must be examined by monitoring human labor in relation to the information and the speed of information flow. This includes setting up the task, its putting into action, the performing of the task, and the result of performing the task. A feedback closes the control loop formed for the HMS and shows that the operator is generally capable of comparing the task and the result. All the disorders of this process are the impacts of the environment. While analyzing the task definition, there are:

- tasks with predominantly physical strain. Here, some people define the difference between static and dynamic physical work. In both cases, stress can be quantified by defining the physical requirements;
- tasks with predominantly mental strain (intellectual work). A generalized concept for defining this stress in numbers does not exist. Intellectual work is therefore taken as a factor of stress;
- tasks with both requirements (physical and mental).

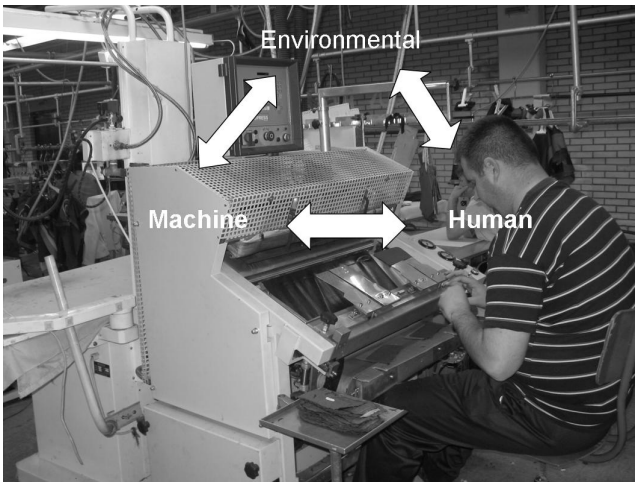

Figure 2.12 Human–Machine system

System ergonomics tends to optimize this interaction and reduces the number of errors made by man (so-called active safety) and to improve the reliability of the overall performance of HMS. The objective of system analysis is to provide requirements for the plan of a MMI within the HMS specifications or the ideas for possible improvements.

The basic procedure in system ergonomics is to define elements of a system and their interactions. Two basic principles are:

- Information is always transmitted through very specific channels from the output of one element to the input of another one.

- Elements are defined by their characteristics in order to change information in a specific way, which was determined by the element.

Fundamental characteristics of systems analysis and therefore system ergonomics are not paying attention to the physical nature of elements and their interaction and the very study of the formal structure of this interaction, and they refer to the transfer of element information. In system ergonomics, components of the "man" and "machine" system are the main subjects of research. As this standpoint does not depend on the physical nature of individual elements, the results of system ergonomics can be transferred through different HMS.

Ergonomics of HMS can be connected with system reliability and evaluation to measure its effectiveness for the optimization of HMS taken for ergonomic system analysis.

System elements include the following:

1. The reason for the existence of the system.
2. Man and his characteristics involved in the HMS, accomplishing the goal of the system.
3. Machine and its characteristics, location, size, shape, access, etc. It can be a simple part or a tool or a very complex system with many components, displays and components.
4. Environment with all its characteristics (temperature, humidity, noise, etc.) where there is a human–machine interaction.
5. Information.
6. The actions that workers need to do interacting with a machine in order to perform the tasks (it can be mental, e.g. decision making, or physical, e.g. catching).
7. Performing the task – the conditions and results of the interaction of a man with the machine and equipment.

Organization of HMS is shown in Fig. 2.13.

The indicators of a well-designed HMS are as follows:

- good and precise performance of work operations
- short time required for training on the machine
- increased work and health safety and
- increased motivation for work

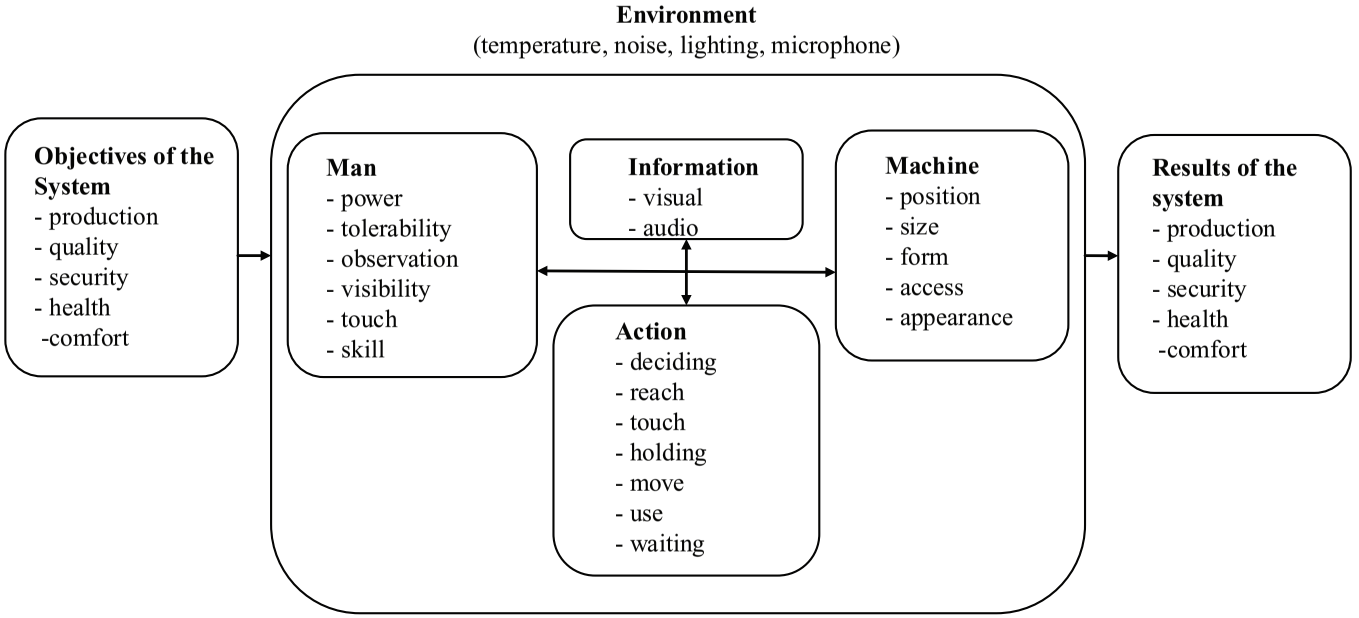

Figure 2.13 Organization of human–machine system

Indicators of a badly designed HMS are:

(a) errors regarding the intention
- slip: right intention and poor workmanship
- mistake: bad intention and workmanship responding to the intention
- lapse: failure to perform the intention due to, e.g. abandoning the workplace, sleepiness, etc.

(b) errors regarding the outcome
- omission
- commission
- wrong schedule of actions in working operation
- bad production time
- too fast or too slow in performing

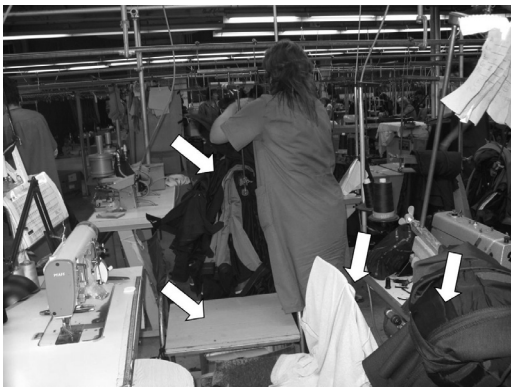

Figure 2.14 Badly-designed human–machine system

While analyzing environmental impacts (ergonomics of environment), there are:

(a) physical environmental impacts, which can be measured, as well as their impact on man and can be assessed quantitatively (lighting, noise, mechanical vibrations, air-conditioning, toxic gases, radiation, dust, dirt, and humidity).

(b) social environmental impacts, which cannot be measured physically and therefore are marked differently (they are sometimes called a work sociology or industrial psychology).

Macro-ergonomics is a top-down socio-technical system approach to a work system design, and the design of related human–job, human–machine,

human–software, and human environment interfaces; although top-down conceptually, in practice, macro-ergonomics involves the analysis of the work system at all organizational levels. It usually involves extensive participation of persons from all units and levels of the work system.

Macro-ergonomics deals with the systematic structure and organization of workflow considering the task, the content and the time factors. It can be divided into the organizational structure and the organization of work processes. The goal of macro-ergonomics is not an individual workplace but the interaction between many workplaces. Its goal is testing ergonomic requirements at this level. In this context, the term macro work can be used as well. The unit area of macro-organization can be divided if a unit of operating system is transferred to a higher operating task in the context of a group. The analysis of workflow provides the right-in-time information necessary for the task that should be performed within the organizational unit and on the basis of internal dependences. This allows the specifying of capacity requirements of humans, the means of production and the time of their utilization. In particular, ways of communication and possible losses of information are determined in order to optimize the interaction between workers and working funds. The development of innovative telecommunications and computer technology is a new challenge for the organization of work.

Environmental conditions are defined as those that do not directly influence the work process and the process of communication but, similar to micro-ergonomics, change it indirectly. It is important to emphasize the difference between the impact that cannot be changed by the organization of work and the influence that can be optimized by the corresponding design of workflow and organizational structure of cooperation.

On the output side of the working process, performance improvement can be obtained by organizational steps, with personally verified methods of the quality of working object and the results, respectively, developed on the one hand, and on the other there is the worker under the influence of motivational factors.

Many of the cases described cannot simply be proved by an experiment. Therefore, partial detailed simulation methods are often used, and through cumulative key numbers they describe personal acceptance, personal qualifications, waiting time, overlapping by simultaneous upcoming order to provide the assessment of organizational changes and new structures.

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3

Ergonomic conditions of work

Abstract: Knowledge of ergonomic conditions prevents employee discomfort, fatigue, and physical injury. Injury related to poor ergonomic conditions can be prevented by designing the physical work environment around the physical needs of individual employees. Therefore, it is necessary to know the physiological, psycho-sociological conditions, and anthropometric ergonomic conditions.

Key words: physiology, motivation, fatigue, monotony, stress, anthropometric, bio-mechanical

3.1 Physiological conditions

Physiology (Greek: *fisis* = nature, logos = word, science) is defined as the science that studies life processes. The physiology of man explains the functions of human body including all chemical reactions that occur in cells, the transmission of nerve impulses from one part of the body to another, using the movement of muscles and other functionings of body parts.

Physiology of work is a special branch of physiology limited to the body of a man who works. One of the fields within the physiology of work is the studying of working capacities of a man and of various impacts on working capacities. A man is most capable of making best sport (and physical) results when he is about 25 years old, and of mental and organizational results when he is about 45 years old.

Rational usage of working capacity of man is a matter of not only being humane but also being economical. If a man in his early age or when too old is entrusted tasks to which he is not physiologically (physically) equal to, it significantly affects the efficiency of human life. Such a man is ill much more during his working life.

Physiology of work studies the impact of work on physiological processes in a man. It explores the consequences that arise in the human organism under the influence of work in different conditions. Its objective is to determine how to work and be healthy, or how not to make the work be the reason for the

disease. So today, except for the impact of physical work on the organism, physiology studies the following:

1. Substances that exist in the workplace or are manipulated with
2. Working time, regime of work and rest
3. Design and construction of equipment for work, workplace and work space
4. Relationships in a working group or by hierarchy
5. Responsibility and fear for success in production and careers
6. Alienation from one's own work
7. Computerization and management of technological systems

Physiology of work studies the work quality and physiological abilities of a man to overcome its various forms and their mutual relations. Work is performed in the interaction of three interrelated factors:

1. The work itself – which by its content, regime and organization, is a burden to a man.
2. Work environment – which can be the meeting place of various aggravating, risk or even harmful factors.
3. The man who performs the work – who must make an effort to overcome the burden of work and hazards in the working environment. At the same time he uses his abilities, knowledge and skills.

When the requirements of work are such that a man can overcome them by making an effort, the functional abilities of his body and his health are not endangered and there is ergonomic balance. In that sense, the physiology of work deals with (Arandjelovic and Jovanovic, 2009):

1. Defining the workload.
2. Defining the requirements of work.
3. Studying human physiological abilities and the amount of physiological effort he can make to respond to the requirements of work.

(1) Defining the workload

Performing any kind of work is a kind of a burden for the body. The type, intensity and duration of the load depend on the work. Physiological workloads should be such that the body can respond to them through physiological functions, i.e. to maintain homeostasis when working. The load that cannot be overcome leads to disorders of homeostasis (the balance in the body is lost), which is an overload that causes fatigue. In case of further

increasing the intensity of overload, there is a pathological response of the body, i.e. fatigue.

Loads can be physical, mental, and sensory.

Physical work (the work of skeletal muscles) is a major cause of physical load because of work. Physical work means the work that a man does while overcoming burden and resistance. Physical work can be dynamic and static work.

(a) Dynamic work: It is the work in which there is a change in the position of the bones to which muscle is attached and which is, from the mechanical aspect, characterized by the change of body position in space. Fatigue rarely occurs in dynamic work because constant contraction and de-contraction of muscles acts as a pump, which accelerates blood circulation (it enables the flow of nutrients and elimination of decay products). At the beginning of dynamic work (because of the energy needs), oxygen consumption and heart rate suddenly increase. After a few minutes they reach the level that is maintained steadily as long as the work is performed (steady state). Upon termination of work, the curve of oxygen consumption and heart rate gradually drops to a value at rest.

Each work is characterized by a degree of difficulty. A particular work should not be more difficult than the one that a man can perform. The evaluation of work in physiology is carried out in order to standardize the workload, program the regime of work and rest and carry out a professional selection.

Each physical activity requires a specific energy necessary for muscle contraction.

The evaluation of how difficult the work is can be done by determining the energy consumption during work. Energy consumption ranges from 4 to 6 kJ/min at rest, and from 50 to 80 kJ/min during extremely heavy physical work. Energy consumption is affected by gender, age, and the level of how trained the workers are. According to energy consumption, work can be:

1. Easy work 10.9–15.5 kJ/min
2. Moderate work 15.5–20.5 kJ/min
3. Hard work 20.5–26.0 kJ/min
4. Very hard work 26.0–32.7 kJ/min

(b) Static work: It is the work of muscles without moving in space. It is also called a static effort because the external mechanical effect equals to zero. During static, work consumes the energy to tighten certain

muscle groups, and they are necessary to maintain the body position in space (standing long, lifting tools, holding a burden, etc.).

Static work is characterized by lower energy consumption compared to dynamic work, but it causes fatigue and tiredness more rapidly. There is an increase in the tone of muscles that perform the compression of blood vessels in static work; hence, circulation is more difficult, the supply of nutrients is reduced (oxygen, glucose), the outflow of decay products of metabolism is reduced (lactic acid) and fatigue occurs more quickly. After completing the work, oxygen consumption continues to increase and returns to the value at rest very slowly.

In evaluating psychological workload three groups of factors are taken into consideration: unfavorable working environment; job requirements and its organizational-technical characteristics; and social changes and problems in everyday life.

(a) Unfavorable conditions of working environment such as noise, vibration, temperature, humidity, brightness, etc. act negatively on the efficiency and sense of comfort at work. In certain circumstances, their impact can be subjectively perceived in a different way. For example, monotonous jobs with moderate-intensity noise activate the body and have a positive effect on performance. If many factors act at the same time the ultimate effect can be different, i.e. they can cause:

1. Accumulation: total harmful effect equals the sum of individual adverse effects.
2. Compensation: mutual cancellation of a number of factors so that the ultimate effect is less adverse than if only one factor were to act.
3. Multiplication: total adverse effect is bigger than the sum of individual adverse effects, which can result in very harmful consequences for human health.

(b) Job requirements and its organizational-technical characteristics, i.e. direct effects of psychological factors related to job characteristics lead to psychosensory and psychomobility workload, as well as intellectual and emotional ones.

Dangerous, risky, complex, stressful, and responsible jobs require appropriate abilities, knowledge and skills of workers, i.e. high degree of engagement of psychophysical capacities of workers. Psychological factors that influence these jobs lead to psychophysiological effort, the size of which depends primarily on job characteristics (terms and conditions), but also on personality traits. If these factors act longer, psychophysiological tension occurs (the state between the normal, physiological and pathological one, with a tendency to take the form of pathology, i.e. a disease).

Emotional state has an important role in decision making, problem solving, communication, negotiation and adaptation to the environment and changes. According to Damasio (1999), emotions may be as follows: happiness, sadness, fear, anger, surprise, disgust, discomfort, jealousy, guilt, pride, serenity, or tension.

Personal characteristics of an individual (the characteristics of worker's personality), which are defined hereditarily by constitutionary characteristics, together with the risks that arise from the work environment, can favor the occurrence of a strain and its negative effects on the health of workers.

Emotional stability, resistance to stress and frustration, anxiety, neurotic personality traits, depressive reactions, self-confidence, etc. are of particular importance. Poor coordination between individual traits and abilities and job requirements can lead to the following: stress, mental fatigue, unruly behavior (alcoholism, lack of discipline, etc.), psychiatric disorders (depression, anxiety), and psychosomatic illnesses (hypertension, asthma, endocrine disorders, etc.). On the other hand, a good psychosocial adaptation has positive effects on the satisfaction of workers with their life and work and on the overall state of his health.

(c) Social changes and problems in everyday life include the following: family problems, divorce, death in the family, family obligations, housing problems, problems at work, conflicts in production–business system (PBS), difficulties in interpersonal communication and bad corporate and economic situation in the country. Estimates of psychological strain are based on the practical experience and researches of psychologists and doctors of work medicine, and what follows are three possible approaches:

1. professional-graphical: it is based on the description and standardization of characteristics of work.
2. individual psychological: it is based on determining the personality profile, health status and behavior of workers.
3. epidemiological: it is based on monitoring the health consequences of psycho-physiological workload in certain jobs.

(2) Defining the requirements of work

Requirements of work define what the workload and adverse effects require of the workers and can be the following:

- Requests for certain functions of the organism. In addition to general health conditions, the work requires some particularly preserved functions of organs and systems or some particularly preserved or marked morphological features of a man. For example, working with

the microscope, quality control of textiles, sewing and so on require certain visual functions.

- Requests for certain age limits of a worker. Depending on the age, some functions are established, some are changed, some disappear or are reduced, so that the same work shall not place the same demands on quite young, middle-aged or older workers. For example, workers in the night shift should not be older than 55 years.
- Requests for a specific sex of a worker. These requirements are not common, and are based on specific differences in the physiology of female and male body. Different requirements for men and women are set by the night work, working with heavy loads (carrying and setting up of textile materials on the table for cutting).

(3) Size of physiological effort

A man must make an effort to deal with the load imposed by a certain work. The analysis of work can specify which functions of the body will be exposed to the influence of that work. So the individual workplace should always be analyzed, not the occupation.

The bigger the load is, the bigger the effort is, although not all the people make the same effort to deal with the same load. In determining the effort, the following has to be determined:

- the limit of physiological strain at rest
- the level of physiological response to work impact and
- the boundary between physiological and pathological responses

Physiology of work therefore studies both the work and the man who works. If one knows the physiological processes of human organism, it is possible to predict and prevent the occurrence of defects and damage caused by unnatural environmental conditions. By proper professional orientation, arrangement of work space in accordance with hygiene standards and production of clothing, especially adapted equipment designed to affect normal physiological activities as little as possible, ergonomics becomes an indispensable "ally in the fight" against professional diseases.

3.2 Psycho-sociological conditions

Psycho-sociological conditions of work are related primarily to achieving a sense of satisfaction in work. The degree of responsibility of PBS to employees must be far higher than that to buyers and consumers because the degree of meeting consumer needs also depends on the employees' satisfaction and their relation to PBS and their job.

Employee satisfaction is a set of conditions that motivate employees to perform their tasks successfully and to respect ethical principles in their workplace. At the same time, the satisfaction of employees can lead to bigger support of employees in achieving the goals of organization, creating a larger and broader market of fashion products and achieving higher profits. On the other hand, employee satisfaction can improve relationships in PBS and build them on trust, communication and coordination between functions.

Job satisfaction refers to cognitive (assumptions and beliefs about work), affective (feelings toward work), and evaluative (work rating) reactions of the individuals to their work.

The factors of job satisfaction can be as follows:

1. Organizing
   (i) Job (variety, autonomy, feedback)
   (ii) The system of compensation
   (iii) Working conditions
   (iv) Colleagues at work (the impact of national culture)
   (v) Organizational structure (flexible)
2. Individual
   (i) The harmony of personal interests and job
   (ii) Work experience and age
   (iii) Position and status
   (iv) Total satisfaction with life

In reaction to job characteristics, there are three psychological states of employees, such as:

- Experiencing the significance of work: an employee must perceive his job as something valuable and important in the system of values that it owns.
- Experiencing the responsibility at work: an employee must believe that he is responsible for the results at his workplace.
- Knowledge of results: an employee must be capable of determining the results of his work.

3.2.1 Motivation

Motivation to work is a very complex phenomenon that people have dealt with ever since the ancient communities. The scientific approach to motivation as a phenomenon began with the industrial revolution in the late 18th century, and

experienced its peak in the late 20th century. Today, this phenomenon is given great importance because it improves the efficiency, effectiveness, creativity and quality of work and the humanization of working conditions. As a result, part of the job of management is finding ways to motivate employees.

Different areas define motivation to work differently. Psychology defines it as internal factors that initiate, organize, direct and determine the intensity and duration of work activities. In sociology, this term implies the system of actions of individuals or groups that promotes certain behaviors in order to achieve favorable working effects. The management seeks to ensure that people behave in a desirable way to achieve organizational goals and meet the needs of employees.

Frederick Herzberg (1966) divides the needs to those of lower level and higher level. According to his theory, the needs of lower level (so-called "hygiene") are generally satisfied and the right motivation is the result of the desire to satisfy the higher-level needs. He believes that traditionally accepted factors of motivation, such as increasing wages, improved interpersonal relations and good working conditions, no longer affect the increase of motivation when they reach the optimum conditions. So the "real motivation factors" are the increased responsibility for planning, performing and controlling work, i.e. insisting on the independence of workers. He also suggested that a worker should do the entire job wherever possible, not only the individual operations. In this way, the job will become a challenge, so the work itself will be a good motivation. In practice, many companies have applied his ideas and found an increase in productivity, while reducing the number of absences. Despite the success this theory has achieved, there are some doubts because of the different reactions among the workers themselves and also due to the lack of evidence that satisfied workers are better manufacturers than unsatisfied ones.

The satisfaction of a worker is influenced by several factors, which are largely related to the motivation for work. Speaking of the motivation for work, one must mention the mechanisms of satisfying basic human needs and motives in the situation of doing a certain job. The situation itself is important for the motivation for work, as well as the activities through which it is manifested.

Job satisfaction implies an emotional attachment and orientation of workers for the job. Satisfaction or dissatisfaction is the generalized experience related to the very contents of the job, the circumstances under which it is carried out and the organization as a whole. The attitude toward work is seen through a series of indicators, such as frequency of fluctuations, the tendency for potential fluctuation, identification with the organization, identification with the profession and so on. Satisfaction is a psychological condition that occurs as the consequence of a successful completion of the work.

Importance	**Satisfaction**		
	R1 – R12 Maximum satisfaction	R13 – R26 Medium satisfaction	R27 – R38 Lowest satisfaction
R1 – R12 Maximum importance	- Clear expectations at work - A manager who respects employees - Nice atmosphere - Team work - A manager who knows how to do business	- Good communication between colleagues - A director who inspires confidence - Competent people at the top of a fashion company - Regularity and security of wages - Good and clear organization	- The amount of wages - Clear and equitable criteria in determining wages
R13 – R26 High importance	- Good physical working conditions - A manager who helps workers - Job security - Professional and reliable colleagues - A manager who is friendly and always available to colleagues	- Quality training - Professional development and training - Absence of intolerance and divisions in the company - Objective grading of individual performances	- Opportunities for advancement - The absence of tension and pressure at work - Good communication between the sectors - Care of the fashion company for employees - Progress on the basis of clear and well-known criteria

R27 – R38 Lowest importance	- Fashion company that works according to international standards - High discipline	- A dynamic job without the monotony - A challenging job - A planned and systematic operation without improvisation - A job that does not require overtime - Wages system in which wages depend on hierarchical position	- Wages that are not dependent on membership of a particular sector - Wages that depend on skills - Wages that depend on the results - Informing employees - Foreign travel to fairs and fashion shows

Figure 3.1 The matrix of relative importance and job satisfaction

Physical conditions of work, material incentives, job security, and participation have little impact on motivation. They contribute to job satisfaction. Job satisfaction is explained by the following five dimensions: the satisfaction that comes from performing work tasks, the satisfaction of belonging to the group, PBS, the satisfaction with economic status, and job status. Higher wages and a secure job are more important for men, whereas the type of work is important for women. The factors of job satisfaction can be divided into the following: factors of enterprise satisfaction, financial work status, work, working group and interpersonal relationships. Figure 3.1 shows the matrix of relative importance and job satisfaction.

Factors of motivation indicate the functionality of links between goals and motives, i.e. a motivated behavior. Factors of motivation in the work situation are determined by numerous social restrictions. The usual division of the motivation factors is repressive (material) and development (immaterial).

(1) Repressive factors

The importance of wages varies in different periods of social development. In times of crisis it gets the lead role, because the family

should be provided materially and existentially, whereas in times of getting out of crisis other motivators prevail. Wages are more important for workers with a lower level of education than for those with higher education. The way of distribution also has a strong influence. In times of crisis, when the wages are equated in order to protect the majority, there is less motivation to work. The solution to housing problem and the loss of job can be other factors as well.

(2) Development factors

The biggest factor is job satisfaction. It arises from the high compliance and adaptability of workers to their job and vice versa. The key moment is the choice of profession. Professional development is also an important factor, e.g., whether after a certain number of years the reward will follow. But since it becomes symbolized, it loses its importance for motivation. Another very powerful motivator is the interpersonal climate of the working group. The dominant strength of motivation does not lie in the areas of material dependence, but in the sphere of self-realization, and in professional and general development of a personality. Therefore, the factors of motivation for work are based on development motivators, with the exception of personal wages.

Formal and informal aspects of the organization affect the motivation of employees and the increase or decrease in performance. Work in the norms, individual or collective, is a more complex relation of workers to the work group and organization. A norm is seen as an established amount of work of a certain quality. Organizing activities in terms of individual or group norms are related to the nature of technological activities, the organization's objectives related to the organization and productivity, the system of distribution of profits, and personal wages. For organizing work in the individual norm (sewing room), it is very important that the employee's work is less dependent on other workers and the flow rate of technological processes. From the aspect of motivation, it is very important for a worker to know his daily work effect. Employees who work in conditions of individual norms are more productive, utilization of working time is higher, the quality is better, and equity of distribution is at a higher level. Collective norm estimates only the contribution of jobs at which the worker is hired. In this norm motivational factors are primarily of developmental nature (psychological reward). Basic prerequisites for determining the working contribution of workers in achieving the profit of the organization are measuring the quantity, quality, and results of work, synthesizing measurable and quantifiable results of work, and their reduction to common denominators. The operating contribution of a worker to personal wages is based on current work, past work, innovation, rationalization, and other forms of creativity.

There is a strong connection between motivation and productivity. Work productivity (i.e. working efficiency) is an economic category, which indicates the relationship between labour and work results, whereas work motivation is a psycho-sociological category arising from the relationship of individuals to work and their willingness to be engaged in achieving the goal. According to Boris Petz (1985), the formula of success of the company is related to motivation and working conditions of its employees:

$$\text{Success} = \text{Ability} \times \text{Motivation} \times \text{Working conditions}$$

In addition to motivation, which is one of the most important factors, productivity is affected by many other factors (which may or may not affect the motivation, e.g. technical equipment, management, etc.). Physical conditions do not have any particular impact on motivation, but do have on job satisfaction.

Designing a workplace is a very important segment of the intangible strategies of motivation since the attitudes toward work and the pleasure of it significantly affect the motivation at work, and also the entire life of the individual. Programs of redesigning the workplace try very hard to make the job interesting and challenging. Significant individual approaches to designing workplaces are job rotation, where people are periodically moved from one specialized job to another in order to prevent monotony and boredom. However, the real motivational potentials are best activated by the enrichment of work, which spreads vertically, including various tasks and skills, responsibilities and autonomies.

Survey research is the most commonly used technique for measuring employee motivation. An example is given of the motivation research of employees in the fashion industry. The company has 645 employees, whose structure is shown in Table 3.1.

Table 3.1 Structure of employees.

Age (years)	%
to 30	3.33
31–35	5.00
36–40	50.00
41–45	16.66
46–50	16.66
51 and more	8.33
Sex	%
Female	88.00

Male	12.00
Qualification	%
Primary school	8.33
High school	81.34
College	6.00
Faculty	4.33
Years of experience	%
to 5	8.33
6–10	16.66
11–15	21.66
16–20	33.33
21–25	3.33
26–30	8.33
31–35	5.00
36 and more	3.33
Workplace	%
Non-managerial	83.33
Managerial	16.66

The results obtained are shown in Tables 3.2–3.5.

Table 3.2 How much is each of these motives important to you personally?

Form of motive	Answers %
Wages according to work	25.00
Salary	6.66
Pensions and security for the old age	31.66
"Do not get stuck too much"	13.33
Agreement with the people at work	26.66
Agreement with the managers	10.00
Possibility of quality work	16.66
Possibility of interesting work	30.00
Possibility of professional development	16.66
Good physical working conditions	71.66

Table 3.3 To what extent are you satisfied with professional status, the possibility of professional development, social, and other benefits offered by a fashion company?

Answers	%
I am very satisfied	1.66
I am satisfied	3.33
I am partly satisfied	43.33
I am dissatisfied	45.00
I am very dissatisfied	6.66

Table 3.4 What is your personal contribution to the overall business of the company?

Answers	%
Of great importance	31.66
Very important	46.66
Partly important	15.00
Little important	3.33
Unimportant	3.33

Table 3.5 Degree of compliance with the established allegations.

Questions	**Answers %**
My job is fun for me	11.66
My job is mostly interesting and not boring for me to do	16.66
I believe that my friends are more interested in their job than I am in mine	5.00
I believe that my job is unpleasant	6.66
I enjoy more doing my work than in my free time	1.66
I am often bored at work	3.66
I am completely satisfied with the job	10.00
Most often I force myself to go to work	18.33
I've always been satisfied with my job	28.33
I think my job is not more interesting than any other job that I could perform	35.00
I do not love my job at all	6.66

I feel that I am happier at work than most people	15.00
I usually do the job with enthusiasm	6.66
Every working day seems to be endless	51.66
I love my job more than most of the workers	1.66
My job is rather uninteresting	3.33
I find real pleasure in my job	6.66
I am disappointed that I have even agreed to do this job	3.33

Rewards direct the activity of individuals and groups in the desired direction. Praise and rewards affect the confidence and safety of employees and encourage the initiative and commitment in further activities.

Censure and punishment affect motivation more indirectly because they should prevent unwanted activities or punish unsafe actions of individuals and groups. From the aspect of an individual, it is the means of braking or preventing their activity. A person looks upon those preventions with dissatisfaction and anger, which can be directed to the manager or the group that pronounced the punitive measure on him, and further behavior can only be directed toward bigger caution in other attempts or forms of illegal behavior. This can lead to many negative consequences not only on the proper managing of the work process, but also on interpersonal relationships. When stating a sentence the manager should be particularly cautious and preferably use other measures before that, such as counselling, warnings, criticisms and so on. If he comes to the conclusion that punishment is necessary, he should ensure not to underestimate or insult the person but to point out the worker's positive qualities as well. The means of motivation act differently upon certain types of personalities. Reserved and shy people react positively to praise or a reward, whereas punishment or reprimand might be experienced as a catastrophe. Confident people do not need much praise because they can get the wrong idea about themselves and ask for what they do not deserve. The effect of certain measures, i.e. the means of motivation, is shown in Table 3.6.

Table 3.6 Means of motivation.

Means of motivation	Rank	% of workers		
		Better results	Same results	Worse results
Public praise	1	87.5	12.0	0.5
Reprimand in private	2	66.3	23.0	1.07
Public reprimand	3	34.7	26.7	38.7

3.2.2 Fatigue, monotony, and stress

Fatigue is a phenomenon that accompanies each man's activity, reducing the work effect and affecting the attitude toward work negatively. Considering production, fatigue is defined as reducing work performance over time. Physiological definition, given the processes in the body, defines it as the chemical and functional changes that occur in the body during work, such as increasing lactic acid in muscles, reducing the amount of sugar, etc. The origin of fatigue is interpreted in the accumulation of decomposing products during work, running out of oxygen supplies, i.e. the lack of energetic substances. None of these theories include the role of nervous system in the development of fatigue, so most scientists today believe that fatigue is the result of complex processes in the central nervous system (brain, spinal cord and its nerves), which are still largely unknown.

Fatigue is usually divided into mental and physical. Mental fatigue occurs when performing intellectual work, whereas physical fatigue is the result of physical load. These two types of fatigue overlap, the same as physical and intellectual work do.

The signs of physical fatigue are: psyshomobility slowdown, clumsy and unnecessary movements, spontaneous breaks, declining performance and errors at work, increased cases of trauma at work, exhaustion, lethargy and apathy, changes of mood, irritability and strife, sleepiness and forgetfulness, feeling of discomfort or pain, increased frequencies of breathing and pulse, increased blood pressure, temperature, and sweat.

Mental fatigue is a feeling of exhaustion, apathy, slow thinking, confusion, irritability, and changes of mood.

Considering the fact how quickly it can arise, there is an acute fatigue after a short work and a chronic, long-lasting fatigue that accumulates imperceptibly after a long time at work. It is often difficult to identify the first signs of fatigue, which is very important in professions that require great concentration. Fatigue is manifested by subjective and objective signs.

Subjective signs may not be associated with a decrease in performance and are reflected in the decline of criticism at work, the weakening of concentration, and a change in behavior and mood. Owing to disorders of emotional balance, a tired man comes into conflict with the environment more often, and he becomes easily irritable and excited.

Objective signs of fatigue are reflected in the decrease in performance. Decrease in the quantity and quality of performance are direct indicators of fatigue. Fatigue can be measured by various psychological tests. Other objective indicators of fatigue are spontaneous interruptions of work activities, accidental, unplanned breaks to take rest, frequent change in the speed of work

and increased consumption of energy in the body. Fatigue also reduces dexterity, so a man has less coordination of his movements and makes excessive movements during his work.

The production indicators of fatigue are lower efficiency, prolonged and increased numbers of breaks, occurrence of errors (rejects), increase in accidents and the occurrence of traffic accidents.

Pulse is a key indicator used to assess the effects of workload on work ability and fatigue among industry workers. Heart rate at rest, before starting any work activity, is approximately a constant value, which doesn't show any major fluctuations in relation to the mean value. Just before the beginning of work, the level of heart rate can be increased as a result of mental reaction to the upcoming physical exertion. After the beginning of a dynamic work of constant intensity the level of pulse increases rapidly. This increase can be of varying durations, usually from half a minute to several minutes, depending on workload, work ability of employees and environmental conditions (temperature, humidity, etc.). After that there is a stable state in which the pulse level remains approximately constant. If the intensity of work increases continuously as a result of increased workload or work tempo, heart rate will also increase, at first rapidly and then more slowly. When the workload is such that the maximum heart rate is achieved, further increase of the load will not cause any increase of the pulse level. After completing the work, the heart rate decreases, depending on the difficulty of the previously performed work.

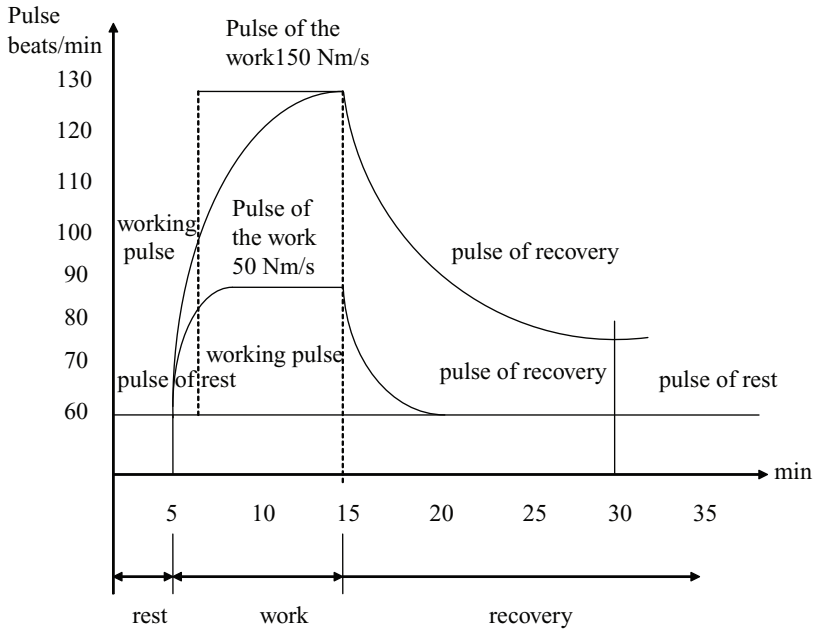


Figure 3.2 shows the change in pulse when changing workloads

Factors that affect the level of pulse during some physical activities can be classified into the following seven groups: work intensity, muscle mass, duration of operation, type of work, posture, being well-trained and the tempo to perform work.

(1) Work intensity – heart rate is proportional to the intensity of work being performed. The level of pulse increases approximately linearly in the range of easy to moderately difficult work. With further increase in load, heart rate increases to the maximum value that a man can achieve. Maximum heart rate depends on the age of a man. Due to ageing, the frequency decreases by an average of one beat for each year of life, with some variations. This reduction applies equally to both sexes.

(2) Duration of work – when performing a work of a long duration with the intensity on a certain level below the maximum, after establishing a stable condition in which the heart rate is approximately constant, there is a gradual increase in the level of pulse until the end of the work. This is explained by the fatigue and activation of additional muscle groups that have not previously participated to a greater extent during a specific work activity.

(3) Muscle mass – when two men of unequal muscle masses perform a work of the same intensity, the heart rate is higher in a man with less muscle mass. It is believed that muscles with less mass provide greater resistance when delivering blood to active muscle fibres, which causes an increase in heart rate.

(4) Tempo to do work – if you change the tempo of the work, the efficiency of muscles will change, which is reflected in an increase or decrease of heart rate.

(5) Type of work – with the period and scope of muscle contractions in static work being significantly smaller than that of dynamic work, the heart rate during static work is smaller in relation to dynamic work.

(6) Posture – when working in a vertical position the heart rate is lower than when working in a horizontal position, as a result of difficult venous flow.

(7) Being well-trained – untrained people have a higher heart rate than those who are trained, as a result of adaptation of the worker to physical effort.

Table 3.7. shows the marking of the difficulty of physical work, depending on the level of pulse according to the American Industrial Hygiene Association (AIHA).

Table 3.7 Rating of difficulty of physical work, depending on the pulse.

Rating of difficulty of work	The level of heart rate (beats per minute)
Very easy work	65–75
Easy work	75–100
Medium hard work	100–125
Hard work	125–150
Very hard work	150–180
Excessively hard work	> 180

Preparation of a man for work depends on his age, too. It changes during life and starts decreasing after the age of 40 years. Such a decline in preparation for work is equated with more experience to work, bigger autonomy and the capacity for communication and decision making, and hence the productivity of workers does not decline so fast because experienced workers spend 20%–50% less energy for the same amount of work compared to inexperienced ones. Therefore, older workers must be assigned jobs that require less physical effort with the equal rhythm of work. Older workers fall sick more easily; however, they are more cautious and have fewer injuries at the workplace.

Monotony at work has a negative effect not only on the concentration of workers, but also on his satisfaction. Mental saturation is a condition that occurs when there is a resistance to accepting or continuing a particular work activity.

Monotony is common in jobs that require physical effort, such as:

1. repetition of operations (e.g. ironing)
2. repetition of operations within a short period of time (e.g. when sewing the operations for the last several seconds)
3. uniformity and simplicity of physical activity.

Monotony at work can lead to reduced concentration of an employee while handling a machine or a tool, which can lead to injury. It is manifested as irritability, restlessness and loss of will to work. Grandjean (1998) lists the following factors contributing to monotony at work:

- chronic fatigue
- poor motivation
- low interest in work

- higher education, knowledge and abilities in relation to job requirements
- no adaptation to work in shifts

New research indicates that many people feel bored at work. Boredom in the workplace causes loss of concentration, and that is the time when half of the people questioned believed they made more errors. Boredom at work "kills" work effectiveness, thereby causing frustration and depression.

Monotony and boredom at work can be eliminated by changing the organization of work.

According to Paoli and Merllie (2001), 28% of workers from 15 countries of the European Union state that work causes stress, thus affecting their health. Stress occurs when a worker feels threatened due to the load or danger to which he is exposed when performing his work. Stress occurs when the employee believes that he is overloaded, or when he is under the impression that he cannot influence the situation. According to Sauter and Murphy (1999), the state of stress in the workplace can be defined as a series of adverse physiological, psychological and behavioral reactions of an individual to situations in which job requirements are not in accordance with his abilities, capacities and needs.

Some of the factors of sources of stress are:

1. factors of working environment (hazardous physical working conditions, or those that are perceived as unpleasant: noise, air pollution, ergonomic unadjusted working conditions) and
2. organizational psychosocial factors (interpersonal relationships, division of jobs, clear and unambiguous communication, working environment, etc.)

Stress represents the dynamic conditions in which the individual is confronted with the possibilities, coercion or requests whose results are uncertain, but important for him. Stress is a pattern of emotional and physiological reactions that occur in response to the demands set inside or outside the organization, and can have both positive and negative effects on the individual. The advantage of stress is that it encourages employees to give their best, to achieve maximum results. Negative effect of stress is reflected in the force, restrictions and requirements. Constraints are related to all the stresses that cause us not to do what we want and give up on what we would like to do. Many studies confirm that 70% of workers in Japan suffer from symptoms of stress. A common phenomenon is "*Karoshi,"* which represents death due to overwork.

The causes of stress can be categorized into organizational and personal ones. The organizational causes of stress can be based on tasks, roles, interpersonal requirements, organizational structure, and management style.

(a) The requirements of tasks

- requirements of tasks – refer to the design of work, autonomy and diversity of tasks
- working conditions – include physical conditions, work in a crowded room, interruptions due to clients, phone, etc.
- strict work norms

Greater autonomy reduces stress, whereas inadequate design of tasks and inadequate working conditions increase the feelings of stress.

(b) The requirements of roles

- conflict of roles – if various roles of employees are in conflict
- overload or inadequately low load
- ambiguity of roles – if the employee does not understand what he is expected to do

(c) Interpersonal requirements

- pressure from colleagues
- lack of support from colleagues

(d) Organizational structure

- excessive workload resulting from a given organizational structure of PBS
- inability to influence decision making

(e) Management style

- Some management styles (autocratic) affect the development of organizational culture, which is based on fear, nervousness, and tension.
- Unnecessary pressure on workers – setting short deadlines, the threat of dismissal and so on.

Personal causes of stress occur as a result of family and personal problems, as well as problems raised by an individual. Basic dimensions of personality are shown in Fig. 3.3.

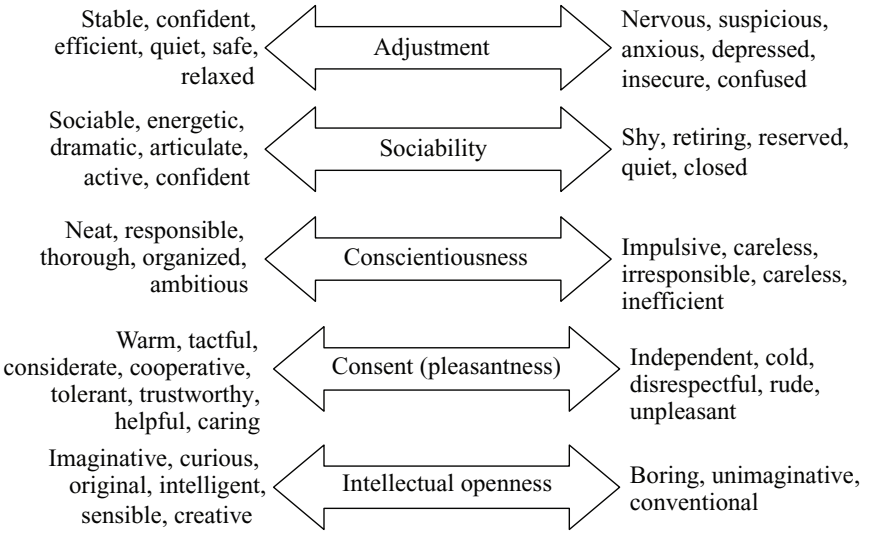


Figure 3.3 Basic dimensions of personality

The feeling of stress is significantly influenced by how employees perceive their personal problems. There are two types of behavior, according to the requirements:

- Type A – always in a hurry, all decisions are brought in at the last minute and the employee is very impatient.
- Type B – has enough time and does not take things too seriously.

Symptoms of stress can be physical and psychological, as well as changes in behavior.

- Physical symptoms are reflected in the change of metabolism, increased blood pressure, increased risk of heart disease, depression and so on.
- Psychological symptoms are manifested as fear, boredom and being late for work, which reduce productivity.
- Problems in behavior lead to smoking, changes in eating habits, disturbed sleeping patterns and reduced concentration.

There are two basic approaches to solving the problem of stress:

- focusing on the problem – solving the problem that causes stress, and
- focusing on the emotions – strategies that help solve emotional problems as a result of stress (positive thinking, the belief that even the worst of situations can bring out something good)

Burnout represents the phenomenon similar to stress. It is reflected in the total expenditure of physical and mental resources to meet unrealistic goals. The symptoms consist of emotional and physical exhaustion, reduced personal success, reduced self-esteem and the inability to relax in an emergency situation and finds the only pleasure in work. General symptoms are decreased productivity and dehumanization of work.

The causes of burnout are as follows:

- characteristics of organization – formal structure, number of employees, amount of work
- perception of organization – leadership, conflicts, staff support, innovations, roles
- perception of role – autonomy, involvement, control, pressure
- personal characteristics – support of friends and family, age, sex, self-esteem
- result of work – performance, satisfaction

According to Merllié and Paoli (2000) and a study conducted among 21500 European employees, the most common work-related health problems are backache (33%), stress (28%), and fatigue (23%). The same study showed that, today, most European employees work at very high speeds or under tight deadlines more than 50% of the time. This causes an annual loss of millions of working days and costs that amount to at least 20 billion.

According to a study by Bond, Galinsky and Swanberg (1998), involving a national representative sample of 3000 American employees, 29% of the respondents found it somewhat or very likely that they would lose their current job in the next couple of years. Twenty-six percent felt "emotionally drained from their work," and 26% felt "burned out and stressed by their work."

In modern work conditions, some new stresses occur in some jobs, and some previously identified change because of changes in job characteristics. Those are, e.g. bullying at work, abuse of power and responsibilities, preference to hire only male or female employees, preference in background and belonging to a party, contamination of personal computers by so-called viruses, electronic monitoring of work, etc.

Adverse effects of burnout can be reduced by the following:

- identification – analysis at individual and organizational levels
- prevention – attempt to avoid causes before the feeling of exhaustion
- mediation – procedures to reduce, rotate or stop the process

- re-mediation – invention and application of techniques to help individuals who are already in the process of exhaustion

Stress management at the organizational level involves careful selection of employees to different tasks based on how they handle stress, creating a healthy organizational climate and culture (reorganization, decentralization, involving employees in decision making), employee training programs, reducing the liability of employees, workshops dealing with stress, as well as talking with employees. Stress management at the individual level is achieved through meditation, physical activity, positive thinking, setting priorities in life and work, healthy food, laughter, and the like.

Studies have shown that employees help one another best through mutual understanding and support. Good communication, socializing with colleagues, freedom in decision making, good division of work and a good manager are the main factors that affect reduction of stress, and thus fatigue.

In the European Union there are regulations about health and work safety and those provisions can be applied to the psychosocial characteristics of work (Council Directive 89/391/EEC; 1993). The European Parliament brought a resolution emphasizing the need for alignment between job characteristics and abilities and needs of employees, as well as the need to prevent discord between job requirements and capabilities of employees (Resolution A4-0050/99; February 1999). The Resolution specifically highlights the problems of the lack of autonomy at work and monotonous and repetitive jobs, and it points out the importance of ergonomics and applying new technologies to improve the working conditions associated with health and safety.

3.3 Anthropometric conditions

The main source of information for determining the applicability of the workspace is anthropometry. Anthropometric working conditions refer to the conditions a worker in a workplace should be ensured in order to adjust the work performed up to his anthropometric (dimensional) features.

Anthropometry (Greek: *anthropos* – man and *metron* – measure) is a method of anthropology that deals with measurement and testing of the human body and the relationship between the size of its individual parts. In other words, it deals with the dimensions of human body and its physical characteristics such as volume, center of gravity, inertial features and the mass of individual body parts. Anthropometry is based on an experience that dates back to the old era, where a module for the proportion of certain body parts and a man as a whole was being searched for. The originator of anthropometry was A. Spiegel in 1600.

The proportions of the human body depend on the arrangement of bones and muscles, i.e. on the anatomy. According to Zeising (1810–1876), the body is divided into eight equal parts. The first one-eighth of the body is the head (the module), the second one-eighth of the body is the line of breasts, the third one-eighth is the line of waist, the fourth one-eighth is the line of the hips, the fifth one-eighth is the line of thighs, the sixth one-eighth is the line of knee, the seventh one-eighth is the line of calves and the eighth one-eighth is the line of the feet (Fig. 3.4).

Anthropometric data are used in ergonomics in order to ensure that the machine or environment is adapted to physical characteristics of a man. Anthropometric data are used to design transport vehicles, workplaces, garments, tools, furniture, in digital identification and for several other purposes.

Anthropometry is divided into the following:

(1) Static anthropometry – It studies and takes into consideration the static measurements (dimensions) of a man, i.e. when a man is at rest. All workplaces do not burden a man and his organs in the same way. There are workplaces in which a relative rest prevails. Static anthropometry measures all static dimensions of a body, the dimensions that contain basic information about the morphological characteristics of a certain population. Morphological anthropometry is a method that includes measuring the human body, the treatment and the study of the obtained measures.

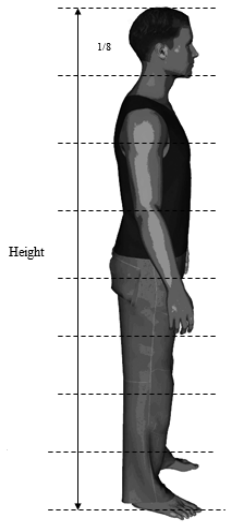


Figure 3.4 The division of the body

According to World Health Organization (WHO), static body dimensions are as follows:

(a) Five static body dimensions for designing machines and tools: height of the upper arm, length of the forearm with the fist, hand, hand width and diameter of a clenched fist.

(b) Ten static dimensions for designing workspace: body height, body height in a sitting position, the width of the body in the elbow joint, the width of the body while sitting, the length of the upper leg, the width of the upper leg, the length of the lower leg, hip width, the width of thighs while sitting, body weight.

(2) Dynamic anthropometry – It studies the factors necessary for the movement of man (joint forces), which are as follows:

(a) external dynamic anthropometry – It refers to the simple division of body (torso, head, forearm, elbow, etc.) and

(b) internal dynamic anthropometry – It refers to the movement (e.g. how the muscles influence hand movement). It studies the forces and torques in the joints. Internal anthropometry is still developing because it is still difficult to define what individual movements are influenced by.

The main task of dynamic anthropometry is to point to the fact that some parts of the human body do not function independently of each other while working.

(3) Kinetic anthropometry – It takes into consideration the scope of human movements (hands, legs).

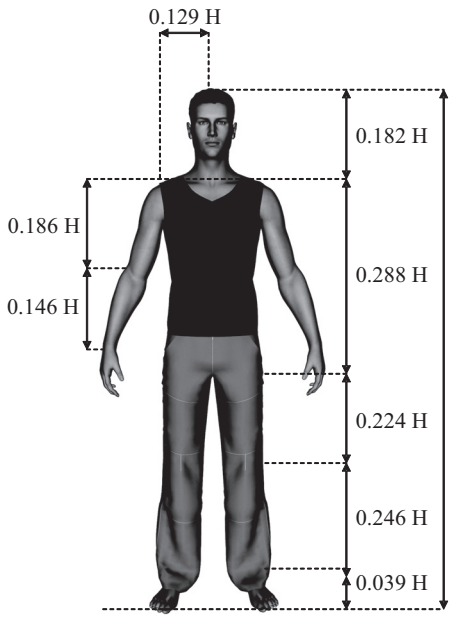
The following factors influence anthropometric data:

1. age – after the age of 40 years people get smaller because of wearing off the rings in the spine and start spreading
2. population
3. gender – men have higher bone mass, which is around 12 kg, whereas women have a mass of around 8.5 kg
4. forces that are applied – women are 30% weaker; training of man can increase his powers by 15%–50%, and
5. clothing – it is important what a man wears, it may affect regulating the scope of his movements

Measurements are carried out on the human body (somatometria) or on skeletons (osteometrics). The distances between certain points on the body

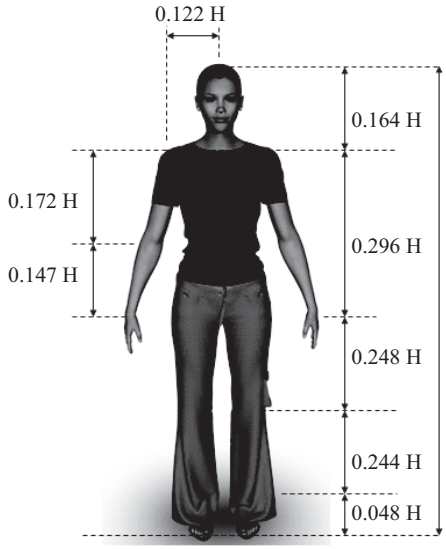
(metric measurements) and the curves of certain parts and lines of the body (goniometric measurement) are measured. Anthropometric dimensions are measured by biological anthropometry, which studies the dimensions of the human body and the variability of biological characteristics of a man, which arises from the growth and development of human population in space and time.

Bones, joints, and muscles move the body, making a locomotive system studied by the science of movements (kinesiology). Functional anatomy studies the changes in the shape of the body in motion and the work of individual organs. The body can be represented by a series of connections where each connection corresponds to one segment of the body, e.g. hand, forearm, upper arm, with each joint being a connection between the segments. The system of kinematic chain can be used to represent spatial and planar problems. The characteristic lengths of segments are defined in relation to the height of the body in a standing position. Average dimensions and proportions of body segments are shown in Figs. 3.5 and 3.6.



	Height distibution	
	In.	cm
5 %	64.4	164
10 %	65.7	167
50 %	68.7	174
90 %	71.7	182
95 %	73.0	185

Figure 3.5 Average dimensions and proportions of body segments of a man



Height distibution		
	In.	cm
5 %	59.9	152
10 %	60.8	154
50 %	63.8	163
90 %	66.8	170
95 %	67.7	172

Figure 3.6 Average dimensions and proportions of body segments of a woman

Figure 3.7 shows the dimensions of the hand, and Fig. 3.8 shows the body dimensions while sitting.

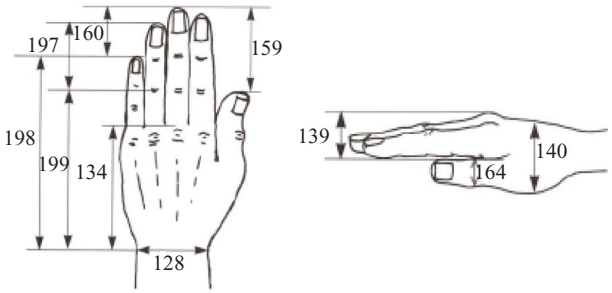


Figure 3.7 Dimensions of the hand

Anthropometric workplace design is based on the field of vision, the area of catching and the area of moving feet, on resting the body (e.g. seat), as well as designing displays and controls. Expressing various body measures in percentage attempts to solve this problem systematically. A large number of individual dimensional differences appear depending on the distribution by gender and race; hence, it is not enough to construct a workplace or shape products according to the so-called average person. Medium dimensions are just the statistics that indicate that around 50% of the population has the reference body measure of a certain size or smaller.

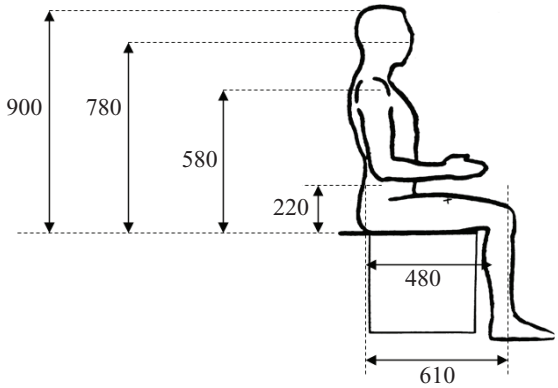


Figure 3.8 Body dimensions while sitting

It is not possible to design workplaces that are suitable for both the tallest and the shortest workers, but for the majority. That is why extreme body dimensions are usually ignored. If a workplace for "medium 90%" of some population is designed, individuals of more than 5% of the shortest (in body dimension to which it relates) and less than 5% of the tallest are taken into consideration. In other words, individuals with 5% of the smallest and 5% of the largest dimensions are excluded. Values are expressed in % and are called percentile. Figure 3.9 shows the data of static anthropometry.

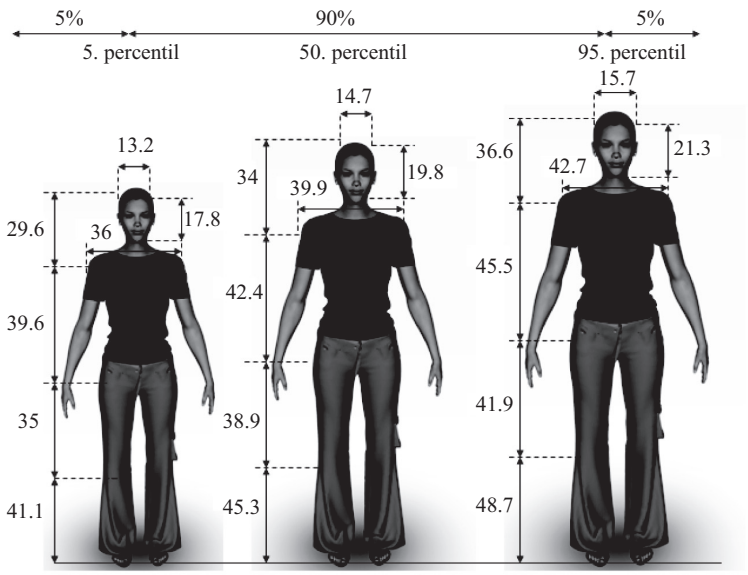


Figure 3.9 The data of static anthropometry

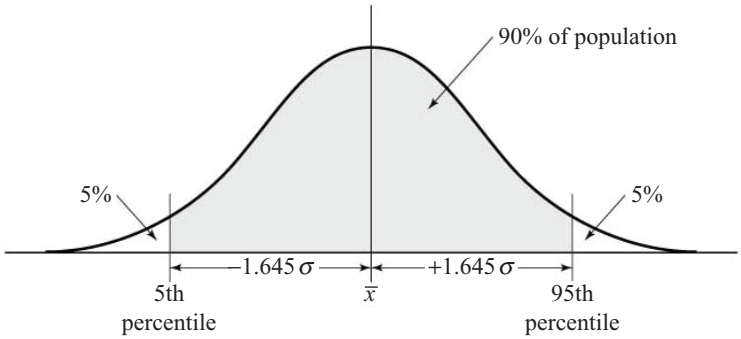


Figure 3.10 Gaussian distribution

In anthropometry there is no term as "the average man." The average man cannot be used in designing. Depending on the nature of the task of designing, it is determined to satisfy the 5th or 95th percentile in order to satisfy the largest group of users. People average by two dimensions represent only 7% of the population, there are only 2% of people average by four dimensions and those averaging by 10 dimensions do not exist.

For most people it can be said that they will fit into the normal or the distribution as defined by the Gaussian distribution (up to 99.73%). Only the Gaussian distribution does not apply to hand and foot. Figure 3.10 shows a typical distribution of anthropometric measurements that can be described by arithmetic mean (average) and standard deviation.

Numerous studies show a decline in job performance when the work environment is not designed in a way that is consistent with the individual physical characteristics. However, there are many difficulties and limitations in measurement and application of anthropometric dimensions, such as the following:

1. Average values of anthropometric measures are not a sufficient data for ergonomic use, i.e. the parameters of a range or variability of these measures are required as well.

For anthropometric variables there is the law on the relatively uniformed growth that allows predicting, in relation to body height, a number of different physical dimensions. Basically, these are the parts of body height (sitting height), arm length, the length of the upper arm and forearm, and the length of the lower leg and thigh.

Anthropometric variables are those variables where the law of relatively uniformed growth cannot be applied, because they are under a considerable environmental impact. These are the weight, the volume of the thorax, and

the scope of certain parts of the limbs in relation to body height. Based on these variables, anthropometric measures in ergonomics are chosen. These measures rely on the so-called anthropometric points. Anthropometric points mark the distance between different points on the body surface and movement of the corner joints.

Fixed anthropometric points are always on the same part of the body and are clearly visible. Virtual anthropometric points change their position with regard to body posture. Selected anthropometric points were established and standardized based on the International Biological Program and currently there are 47 points in use, of which 13 fall in the category of fixed main anthropometric points.

2. In anthropometric measures, there are group differences in relation to race, sex, age, nationality or ethnicity, even different professions (e.g. senior directors are taller than unskilled workers).

In general, women are smaller than men in all dimensions except in the dimensions of hips. In the function of age, many adults get shorter, but heavier. In Europe, women are shorter than men for about 10 cm on average, and moving toward the trunk, their limbs are shorter. Table 3.8 shows sex differences in anthropometrics considered for the example of height.

Table 3.8 Standard classification of body height.

Height	Men (cm)	Women (cm)
Dwarf	below 130.0	below 121.0
Very small	130.1–150.0	121.1–140.0
Small	150.1–160.0	140.1–149.0
Normal	160.1–170.0	149.1–159.0
Large	170.1–180.0	159.1–168.0
Very large	180.1–200.0	168.1–187.0
Giant	above 200.0	above 187.0

3. Anthropometrical dimensions change over time and become outdated not only gradually but also abruptly, e.g. due to changes in eating habits. According to Singleton (1974), anthropometric data should be restored, checked and updated every 10 years.

Before using any of the anthropometric data, it is necessary to consider the criteria that will guide the development of applications and be the framework to test its decisions. In this sense, ergonomic criteria define the limits within which the specific product (machine, workplace) is in compliance with human characteristics. The criteria that, in ergonomic sense, determine the success

of designing solution can be classified into three basic groups: comfort, performance and health and safety.

Design criteria have a hierarchical character and it is therefore necessary to transform them into larger groups of sub-criteria, i.e. anthropometric criteria are divided into three categories: free space, reach and the working position.

Problems of free space are related to providing enough space for legs, head, etc. as well as to the issues concerning moving through passages freely, securing the area around and between machines. When designing workspace, meeting these criteria is of great importance because each failure can be potentially hazardous to workers. In order to solve the problem of free space the population of the biggest workers should primarily be taken into consideration.

Problems of reach are primarily related to the location of commanding organs, the positioning of various surfaces and the like. Solving the problem of reach requires taking into consideration the population of primarily the smallest workers in the physical sense. Solving the problem of free space and reach implies limitations in only one direction.

"Haptic areas" (areas of the reach of arms) are determined by the anthropometric characteristics in sitting and standing positions. Reaches of arms can be different depending on how much the arm is stretched at the elbow. The more stretched the arm is, the bigger the load is, thus making the energy losses higher, the movements less accurate and so on. Hence, when designing a workspace in ergonomics the following zones of the reach of arms can be differed:

(1) The zone of normal reach is the area limited by the front edge of the work surface and the radius of forearms (left and right) with centers in the shoulders (horizontal projection of the shoulder and elbow in a vertical position of the upper arm where the forearm and the upper arm close the angle of 90º).

(2) Extended zone is the area determined by the radius of the length of stretched arm (normal reach of stretched arm) and the reach of stretched arm, when the arm is fully stretched at the elbow (upper arm and forearm angle is 180º, with the center in the joints of the left and right shoulders).

(3) Maximum zone of reach consists of maximum reaches of the arm when it is fully stretched at the elbow (upper arm and forearm angle is 180º), and the body leans forward with a maximum leaning of the body to one side.

Figure 3.11 shows the areas of the reach of arms.

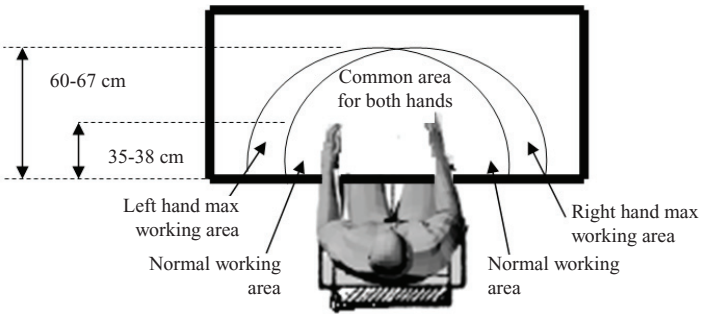


Figure 3.11 The areas of the reach of arms

When a disabled person is sitting in a standard wheelchair, the length to be counted within their usage, due to the person's feet, increases at about 120 cm, and the width, due to the arms, at about 90 cm. Top of the head of a person of average built sitting in a wheelchair is at a height of about 135 cm, and for a very large person it is at a height of about 150 cm. The eyes of the former are at a height of about 125 cm and of the latter at a height of about 140 cm.

Dimensions of a standard wheelchair of medium size, when a person of average built sits in it, are shown in Fig. 3.12. Movements of people in wheelchairs, due to their sitting position, are significantly more difficult. Figures 3.13 and 3.14 show the reaches of a disabled person with a healthy upper body straight in front of himself and in the horizontal surface.

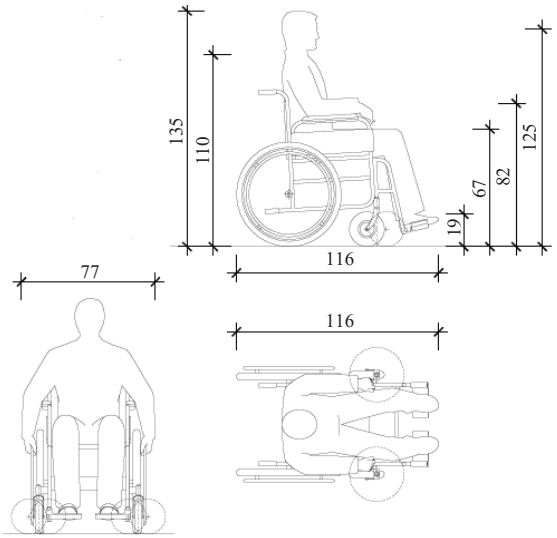


Figure 3.12 Dimensions of standard wheelchairs of medium size, when the person of average built sits in it

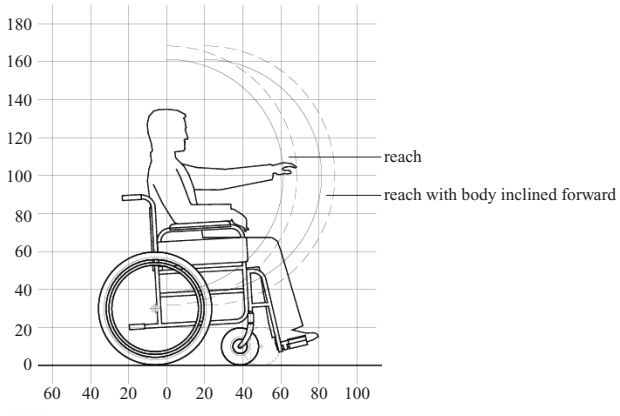


Figure 3.13 The reaches of a disabled person with healthy upper body and the body leaning forward

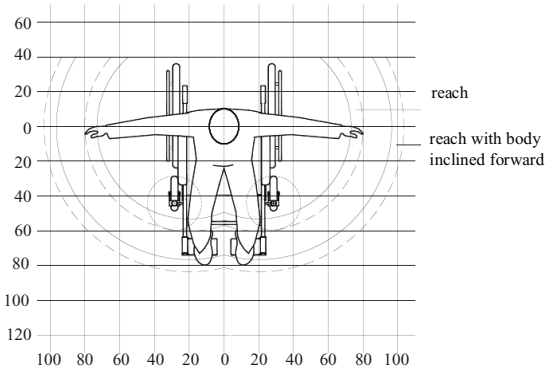


Figure 3.14 The reaches of a disabled person with healthy upper body in a horizontal surface

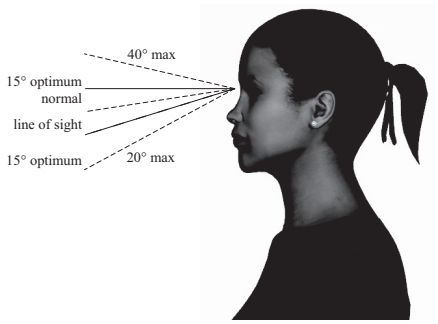


Figure 3.15 Eye rotation

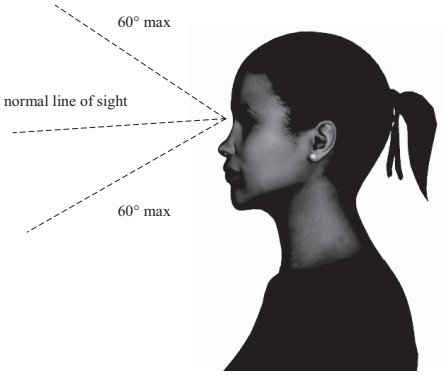


Figure 3.16 Head rotation

With working comes eyestrain and hence it is necessary to know the visual fields. Figures 3.15 and 3.16 show the zones of vision such as eye rotation and head rotation.

According to Pheasant Stephen (1986), the criteria of the working position limit the design solutions in both directions mentioned above. Unsolved problems of free space can lead to problems of inadequate working postures. For example, if the distance between the surface of the chair and the bottom surface of the sewing machine is not big enough for a femoral part of the leg, a sewer can try to solve this problem inadequately by moving the chair away from the desk of the machine, which will result in an inadequate working position, as shown in Fig. 3.17.

Figure 3.17 Inadequate working position while sewing

3.3.1 Biomechanics

Dynamic anthropometry is based on biomechanics, i.e. the application of mechanics in biological systems. In ergonomics, it is the biomechanics of man.

Biomechanics is a multidisciplinary science that uses the laws of physics and engineering concepts to describe the movements of different body segments and the forces acting on these segments during normal daily activities.

Biomechanics deals with the system of measuring body posture, the speed of movement, acceleration, forces and moments in the course of various activities in order to determine the best starting position for a complex movement. In biomechanical analysis of body movements and studies of time when performing work tasks, the attitudes and positions of people with their mobility actions can be established, which of these are most comfortable and which require the least psychomobility tension, while allowing the most successful job performance.

Biomechanics of work can be defined as the study of physical interaction of a man with his tools, machines and materials he uses, aiming to enhance human performance while reducing fatigue and the risk of muscle-bone disorders.

Comparative biomechanics is about researching the anatomic approach to:

1. System – examines the biomechanical characteristics of certain systems (skeletal system, joints, muscles, blood flow).
2. Topographic units – studies parts of the body from the standpoint of biomechanics (the head, limbs, trunk, etc.).

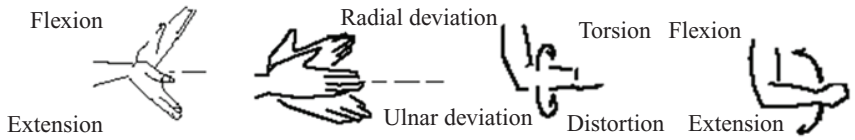
Locomotion system allows the man to move in space. The components of this system are the bones, muscles and joints. The human skeleton consists of more than 200 bones. When moving, the body is exposed to external (gravitational) forces and internal forces by which the muscles act upon the bones they are connected with. Under the influence of these forces, bones act as the levers connected to systems by joints. Muscles constitute a significant part of human body weight in the range of about 40% of its total mass, whereas the skeletal system consists of 12.8% in men and 9.8% in women of their total mass.

The connection of two or more bones is achieved through the joints. All joints can be divided into immovable, semi-movable and movable joints. Movable joints (diarthrosis s. articulationes synoviales) are the centers of motion in the apparatus for moving. The following seven types of body movements may occur in the joint:

1. Flexion (bending, reducing the angle between body parts, such as, e.g., bending the elbow).
2. Extension (stretching, straightening, increasing the angle between body parts, such as, e.g., straightening legs at the knee).
3. Abduction (removing, moving a body part from the center line of the body or the body part to which it is connected, such as raising up the hands).

4. Adduction (attaching, moving a body part toward the midline of the body or the body part to which it is connected, such as lowering the arm against the body).
5. Rotation (moving a body part in a circular motion around the joint, such as moving the arm around in the shoulder joint).
6. Pronation (turning the forearm so the palm is turned downwards).
7. Supination (turning the forearm so the palm is upwards).

Figure 3.18 shows the positions, movements and limits of movements of the upper extremities.



Motion		Scope + standard deviation
Joint	Flexion	90 ± 12
	Extension	99 ± 13
	Radial deviation	27 ± 9
	Ulnar deviation	47 ± 0.7
Forearm	Distortion	113 ± 22
	Torsion	77 ± 24
	Bending of the elbow	142 ±10
Shoulder	Bending	188 ± 12
	Protrusion	61 ± 14
	Closure	48 ± 9
	Opening	134 ± 17
Upper arm	Rotation -medial	97 ± 22
	Rotation -lateral	34 ± 13

Figure 3.18 Positions, movements, and limits if movements of the upper extremities

Bones are connected with the surrounding tissue by muscles. Positions taken when working determine which muscles will be used, as well as how the forces are transmitted from the muscle to the object of handling.

There are two forms of muscular effort:

- static effort, its significance is in a prolonged state of the contraction of muscles (the effort of maintaining posture or body position) and
- dynamic effort, its significance is a rhythmic exchange of the contraction of muscles.

According to Rohmert (1986), maximum periods for a muscle load are:

(a) 100% of maximum force duration is 0.1 minute

(b) 75% of maximum force duration is 0.35 minutes

(c) 50% of maximum force duration is 1.0 minute

(d) 25% of maximum force duration is 3.4 minutes

Incorrect posture at work requires the usage of greater muscle forces because muscles cannot perform the work effectively. Static or improper posture contributes to the fatigue of muscles and tendons and the sensitivity of a joint participating in performing a particular task.

Muscle-bone disorders are the most expensive category of illnesses caused by work (see Chapter 2). Muscle-bone disorders prevail in relation to other illnesses and affect 7% of the population. They constitute 14% of the physical examinations of doctors and 19% of hospital treatment. Around 62% of patients with muscle-bone disorders have a certain degree of limitations in activities. Therefore it is necessary to follow biomechanical principles. Basic biomechanical principles are as follows:

1. Limited and strictly programed movements should be replaced by natural and free movements.
2. Avoid static muscle strain.
3. Rectilinear movements are to be replaced by circular movements.
4. Use ballistic and gravitation movements to deal with large resistance.
5. Ensure that elbows are in neutral position when working (low and close to the body).
6. Avoid head movements, flexion, rotational movements of the trunk and extremities.
7. Avoid increased muscular tension in the simultaneous vibration effect.
8. Use legs instead of arms for large muscle strains.
9. Avoid both fast and powerful movements.
10. Provide sufficient space for work movements.

All forms of human movements are the result of muscle contraction. Therefore the biomechanics depends on the division of mass while moving. For the analysis of the movements of the human body or its individual components, it is necessary to know the forces and moments, velocities and accelerations of individual anthropometric points of the body, positions of mass centers and dynamic moments of inertia in the observed moment.

The application of computers and CAD/CAM has been so far to enable the research of designing and establishing ergonomic and biomechanical harmony between the dimensions of a man, the workspace and his working positions and movements (Computer Aided Analyses Ergonomy – CAEA). To simplify the complex geometric problems in designing, the models of the human have been computer-generated (3D models) in order to allow easier designing of workplaces in the CAD environment.

Human Computer Aided Design (HumanCAD) is a human modelling solution that creates digital humans in a three-dimensional environment in which a variety of ergonomic and human factor analyses can be performed. HumanCAD aids users with the design of products and workplaces by determining what humans of different sizes can see, reach or lift.

The company NexGen Ergonomics Inc. provides the most extensive product line of systems for ergonomic and biomechanical job-analysis, design and research in the world. These include 3D human modelling software, ergonomic design systems, video analysis and other job analysis systems, force measurement systems, electromyography (EMG) analysis systems and data acquisition systems.

Some of the included features to aid in mannequin positioning are:

- Completely articulated body within human ranges of motion.
- Library of pre-defined mannequin body and hand postures.
- Real-time inverse kinematics (IK) and forward kinematics (FK).
- Mannequin reach to selected point.
- Digital floor with manikin snap-to-floor feature.

Figure 3.19 shows HumanCAD (company NexGen Ergonomics).

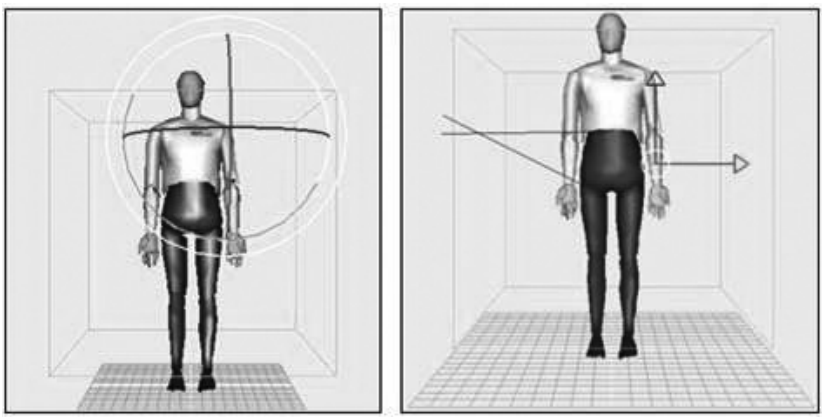


Figure 3.19 HumanCAD (company NexGen Ergonomics)

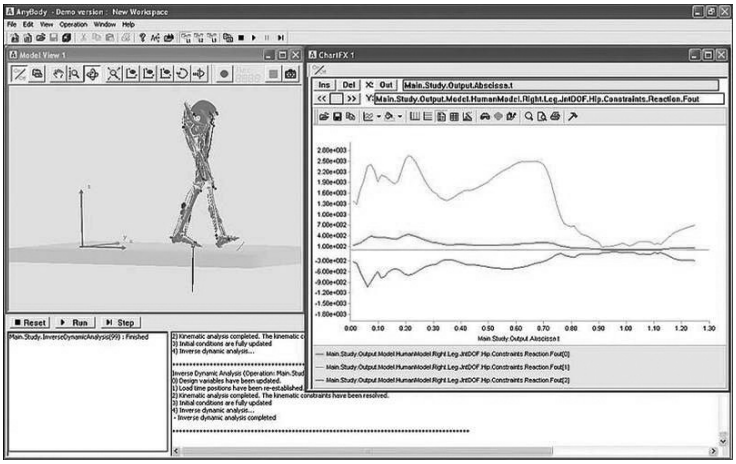


Figure 3.20 Company AnyBody Technology's AnyBody Modeling System™

AnyBody Modeling System™ is a software system of the company Anybody Technology Inc. and also distributed by NexGen Ergonomics Inc. for simulating the mechanics of the live human body working in accordance with its environment.

The environment is defined in terms of external forces and boundary conditions, and the user may impose any kind of posture or motion for the human body – either from scratch or from a set recorded motion data. AnyBody then runs a simulation and calculates the mechanical properties for the body–environment system.

Figure 3.20 shows Company AnyBody Technology AnyBody Modeling System™.

3.4 Ecological conditions

Ecological conditions of work are a new attitude toward the environment.

Environmental protection and its improvement are some of the most important problems modern society is faced with. Rapid scientific and technological development, the application of new and powerful sources of energy, the construction of a large number of industrial buildings and the creation of large urban areas have all led, in recent decades in particular, to a high level of pollution of basic natural resources of wildlife, to a disturbed harmony of a man–life environment and to a very serious threat to natural conditions necessary for the preservation of the environment, which ultimately question the very survival of humanity.

The development of ecological awareness emphasizes the notion that a man with his actions must not disrupt the process in the nature according to his needs, or disturb the functioning of the balance that has always existed between living things and their environment.

According to Vasovic and Biocanin (2007), the material practice of sustainable society must include the following:

a. Eternal quest for more efficient environmental solutions
b. Serious treatment of environmental hazards
c. Regular checks of designed environmental policy
d. Informing the public about the environmental performances of environmental activities
e. Manufacturing processes in accordance with the latest scientific and technical capabilities
f. All production processes must give preference, i.e. priority, to the implementation of environmental objectives
g. Environmental policies, goals and standards have to be integrated into all areas of company management;
h. Implementation of eco-management activities is expected to develop ecology as a continuous process
i. Eco experts should have a major and final word in creating business and economic situations and consequences
j. All employees in business systems should be educated to support a responsible environmental awareness
k. The main imperative of business policy should be environmental consciousness, which is the result of environmental protection, rational use of energy and resources, the safe usage of emerging products, reusing of products, recycling, and by deposits

It is necessary to use the standards in this area. The main goal of ISO 14000 is to provide environmental protection through the implementation of provisions and procedures of protection. Standard is based on a systematic and determined approach that enables the fulfilment of environmental needs, using the specified requirements and the obligation of good conduct of the environment in the field of environment protection.

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4

Ergonomic principles

Abstract: Unless ergonomic principles are complied with, a man is exposed to a series of risk factors that has been confirmed in thousands of epidemiological researches, laboratory tests and histories of diseases including action force, repetitive movements, uncomfortable body position, bad posture, vibration, stress, and coolness.

Key words: principles, workplace, working processes, microclimate

4.1 Ergonomic principles in designing the workplace

The workplace is the least economic and technical unit in the manufacturing process, the place where the process of making the product is carried out, the place for the worker himself. Productive activity of workers in the workplace, i.e. the process of work, has the following three inseparable factors: items of work, means of work, and a man.

Defining workplaces (jobs) is determining the type and number of tasks performed by individual workers. Managers decide how to split the job into smaller tasks. They share all the activities of the task into smaller sets of related activities. The effect of these decisions is to define jobs in terms of specialized activities and responsibilities. Managers have the task of distributing authority to specific jobs. The authority has the right to make decisions without the approval of senior management and consulting subordinates. A job itself has the right to decide without the prescribed limits. Managers decide about the basis on which the individual jobs are associated – grouped. Groups of related activities are by their nature relatively homogeneous or heterogeneous.

Jobs have several characteristics, the most important one being the degree of specialization. Managers have the task of dividing the overall task of the organization into a number of specialized jobs or activities to be performed. The division of work is "breaking" complex tasks of organization into specific components so that individuals are responsible for a specific set of tasks instead of the tasks of a whole unit – the organization as a system. The division of tasks into lower, smaller tasks provides two significant advantages:

the specialization of an individual in one type (or group) of jobs or activities and the rational use of available resources and time.

The workplace is often a potentially dangerous environment. According to some estimates, 30%–50% of workers are exposed to unfavorable physical, chemical, or biological factors, excessively heavy physical work or unfavorable ergonomic conditions.

The ergonomics of workplace deals with the quality of workplace and it studies the relations between people and other parts of the work process, with the aim of creating an optimal working environment for people and the required efficiency of the work process. Workplace ergonomics cannot be imagined without a proper hygiene of working environment. Along with optimal conditions, the important factor of productivity and safety is the organization, layout and equipment of working space.

In designing a workplace it is necessary to pay attention to the conditions of work and harmonize them with four characteristics of a worker. These are motor-physical (height, weight), sensory (hearing, sight), mental (intellectual ability, memory, attention), and spiritual (morality) characteristics. It is necessary to avoid unnatural body postures, such as leaning on the back or aside but to lean forward 15° maximum instead; working with arms held out because it reduces the precision of work; and squatting and stooping. It is necessary to consider the relationship between static and dynamic muscle work (the relationship between the angles of different parts of the body, the mass distribution of individual body segments, the duration of a movement and the risk of a certain posture) using:

- indirect methods – taking photographs or recording workers
- direct methods – watching the man working
- subjective methods – analysis of employees, i.e. when a worker is asked about his movements at work.

Figure 4.1 shows the unnatural body postures when working at sewing machines.

Figure 4.1 Unnatural body postures

The following are the two most important dimensions of work design:

- The scope of work that represents the number and type of tasks that should be performed by the worker.
- The contents of the work relate to the authorities of the worker in terms of planning, organizing, setting the work tempo and type of communication.

Work design approaches can be as follows: mechanical, motivational, biological, mobility, and socio-technical approach.

(1) Mechanical work design approach – the nature of jobs at different dimensions of work design when a mechanical approach is applied:

   i. Job specialization: Is the job highly specialized in terms of its contents and/or work activities?

   ii. Specialization of equipment and procedures: Are the equipment, procedures, materials, etc. used in that job highly specialized in terms of its contents?

   iii. Simplification of tasks: Are the tasks simple and easy?

   iv. Individual activities: Does the job require the employee to perform a task one by one? Is the employee expected to perform several activities at the same time or within a short period of time?

   v. Simplification of job: Does the job require relatively little skill that requires very little training?

   vi. Repetitive nature of job: Does the job require performing the same activity or few activities many times?

   vii. Unproductive time: Is very little time wasted between two work activities?

   viii. Automation: Are most of the activities in the workplace automated or assisted by automation?

(2) Motivational work design approach – the nature of jobs at different dimensions of work design when the motivational approach is applied:

   i. Autonomy: Does the job allow freedom, independence or discretion in planning, methods, quality control, procedures and other types of decisions related to work?

   ii. Internal feedback: Do work activities themselves provide direct and clear information about the effectiveness (in terms of quantity and quality) of performing a job?

iii. External feedback: Do other employees in the organization (such as managers and staff) provide information on the effectiveness (in terms of quantity and quality) of doing a job?

iv. Social interaction: Does the job enable positive social interaction (such as teamwork and support from colleagues)?

v. Clarity of mission and goal relationship: Are business obligations, requirements and goals clear and precise?

(3) Biological work design approach – the nature of jobs at different dimensions of work design when the biological approach is applied:

i. Physical strength: Does the job require very little muscle strength?

ii. Lifting weight: Does the job rarely require lifting weights or lifting a small weight load?

iii. Endurance: Does the job require a very little level of endurance?

iv. Differences in sizes: Does the workplace allow people of different builts to do the work on it?

v. Noise level: Is the workplace free from excessive noise?

vi. Climate: Is the air at the workplace pleasant in terms of proper temperature and humidity?

vii. Work breaks: Does the job allow adequate time for breaks?

viii. Working in shifts: Does the job require working in shifts or overtime work?

(4) Mobility work design approach – the nature of jobs at different dimensions of work design when the mobility approach is applied:

i. Lighting: Is the lighting in the workplace adequate and without glare?

ii. Programs: Are the programs contained in the computerized equipment used in the workplace easy to use and can you quickly learn to work on them?

iii. Monitors: Are the screens, gauges, measuring devices and computerized equipment used in the workplace easy to read and understand?

iv. Other equipment: Are the other equipment used in the workplace easy to use?

v. Printed material: Is the printed material used at work easy to read and interpret?

vi. Requests for inputs: Is the amount of information required to perform the job reduced to a minimum?

vii. Requests for output: Is the amount of information that an employee needs to produce in his job, in terms of actions and communication, very small?

viii. Requests for information processing: Is the amount of information that must be processed, in terms of thinking and problem solving, very small?

ix. Requirements for storage of information: Is the amount of information that must be remembered by workers in the course of their job reduced to a minimum?

x. Stress: Is the work being performed relatively stress-free?

(5) Socio-technical work design approach – emphasizes the technical and social characteristics of the work environment, because each production–business system (PBS) has different characteristics. According to this approach, it is necessary to take into consideration the role of the employees in the design process, the nature of tasks, and the autonomy of work teams in designing the work processes.

In contrast to the work design, which is the process of structuring the work and assigning tasks to individual or group operators, work redesign is related to changes in the amount and type of tasks performed, or changes in the ways of carrying out the existing work. The most frequently used methods for work redesign are broadening the work, extending the work, and the rotation of work (see Chapter 2).

4.1.1 Analysis of workplace

Workplace analysis is the process that systematically, under predefined elements, defines the requirements to be met by a human in a particular workplace. The analysis of work is the process of organization and transformation of data related to a certain job into the information required to establish descriptions and specifications of a job, on the basis of which the evaluation of work will be made. In the analysis, six questions shown in Fig. 4.2 can help indicate the areas of training.

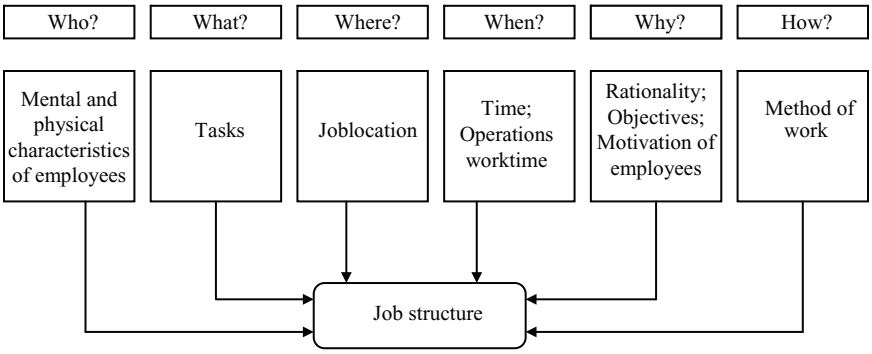

Figure 4.2 Analysis methods for performing operations

Data obtained in the process of analysis are the input variables to perform different activities such as work defining, work redesign, selection and orientation, staff training, professional orientation, employee safety, the evaluation of performance, and the system of wage calculation.

The methods used for work analysis are as follows:

1. Observation method
2. Method of interview
3. Survey method
4. *Management activity analysis questionnaire*
5. *Position analysis questionnaire (PAQ)*
6. Method of recording work activities
7. Method of evaluation of work elements
8. Taxonomy of tasks
9. Fleishman job analysis survey (FJAS)
10. US Department of Labor (DOL) *procedure*
11. Functional job analysis

(1) Observation method

The observation method consists of monitoring the work process of the individual or a group carried out by analysts. The analyst records what was done, how it was done, with what equipment, for how long, in which work environment and with what kind of organizational relations.

The advantages of the observational method are that a direct attendance to the process of doing business can provide a richer and deeper understanding

of the requirements of a particular job than it could be achieved by worker's description of the activities performed.

In case that the work, which is the subject of review, is primarily mental, the use of observation as the only method of analysis can bring very little useful information. There is a possibility of atypical behavior of individuals in their workplace, when they know they are being observed. Very few people can make observations adequately.

(2) Method of interview

The interview is a method that is a conversation between the analyst and one or more employees. The types of methods of interview are as follows:

(a) According to the criterion of structure – structured interviews and unstructured interviews.

(b) According to the number of people to be interviewed – individual interviews and group interviews.

Typical questions in the interview are as follows:

i. What is your job?

ii. What are the main duties and responsibilities of your job?

iii. 'On which physical locations do you do your job?

iv. What kind of education, experience, skills, certificates and licenses are required to perform the job?

v. Which activities do you take part in?

vi. What are your duties and responsibilities?

vii. Name basic performance standards that symbolize your job?

viii. How do you assess the environmental conditions and working conditions?

ix. What are the physical and mental demands of the job you do?

x. What are the health and safety conditions of work?

xi. Are you exposed to any risks or unusual working conditions in the workplace?

(3) Survey methods

A questionnaire consists of a system of questions designed according to certain principles. It usually has a volume of 3–5 pages and includes the goals of analysis and questions. Figure 4.3 shows the questionnaire for analysis of workplace.

The questionnaire for analysis of workplace

Job title _____ _____ **Date** _____
Sector/plant _____
Working hours _____ **to**_____

(1) What is the main purpose of workplace? _____
(2) If there are more employees who do the same work, must include the number of employees ____
(3) If a management position if an employee performs:
  (a) Control of work
  (b) Training
  (c) Evaluation of performance
  (d) Giving instructions and/or advice
  (e) Other _____ _____ ___
(4) In what ways and how to oversee the work of the employee _____ _____
(5) The duties of workplace (what and how the employee works):
  (a) daily duties (those that are performed regularly every day or almost every day)
  _____ ____ _____
  (b) periodic duties (the ones that are done once a week, once a month or at some other regular interval)
  _____ ____ _____
  (c) duties performed at irregular intervals
  _____ ____ _____
(6) Does the employee on his work place perform duties as it considers not necessary?
_____ ____ _____
(7) What kind of education is needed for the workplace? ____ _____ ____ ____ _
(8) How much experience is required to perform the duties on workplace?_____ _____
(9) Negative factors that occur during the performance of job:
  (a) dirt
  (b) dust
  (c) heat
  (d) cold
  (e) noise
  (f) moisture
  (g) vibration
  (h) low light
  (i) other
(10) Is the workplace healthy and safe for the employee ? _____
(11) What kinds of machines, tools and equipment employees regularly employed?
_____
(12) Is the working standards established precision (allowable error, the time required for a specific task, standards, etc.) ?
_____
(13) Does business requires certain personal characteristics (physical characteristics, talents, etc.)?
_____ _____
(14) Are there any special problems that employees may encounter while enveloping the job under normal conditions?
_____ ____
(15) How serious are the errors that arise in the workplace? Who or what influenced mistakes employees make?
_____

Figure 4.3 The questionnaire for analysis of workplace

(4) Management job description *questionnaire*

Management job description *questionnaire* is a questionnaire with 197 positions that analyze 13 factors. The main categories of managers' activities are as follows:

- production planning
- coordinating the work of organizational units and employees
- internal control of operations
- responsibility for product quality
- public relations and relations with consumers
- consulting
- independence in their work
- management of financial transactions
- providing technical assistance to employees
- control
- complexity of the work and stress
- financial responsibility and
- responsibility for employees

A questionnaire that has three categories of behavior is used in order to differentiate managerial jobs at the same organizational level. Managerial jobs here differ by function (e.g. marketing, production, human resource management, etc.) and organizational level (e.g. executive vice president, supervisor, etc.), so the tasks differ by behavior according to:

i The impact on management activities.

ii The type of interpersonal contact.

iii Managerial access to performing tasks.

(5) *Position Analysis Questionnaire*

Position Analysis Questionnaire (PAQ) was developed by Dr. Ernest J. McCormick and associates at Purdue University. PAQ is one of the broadest and best-researched instruments for analyzing jobs. This is a standardized job analysis questionnaire containing 194 items to represent:

i. Work behaviors

ii. Work conditions

iii. Job characteristics

The questionnaire organizes these items into six sections concerning different aspects of the job:

i. Information input
ii. Mental processes
iii. Work output (physical activities and tools)
iv. Relationships with other persons
v. Job context (the physical and social environment)
vi. Other characteristics (such as pace and structure)

Table 4.1 Example of position analysis questionnaire.

Category	Description	Example	Number of elements
Information input	Where and how the worker receives the information necessary to perform the job?	Technical documentation Visual data (instrument panel)	35
Mental processes	What mental processes of reasoning, decision making, planning and processing should be undertaken in the course of their job?	Synthesis and processing of data Quality control	14
Work output	What physical activities are undertaken by an employee? What tools and machines does he use?	Using a sewing machine, CAD system, trolley, etc.	49
Relationships with other persons	How much and in what area of work depends on the rest of the workers in the working process?	Technology of production of garment Line of garment production Relationships with customers	36

Category	Description	Example	Number of elements
Job context	What are the physical and social conditions of work?	The high temperature Conflicts	19
Other characteristics	What are the important features of the process of work?	Rhythm of production line Workload	41

For every job that is the subject of analysis the analyst singles out the elements of the provided 194, which appear in that job. That is followed by evaluation of each element of the job based on the following criteria: the extent of usage, the amount of time spent, the importance of work, the probability of occurrence, the applicability, and the special code.

PAQ allows quantitative assessment of each job that is ranked in relation to the following five activities:

a. Decision making, communication, and social responsibilities
b. Carrying out activities that require skills
c. Physical activities
d. Working with equipment and vehicles
e. Information processing

According to PAQ, jobs can be compared regardless of the fact whether those jobs are similar or different.

(6) Method of recording work activities

The method of recording work activities requires employees to keep a daily diary of activities performed in the course of his working time. Any completed work activity is recorded in the diary, as well as the time required to perform it.

(7) The method of valuation of work elements

The method of valuation of work elements consists of compiling a list of knowledge, skills, abilities and personal characteristics (operating elements) necessary for quality work. This list of working elements is compiled by experts, who then make the ranking (score) of each working element using a four-step scale, which includes the following four situations:

i. "Hard to accept" – shows the percentage of workers who can hardly meet the requirements of the job.

ii. "Superior" – shows the percentage of superior workers who possess all the necessary working elements.

iii. "Problem" – refers to the percentage of workers the problems are possible with and who do not possess all the necessary working elements.

iv. "Practitioners" – refers to the percentage of workers who were trained for the job while working.

(8) Taxonomy of tasks

Taxonomy of tasks is related to a number of different methods that are very similar. A common fact for these approaches is that they are focused on the analysis of all the tasks that should be performed in order to do the job.

One of the methods of taxonomy of tasks is the Comprehensive Occupational Data Analysis Programs (CODAP) method. The emphasis of this approach is on work activities. According to CODAP the experts make a list of all the tasks performed within a particular job. Then they rank each task performed by the following dimensions:

i. time required to perform the task

ii. frequency of performing the task

iii. relative importance of the task

iv. relative difficulty of the task

v. the ability of training to perform the task while working

Another variant of the taxonomy of tasks method is the method of task analysis. This method also consists of creating a list of tasks that are performed within the job, but it differs from the previous one in the fact that the experts are required to identify the necessary skills for each task, as well as the skills and personal characteristics necessary for their implementation.

(9) Fleishman job analysis survey (FJAS model)

A taxonomy of job analysis methods produced by Fleishman and Quantance (1984) could provide a useful basis for identifying the kind of information required to construct a job description and person specification: the behavioral description (what exactly is done), behavioral requirement (what exactly is required), ability requirement (what abilities and attributes are required), and task characteristics (external to the individual, like working conditions and tools).

The FJAS model is a system to describe jobs from the point of view of the necessary capacities. This method includes 52 cognitive, physical, psychomotor, and sensory abilities:

1. perspicuity of speech
2. legible handwriting
3. eloquence
4. written expression
5. continuity of ideas
6. originality
7. rote
8. sensitivity to problems
9. mathematical reasoning
10. counting ability
11. deductive reasoning
12. inductive reasoning
13. sequence of information
14. categories of flexibility
15. conclusion speed
16. flexibility of reasoning
17. orientation in space
18. visualization
19. perceptual speed
20. selective attention
21. time division
22. precision control
23. simultaneous coordination of movement
24. orientation in space
25. speed control
26. response time
27. stillness of the hands and fingers
28. dexterity

29. finger dexterity
30. speed of movement of the joint-finger
31. speed of moving limbs
32. static force
33. explosive power
34. dynamic forces
35. power torso
36. motion
37. mobility
38. coordination of the whole body
39. balance of the body
40. endurance
41. distinguish near objects
42. distance vision
43. distinguish colors
44. night vision
45. peripheral vision
46. substantiality of perception
47. sensitivity to glare
48. hearing sensitivity
49. listening carefully to the sound
50. locating sound
51. voice recognition
52. purity of pronunciation

This information is especially important and useful for an employee's:

1. Selection
2. Training
3. Career development

(10) DOL *procedure*

The DOL job analysis procedure is a standardized method by which different jobs can be quantitatively rated, classified, and compared based on

data people and things scored. The DOL job analysis procedure also provides a standardized method by which to quantitatively rate, classify, and compare different jobs.

First it is necessary to gather information by observing and interviewing employees about the activities performed in the course of their work. Then these gathered information can be classified into three general functions common to all jobs, and these features are people, data, and resources (Table 4.2).

Table 4.2 DOL job analysis procedure.

Data	People	Resources
0 Synthesizing	0 managing	0 installation
1 coordination	1 negotiation	1 performing precise operations
2 Analysis	2 instructing	2 management/control
3 Translation	3 control	3 ride/handling
4 Calculation	4 routing	4 operation
5 Copying	5 persuading	5 maintenance
6 Comparison	6 collusion	6 supply of raw materials
	7 service	7 handling
	8 receiving instructions	

A set of three actions within the general functions (people, information and assets) are a code of work. For example, a job of an administrator can be marked with a code 5, 6, 7; where 5 means copying data, 6 means communicating with other people, and 7 means operating.

(11) Functional Job Analysis

Functional Job Analysis (FJA) was developed by Sidney A. Fine Associates; this comprehensive approach has the following five components:

1. identification of purposes, goals and objectives
2. identification and description of tasks
3. analysis of tasks on seven scales, including three worker-function scales (one each for data, people, and things)
4. development of performance standards and

5. development of training content

FJA is very similar to the DOL method, but differs in the following two ways:

(a) FJA ranks jobs not only on the basis of data functions, personnel and resources, but also in relation to four dimensions more (the need for specific instructions for performing the tasks, requirements for reasoning and judgment in performing duties, the skills to do the job and necessary verbal and communicative skills to perform tasks).

(b) FJA also identifies performance standards and requirements for additional training of the staff.

In this way, FJA provides the answer to the question:

1. What kind of training is needed to do a specific task?
2. What kind of training is needed to achieve the set performance standards?

Figure 4.4 shows a questionnaire about workplace.

Questionnaire about workplace

Name:_____ Position: _____
Sector: _____ Date:_____

1. Specify in your own words your main duties and responsibilities.
_____

2. Specify the qualifications, completed courses and other types of training that you have made.
_____

3. List the machines, tools and other equipment that you use in your work.
_____

4. Describe the duties you usually carry out. Specify them according to their importance and the time you spend doing them._____
_____

5. Does your job require communication with other departments, clients etc.?
_____

6. Does your job involve supervising others? If the answer is "yes," please indicate who you are superior to._____

7. Specify the decisions you makein your daily work! What is the impact of your wrong decisions or actions?_____

8. Describe the conditions in which you work._____

9. Does your job require physical effort? If the answer is "yes," describe the type of physical effort.
_____

10. Does you work expose you to a mental stress? If the answer is "yes," describe the circumstances.
_____

11. Specify the minimum requirement which you think are necessary to do your job successfully
._____

12. Please specify what you think is not covered by these questions, which could affect the documents related to your job._____

Signature: _____

Figure 4.4 Questionnaire about workplace

Regardless of the method used there are often problems in the analysis of work. The most common are the following problems:

1. lack of support from top management
2. irrelevant and inaccurate input variables
3. lack of management and employee participation in the planning of analytical process
4. lack of training and motivation of employees
5. bad timing
6. incorrect and unusable output information and
7. absence of critical aspects

4.1.2 Analysis of movement

The analysis of movement deals with motion study. The purpose of motion study is to do every job with the smallest possible number of movements, greater ease and smaller energy consumption of workers. It is focused on studying the operations and their parts – grips, movements and micro-movements.

The motion study at work is the study of hand and body movements that are required for performing the operations. Motion monitoring at work leads to elimination, shortening or combining certain movements, so that the work cycle can be carried out efficiently. Basic movements (work elements) in the process of work are:

1. Search
2. Choice
3. Catching
4. Retrieval
5. Moving
6. Holding
7. Releasing
8. Positioning
9. Pre-positioning
10. Examination
11. Assembling

12. Disassembling
13. Using
14. Non-allowed delay
15. Allowed delay
16. Planning
17. Rest for overcoming fatigue

For example: Taking = reach and capture
Placing = moving + positioning

The largest number of movements that humans use to perform a task is hand movements. The basic types of movements are as follows (Sanders and McCormick, 1993):

a. Positioning movements are those in which the hand or foot moves from one specific position to another, such as when reaching for a control knob.
b. Repetitive movements are reduced to frequent repetition of identical movements.
c. Sequential movements are related to discrete movements in relation to a number of stationary positions properly or improperly distributed in space.
d. Continuous movements are those that require muscular control adjustments of some type during the movement, such as when operating the steering wheel of a car.
e. Manipulative movements involve the handling of parts, tools and control mechanisms, typically with the fingers or hands.
f. A static posture involves maintaining a body segment in a specific position for a period of time.

The area of motion study includes the study of different body positions at work (standing, sitting, squatting, bending down, lying). Unnecessary human movements are reflected in the poor ergonomics of walking, bending the body, lifting to a certain height, handling tools and materials, requiring engaging both hands in the process instead of just one, etc. It can be very useful to record technological operations and make comments with the operators from the side of the management. In addition to the losses that are reflected in people"s movements, this form of loss also implies the unnecessary loss of the machine, which causes additional maintenance, energy costs and machine fraying, which leads to the problem of maintaining the quality provided.

The range of motion includes all the movements related to the joint observed in the plane in which the movement is performed. It is measured and expressed in degrees. Range of motion in each joint is in the function of the joint bone structure, muscle volume and other tissue surrounding the joints as well as the elasticity of muscles, tendons and ligaments around the joint. It can vary from person to person due to anatomical differences as well as some other factors such as gender, age, race, body build, practice, fatigue, illness, posture, etc.

According to Nachemson and Elfstrom G (1970), Table 4.3 shows the spine load at different body positions and tasks.

Table 4.3 The spine load at different body positions and tasks.

Posture/activity	**N**
Standing upright	860
Slow walk	920
Flexion of trunk for 20º	1140
Rotation of trunk to around 45º	1140
Flexion of trunk for 30º	1470
Flexion of trunk forward for 30º to hold a burden of 20 kg	2400
Upright standing posture with a load of 20 kg (10 kg in each hand)	1220
Raising 20 kg with your back upright and knees bent	2100
Raising 20 kg with bowed backs and knees upright	3270

Repetition can be defined as cyclical and repetitive work activity that involves repetitive movements of certain body parts. Repetition refers to tasks or a series of movements that are performed over and over again with slight variations in the given time. If the tasks or movements are repeated frequently (e.g. every few seconds), tendon and muscle strain can be accumulated, which can lead to permanent tissue damage. Tendons and muscles can often recover from the effects of repetitive stress if there is enough time to rest between repetitions. The duration of rest (recovery) plays an important role in repetitive work. The recovery time can be calculated on the basis of the chart, taking away the time of effort duration or the time of holding an object from the total cycle time. For example, a task that requires little physical effort, but it is necessary to hold the object of work for 10 seconds, will require a cycle time of 12 seconds, which allows 2 seconds for tissue repair. If performing

the task requires heavy physical exertion, the time of holding an object of 10 seconds requires a cycle time of 65 seconds, allowing a muscle recovery period of 55 seconds.

Figure 4.5 shows the influence of repetitive movements on the difficulty of work.

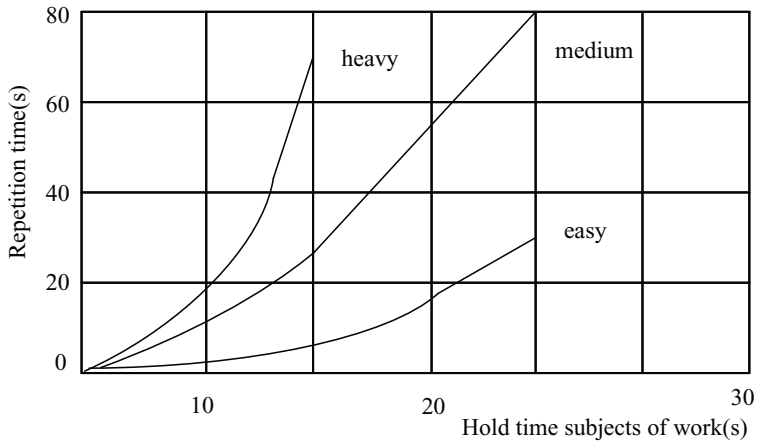

Figure 4.5 The influence of repetitive movements on the difficulty of work

The movements of the man at work are more or less tiresome (body movements, body parts, forearms, hands, fingers) and depend on the load of muscles while moving, movement duration, frequency of using the same muscles, etc. According to Grandjean (1984), small or local movements are those that are achieved by using less than one-third of the total body muscle mass. Motions that require one-third to two-third of the total muscle mass are called regional movements, and motions with more than two-third of muscle mass are called global motions.

When planning the performing of an operation, i.e. determining the ways of performing an operation, certain principles that provide better performing of operations and less strain for a man at work are very important.

- Both hands should work without interruption.

This principle avoids unnecessary delays in work and the usage of one hand only, which puts uneven pressure on the human body and does not let the person to use both hands at work.

- Hand movements should be simultaneous.

This principle ensures less mental effort, because a simultaneous beginning or ending of two movements requires only one command of the human brain.

- Hand movements should be symmetrical.

The movements of the left and the right hand are 'the same' for the human brain only if they are symmetrical. This means that each hand moves as a mirror image of the other hand. It takes only one mental effort, not two, to control the symmetrical movements.

- Hand movements should be reduced to the lowest class.

This principle suggests that less force and more speed require less muscle mass and vice versa. Thus, human energy will be used rationally. Classes of muscle mass correspond to classes of movements. Movements "from the elbow" are the most suitable ones for removing the product. As for the movements that must be frequently repeated, such as the wrench and wring, the optimal movements are "'from the wrist."

- Use the force of inertia in movement.

When stopping a moving load (braking), the force of inertia pulls the load further on in the direction of movement. This force depends on the speed of movement and the weight of load. This force should be used when planning to perform an operation.

- Movements should be punctured.

A number of researches proved that any movement with sudden changes of direction causes the loss of up to 80% of time on controlling the power of inertia when stopping and developing of speed when moving in opposite directions. That is why only smooth and continuous movements are recommended.

- Movements should be ballistic.

The characteristics of a ballistic movement are that at the very beginning of the movement the hand muscle gives the force to the burden. Hand muscles are relaxed during the movement.

- Movements are to be performed in natural rhythm.

Man is prone to the rhythm in work and this tendency should be used. Natural rhythm eliminates unexpected delays. Durations of operations, which are repeated, are shorter and more equal if a natural rhythm of movement is used. In this way a man develops working habits and does not put any effort and time into making decisions during the work.
The following rules are especially taken care of:

- whenever possible – to eliminate the grip
- whenever possible – connect with the previous or the following grip or movement
- whenever possible to do a set of grip in several areas simultaneously

- whenever possible to release hands and perform grips by feet • change the sequence whenever it leads to more efficient work • loaded grip should be performed by those parts of the body whose features are most appropriate
- sequence of hand movements should be designed to be simultaneous, symmetrical, and in opposite directions.

In order to study the sequence of grips and movements when performing an operation various methods are used, such as:

(1) The method of model – the model map – for studying the arrangement of equipments and commands when performing an operation, i.e. a model of work is drawn into such as:
   - changing of arrangement of equipment in the workplace
   - providing the procurement of organizational supplies and performing their schedule
   - reconstructing existing equipment

The method of model allows increase in productivity, improvement in humanization of work and better utilization of the surface and volume of a workplace.

(2) The method of thread – studies the arrangement of equipment in the workplace while performing an operation. By pulling a thread from one landing point of the object of work to another along the approximate path of their movement, it is possible to study the schedule of the workplace, taking into consideration the impact of movement of the object of work. The method of thread allows determining the shortest path of items or tools in order to change the schedule and introduce the organizational aids, the increase of productivity, the improvement in humanization of work, and better utilization of the surface of a workplace, thereby reducing the total path of movement of the object of work.

(3) The method of stroke – studies the arrangement of equipment in the workplace when performing an operation. Graphical models of equipment are applied in the workplace and strokes of workers are drawn in the shapes of curves that represent the projection of body bearing on the plane of movement.

A small circle is noted down at the beginning of a stroke and an arrow at the end. Strokes are separated by boundary points, which represent the inaction or grips that do not belong to the grip of transport. The shortest total path allows the increase of productivity and humanization of work, better utilization of

the surface of a workplace, thereby reducing the total path of movement of workers, which reduces the energy while carrying the object of work.

(4) The method of a map of the sequence of grips on work object – studies the schedule of grips on the work object while performing an operation. The action undertaken is changing the sequence of grips on a work object while performing an operation; the elimination or reduction of certain grips (relief) is suggested while performing certain grips. The method of a map of the sequence of grips on work object allows the increase of productivity and humanization of work, especially the shortening of a total path of work object, thereby reducing the number of grips and shortening the duration of operation.

(5) The method of spatial schedule and the sequence of grips – studies the sequence of grips while performing the operation in the workplace, besides the arrangement of equipment. The change of the sequence of grips while performing the operation is carried out and the elimination of certain grips is suggested, together with actions to change the schedule. The method of spatial schedule and the sequence of grips helps increase productivity and improve humanization of work, besides shortening the path of moving the work objects, the duration and the length of movement of workers.

(6) The method of a map of grips – studies the sequence of grips while performing an operation besides the arrangement of equipment and commands in the workplace. The change of the sequence of grips while performing an operation is carried out and the elimination or reduction of certain grips (relief) is suggested, together with actions to change the arrangement of equipment and commands. The method allows the increase of productivity and the improvement in humanization of work, better utilization of existing resources, shortening the total length of moving the work object, the length of path, the number of grips, the duration of the operation, and the relative time of work.

(7) The method of a map of movement – studies the interdependence of movements when performing an operation and the sequence of movements and arrangement of equipment and commands in the workplace. The change in the interdependence of movement is carried out and the elimination of certain movements is suggested, along with reducing the work (relief) their performance. The method allows increasing productivity and humanization of work, better utilization of certain resources, shortening the total path of moving the objects of work, reducing the number of movements and shortening the duration of operations.

(8) The method of a map of interdependence grips – studies the interdependence of grips performed during the operation in the workplace. The map of interdependent grips follows the process of work and not the object of work; therefore, all the grips are grouped into three larger sets: work, transportation and waiting. The resources are shown on the abscissa and the cumulative time on the ordinate. The change of interdependent grips in performing the operation is carried out, as well as the elimination of certain periods of waiting, or their reduction and parallel work on various resources. The method allows the increase of productivity and humanization of work, proper utilization of existing resources and shortening the total duration of the operation cycle.

(9) The method of movement – studies the arrangement of equipment and commands in the workplace, the sequence of movements and the interdependence of movements of the left and right hands. The change of the arrangement of equipment and commands is carried out and the change of the sequence of movements when performing an operation is suggested, besides the elimination of certain movements and changes in the interdependence of movements of the left and right hands when performing an operation. The method of movement allows the increase of productivity and humanization of work, better utilization of a working place, shortening the total length of the hand movements of workers, reducing the number of movements, synchronizing the movements of the left and right hands and shortening the duration of the operation.

Modern software applications have modules for human work simulation, analyzing ergonomic conditions, human resource activities as well as their loads in the virtual environment.

Two upper-body assessment methods have been developed by UK researchers. The Rapid Entire Body Assessment (REBA) method was proposed by Higgnett and McAtanamey (2000) and the Rapid Upper Limb Assessment (RULA) method was developed by McAtamney and Corlett (1993). They promoted a fast evaluation of a body's constraint due to work activity. The RULA method was developed to investigate the exposure of individual workers to risks associated with work-related upper limb disorders.

A computerized RULA assessment makes it easy for many companies to use such tools for ergonomics analysis.

NexGen Ergonomics' RULA provides a rapid assessment of the musculoskeletal loads on workers due to posture, repetition and force (Fig. 4.6). It aids in evaluating jobs or tasks that may expose workers to upper-limb disorders (neck, shoulder, upper and lower arms, and hand).

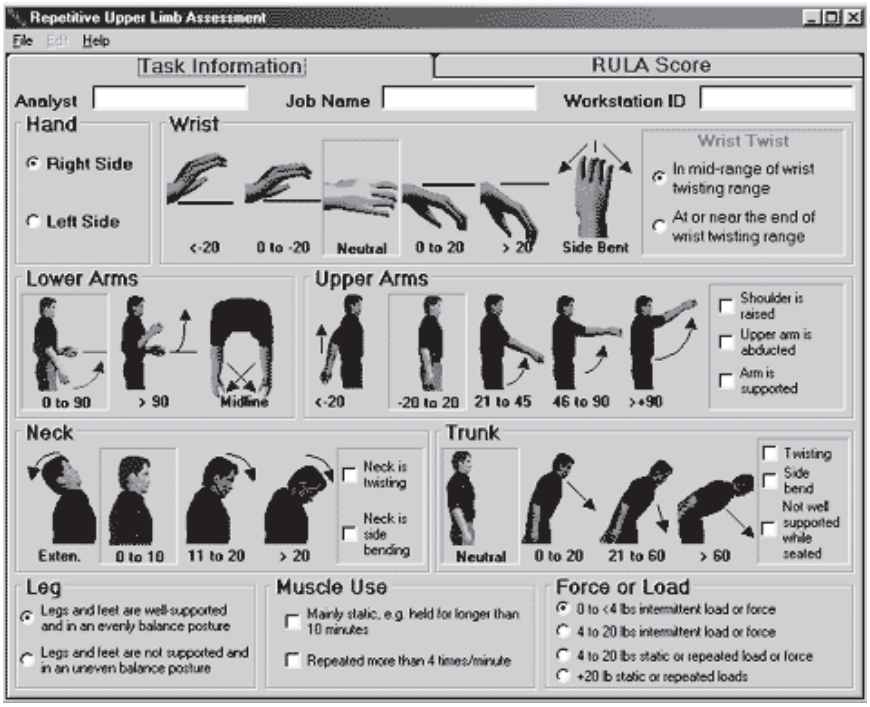

Figure 4.6 RULA analyses from tools company NexGen Ergonomics

4.1.3 Standing workplace

Standing is one of the basic positions of the body. Standing workplace is defined as the workplace at which the task is done in a relatively static standing position at one workplace. In a standing position, the body is held upright with the help of large muscles of the lower extremities and trunk. When standing, with the help of the upper extremities the burden can be carried, with the movements of lower torso and legs used to enable the force to move these loads. To perform work tasks certain movements of the whole body must be performed, such as bending, turning and moving the trunk, and reaching up and aside, whereas the legs remain in a relatively stable position.

Some types of standing activities are not considered to be standing workplaces because employees do not have a specific workplace, because they move around the work area.

Standing, in contrast to sitting, includes the static strain of major muscle groups, so that the energy consumption is about 10%–15% higher than at rest in a lying position. But standing is a very productive position for people because energy consumption and normal standing on two legs hardly require

any effort. Moderately hard and difficult tasks should be performed while standing, because the body must use large forces. In applying large forces the body uses large muscles that are found on the shoulders, back and thighs.

Figure 4.7 shows a standing workplace, i.e. working on the machine for sewing buttons.

Figure 4.7 Standing workplace

Good posture in the standing position can be an imagined as a vertical line running from the top of the head through the center of the body to the bottom of the foot (Fig. 4.8).

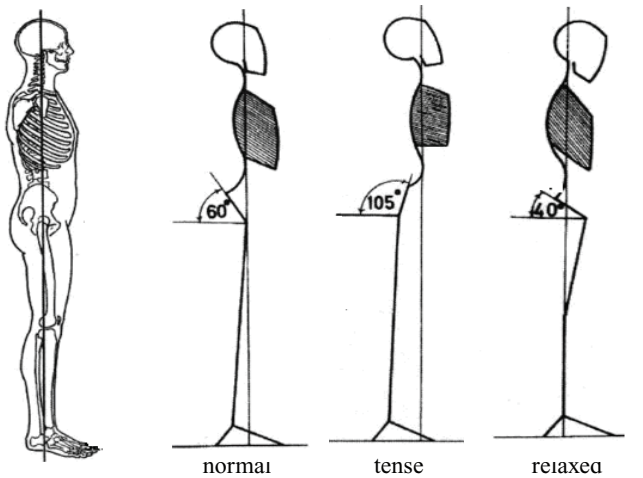

Figure 4.8 Body postures

Vertical projection of the center of gravity of the body to the surface of support can be in (Fig. 4.9):

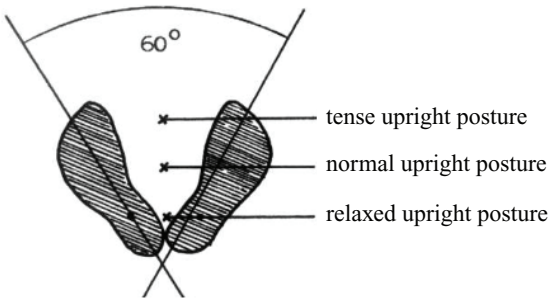

Figure 4.9 Vertical projection of the body center to the surface of support

1. normal upright posture
2. tense upright posture and
3. relaxed upright posture

Normal upright posture is the most rational posture, because the conditions for the beginning of movement are the most favorable ones. Tense upright posture is applicable for a certain time at work, and a relaxed upright posture is the worst position for a correct posture. During prolonged standing, a relaxed upright posture is most commonly used.

Non-physiological position of the body can also occur if the body is slightly bent forward. It can cause strain and pain in the neck area of the spine due to uneven and unilateral loading. If the body is bent forward a lot, the result is very difficult and tiring (Fig. 4.10).

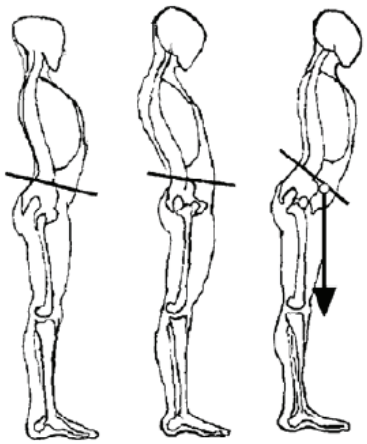

Figure 4.10 Non-physiological position

There are jobs and work tasks that are better performed in a standing position, because a standing posture at work has the following ergonomic advantages:

1. In order to be able to sit comfortably, it is necessary to provide a relatively large space for legs, which may be a construction problem.
2. Reach hands field when standing is twice bigger than while sitting, which is very important in modern complex systems with a large number of machines in which the standing position of an operator can use a much larger area for the deployment of machines.
3. Vertical signal-control panels cannot be used for sitting.
4. The use of mass and momentum of force to achieve maximum power is not possible in a sitting operating position.
5. Legs are suitable for the neutralization of different vibrations because of which, however, the vibrations are more tolerable while sitting.
6. When the nature of job requires the employee to stand up often, the effort to stand up and sit down again may require higher energy consumption than when constantly standing.

For shaping standing workplaces (the height of table, counters, working tables of machines, etc.) it is necessary to know the average height of people. Table 4.4 shows the standing heights of males and females throughout the world.

Table 4.4 Standing heights of males and females throughout the world.

	Males		**Females**	
Region	Centimeters	Inches	Centimeters	Inches
North America	179	70.5	165	65.0
Northern Europe	181	71.3	169	66.5
Central Europe	177	69.7	166	65.4
Southeaster Europe	173	68.1	162	63.8
India, North	167	65.7	154	60.6
India, South	162	63.8	150	59.1
Japan	172	67.7	159	62.6
Southeast Asia	163	64.2	153	60.2
Australia	177	69.7	167	65.7
Africa, North	169	66.5	161	63.4
Africa, South	167	65.7	153	60.2

4.1.4 Sitting workplace

Sitting is physiologically the most favorable position at work and should be used whenever the nature of work allows it. When sitting, a human spends only about 5% more energy than when lying quietly. The amount of static muscle strain while sitting depends largely on the design of the chair and its connection to the workplace. Sitting, if the body is supported ideally, consumes 20% less energy than standing when performing the same job. The pressure on the spine in a sitting bent position is up to 50% less than that in the upright standing position.

Precise operations are carried out mainly when sitting, because a small power the body must produce is required. The forearm and hand are usually involved in such activities. Precise operations can be performed while standing, but for a short period (preferably less than 10 minutes). For longer periods, precise and easy jobs should be performed when sitting in order to increase concentration and reduce fatigue.

When sitting, the energy consumption is reduced and the legs are free of load. Sitting provides stability to the upper body and less strain on the cardiovascular system. According to research, people tend to sit:

a. At the front of the chair seat – 15%
b. In the middle of the chair seat – 52%
c. On the back of the chair seat – 33%
d. Leant back in the chair – 42% and
e. Hands resting on the table – 40%

The following problems arise when sitting:

- deviation of the spine
- weakening of the abdominal muscles – so-called "sitting stomach" and
- bad effect on digestive organs

As defined by Graf *et al*. (1995), a good chair is one that allows multiple desired positions for the body and prevents stress by giving the user the ability to alter different sets of muscles that support that position.

For comfortable sitting not only the characteristics of the seat and backrest are important, but also the other factors such as feelings, relief, comfort and relaxation of the body, as well as fatigue, biomechanical conditions, stress and blood circulation. According to De Looze *et al.* (2003), Fig. 4.11 shows a theoretical model of comfort and discomfort and its underlying factors at the human, seat and context levels.

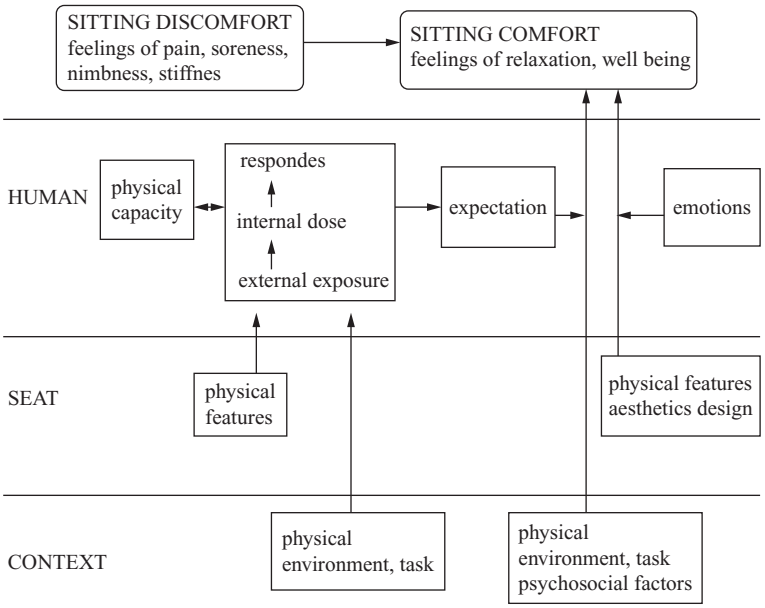

Figure 4.11 Theoretical model of comfort and discomfort and its underlying factors on the human, seat, and context level

Recommended dimensions of chairs and tables are shown in Fig. 4.12.

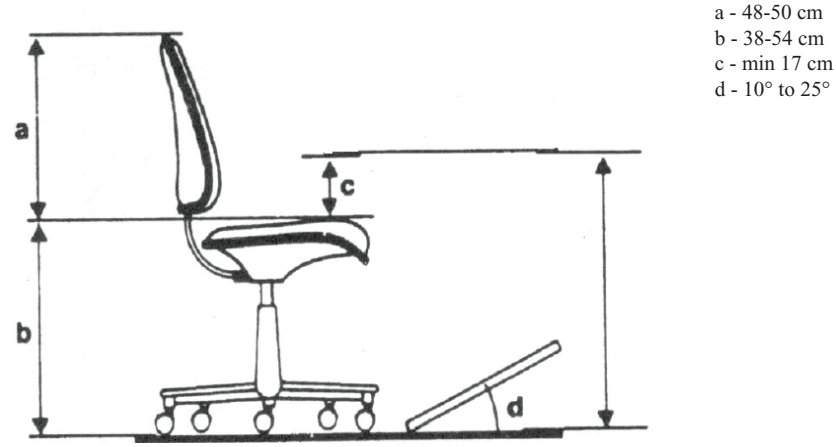

Figure 4.12 Recommended dimensions of chairs and tables

A sitting surface should be at least 2–3 inches wider than the width of the hips. The height of knees should be in the level or slightly below the level of the height of the sitting area and the feet should be firmly on the ground. In most cases footrests are not needed. The mechanism by which the height of sitting is adjusted should always be within reach.

Table 4.5 shows the height of a working table while sitting. The space below the table should be 70 cm wide and 80 cm deep.

Table 4.5 Working table height while sitting (cm).

Type of work	Women	Men
Precise work	800–1000	900–1000
Office work	700–740	740–780
Physical work that requires strength or storage space	650	690

4.2 Ergonomic principles in designing working processes

Modern techniques and machinery, as well as new technological procedures, require a new division of work and the internal organization of work processes. It is common for modern companies to have different technologies, and the impact of technology on the design of the organization is determined based on certain key or leading technologies, i.e. the ones that were applied in the production of the main product or service of the company. Different technological processes require different ways of parsing jobs and tasks in the company and its organizational units. New technologies lead to increased growth, development, and diversification of the company, and a special effect on the organizational structure is realized by IT.

The basic requirement of every organization"s work processes is achieving higher productivity with less physical effort of workers and lower costs per unit. The effect size, as well as the amount of expenses, for its achievement depends primarily on how rationally the work process is organized.

The basic ergonomic principle in designing working processes is the rationalization of a process. Rational organization of a work process implies such work organization that provides maximum performance, optimal utilization of resources, optimal costs, minimal strain on workers, quality and timely performance of work processes. Rational organization of a work process requires knowledge about the means of production, technology, engineering and performing work processes and methodological procedure for the organization of a specific work process.

The organization of work processes is an integral part of the management function of the production process, which is why this function, i.e. this element of leadership, should be regarded inter-connectively and through mutual alignment of all elements of the management. It is clear that the management

of production includes not only the organization but also the planning, analysis and control of the work process. Therefore, the organization of the work process is preceded by a defined objective and planning, i.e. making the appropriate plan.

Based on precisely defined objectives, it is possible to define the task of performing a certain work process, which is limited by

- time – when to perform a single task
- location – where to perform the task
- way – how to perform the task
- operator – who will perform the task

For a more detailed observation and analysis of complex work processes, it is necessary to divide them into operations. The analysis of the operations leads to the knowledge of the measures to be taken for their rational performance, discovering the savings and reserves for increasing labor productivity. The analysis of the organization of work processes reveals the most important elements in designing standard norms of time and performance, which are also used for the rational organization of work.

The implementation of the organization of a work process must be followed by control and analysis.

4.3 Ergonomic principles in determining working time

Effectively organized and used time helps achieve all the different requirements and ways of organizing the working time. Working time is any period during which the worker is working, is at the employer's disposal and carrying out his activity or duties, in accordance with national laws and/or practice. In each country, mandatory working time regulation is a complex mix of general and sectoral rules founded in statutory law and collective agreements.

EU Directive 2003/88/EC sets minimum standards for maximum weekly working time, daily and weekly rest periods, work breaks and paid annual leave, as well as night work and reference periods for calculating weekly rest and maximum weekly working time. The EU Working Time Directive regulations are as follows:

- A limit of an average 48 working hours per week that a worker can be required to work.
- A right to a rest break of at least 20 minutes during a working day of 6 hours or more.
- A right to 11 consecutive hours rest per day.

- A right to a full 24-hour rest period each week, or a full 48 hours in a fortnight.
- A right to 4 weeks paid leave per year.
- A limit of an average 8 hours work in any 24 hours that night workers can be required to work.
- A right to free health assessments for night workers.

Eurofound's annual update on working time developments considers a number of issues related to the time spent at work across all Member States of the European Union and Norway. In the EU27, the actual working week was 39.7 hours in 2011, 1.6 hours more than the agreed working hours. Across the 27 EU Member States, full-time employees in Romania worked the longest actual weekly hours in their main jobs in 2011 – 41.3 hours, the same as in 2010. They were followed by employees in Luxembourg (40.7 hours), Germany (40.6 hours), Estonia and the UK (both 40.5 hours), Austria and Bulgaria (both 40.3 hours), and the Czech Republic and Poland (both 40.2 hours). Employees in Finland worked the shortest hours (37.8 hours). This was 3.5 hours less than their counterparts in Romania or 4.5 weeks of work in Romania in a full year.

Working time can be as follows:

1. Flextime – full-time employees have the provision to choose the time of the beginning and completion of work in accordance with the rules of PBS. There is a core time when all employees are expected to be at work (e.g. from 9 hours to 15 hours), and the remaining hours are flexible, and the employees can choose when to work but must achieve a certain number of hours of work determined by the employer.

   Flextime affects the increased morale of workers and reduces absenteeism, thereby giving more freedom to employees to fit work commitments to private life. Employers use flexible work schedules to recruit and retain employees, as well as to increase employee satisfaction and productivity.

   Some of the advantages of flextime are harmonizing working time with the family and personal obligations, reducing unproductive labor, reducing stress, reducing absence from work, and increasing employee satisfaction. The disadvantages of flexible working hours are insufficient numbers of employees (except for the mandatory period of presence), reducing communication between employees, worse control, increased costs, and dissatisfaction of other workers who are not in the system of flexible working hours.

2. Part-time work – normal working hours for a particular employee is less than the normal working hours. Within this system there is job sharing where two employees with part-time work share a job that requires full-time work. Job sharing can be progressive retirement, parental part-time work and part-time shift work.
3. Compressed workweek – employees perform work for less than five days a week. This system includes four days, but with an increased number of working hours.
4. Telework or telecommuting – employees perform work outside the office.
5. Stagged hours – beginning and time limit of completion of work in different periods of time. Workers have the freedom and responsibility to decide the beginning and ending of the work. It can also refer to stagged hours of rest and/or lunch. This work time reduces congestion on arrival and departure from work but requires a detailed record-keeping of the presence of workers.
6. Annual hours and hours-averaging schemes – system with allowed varying time in the daily, weekly, monthly or yearly number of working hours. In this system there is no overtime work and requests for time off. The system enables faster production and lower costs for storage of products, but also results in increased administrative costs.
7. Shift work – system of the organization of working time with interpersonal replacing of workers at a particular workplace. Shifts can be morning, afternoon and night or weekend shifts. They last from 8 to 12 hours a day.

For employees shift work allows for shorter working hours, opportunities to earn overtime, extra days off and possibility for earlier retirement. During the organization of working time, a shift work system increases administrative costs, medical costs, insurance costs, and labor costs.

When discussing physical work, it should be noted that people work better during the day because they have better movement coordination, increased strength and agility of muscles as well as static endurance. However, although the human capacity for work varies throughout the day, shift work, particularly night work, disrupts the rhythm of biological functions and thus undermines the physical and mental health. This work is followed by reduced efficiency, increased work accidents, errors and absences from work. A large number of functions in the human body are subject to changes in accordance with the time cycles. These periodical changes or time-dependent oscillations of physical, chemical, biological, physiological and psychological functions, typical of living organisms and humans, are called biological rhythms. Many functions in

the human body oscillate in accordance with external time cycles (i.e. sleep and wake mode, which follows the cyclical changes of day and night).

Physiological functions oscillate significantly during the day–night cycle, showing a high level of correlation with the circadian rhythm of body temperature, which is an indicator of general metabolic activity. Body temperature has a minimum value at night during sleep (3–6 hours) and a maximum in the afternoon and early evening (18–20 hours). In keeping with the day–night variations in physiological functions, there comes a cyclic change of physical and mental efficiency of a man. It was found that physical capacities of a man are much better during day than during night. When talking about mental ability, performing simple sensory and repetitive tasks is most efficient in the afternoon. The success of performing complex mental tasks is intricately related to body temperature, i.e. they are best done in the evening.

The problem of desynchronization of biological rhythms and the need for adjustment of workers to a changed mode is most common among workers who work in shifts. Sleeping during the day after a night shift is significantly shorter (almost one-third) and the quality of sleep is lower (broken sleep). This leads to a lack of sleep (insomnia), which has a negative impact on operating efficiency, concentration, attention and other mental functions, and more serious disruption of mental health is also possible.

Many studies have shown that the minimum performance is in the night shift and the best one is in the afternoon shift. The differences of performance vary up to 30%.

Stajnberger I and Cizmic S (1991) stated three categories of suggestions for better organization of shift work:

(1) Organization of shifts in terms of time required to do the work

Adapting to new schemes of circadian rhythms is very slow and decreases quickly if the person returns to normal circumstances. Hence, it is recommended to either rotate shifts rarely or not rotate them at all. Although such work organization proved successful, it should be noted that it is not always possible to introduce a fixed shift. It was also noted that in the course of one or two days of return into normal routine, the adaptation is distorted.

As a better solution, fast rotation of shifts with inserted days off is proposed. It is useful to introduce a shortened work at the night shift, if the organization and the technological processes allow.

(2) Selection and training of people to work in shifts

Shift work requires good selection of employees that must include physiological parameters and questionnaires about the possibilities of adaptation for confirming to the rigidity-flexibility of sleeping habits, ability–inability

to overcome sleepiness and habits such as "morningness," "eveningness," and "capacity for sleep." (3) Planning and scheduling of activities and tasks within each shift

There is a very important recommendation relating to the need for the optimal time schedule of tasks, avoiding lengthy and monotonous operations as well as tasks after midnight and early morning hours (especially if there is a high risk of errors, omissions or injuries). In cases when it is not possible to introduce such changes, it is necessary to increase the number of operators and introduce various systems to maintain vigilance and activation.

Circadian rhythms are very important for a man because they shape his behavior. In fact, most psychological functions follow the oscillations of physiological and metabolic processes that they are in some cause-and-effect relationship with. These rhythms are characterized by a natural period, which is very precise and independent of external changes such as changes in ambient temperature. Rhythms, however, might be disrupted by various factors that further negatively affect the functioning of the body and can lead to pathological processes and decreasing efficiency.

Circadian rhythms belong to medium-frequency biological rhythms. Those are the rhythms of major component fluctuation of body fluids (blood and urine in cycles of 30 minutes to 20 hours), a sleep–waking cycle, body temperature variations (up to 20–28 hours), the rhythms of metabolic functions (which vary from 28 hours to 6 days). Apart from them, there are the high-frequency rhythms (cardiac and cerebral rhythmics) and low-frequency rhythms (which include rhythms with periods of oscillation from 6 days to several years, macrobiological rhythms that regulate metabolic processes, the production of hormones and hormonal functions as well as rhythms synchronized with solar activity).

Circadian rhythm of organic functions is the change of different biological and psycho-physiological functions and processes over 24 hours, with the phases of ups and downs during certain periods that are repetitive.

Figure 4.13 shows the human's ability to work during the day.

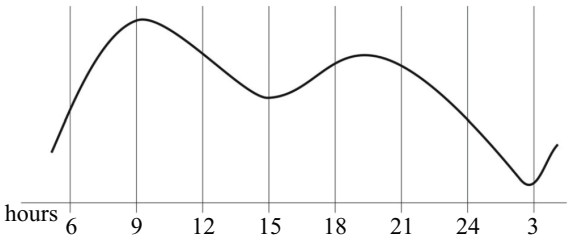

Figure 4.13 Human's ability to work during the day

In the industrial work, as in many other forms of work, in addition to the rest after finishing work, i.e. after working hours, shorter rest periods during work in spontaneous or prearranged breaks are also practised. Breaks during working hours, which are made to mitigate or neutralize fatigue, have been much studied, particularly regarding their optimal placement and duration. One of the generally applicable principles is that only a relaxing break significantly reduces fatigue, because the cessation of work itself is not sufficient to eliminate fatigue significantly (Schultz DF and Schultz SE, 1990).

Breaks are the pauses in the work of an employee in which the elements of operations are suspended, during which an employee does not perform any elements of work while resting. They arise due to the nature of work, environmental effects and personal needs. The factors that determine rest can be:

1. Constant – caused by personal needs and minimum fatigue; they are the same for all workplaces, amounting to about 9% of men and 11% for women.
2. Variable – caused by the nature of work and the working environment (physical and mental fatigue); it depends on the severity of the operations and are more difficult to determine.

Standards are set for the breaks because they depend on personal needs, physical and mental stress and the conditions of work, i.e. different people need different times for rest, so a break is standardized. The work study has shown that there are four types of breaks:

1. Spontaneous work breaks – the breaks workers take voluntarily, interrupting work in order to have some rest. These breaks are usually short and have even more value than the longer ones.
2. Covert work breaks – occur when a worker performs something temporarily with his main job. This covert activity is a little easier and allows the employee to take a rest. It may be, for example, cleaning a part of the machine or abandoning a sewing machine to come to some agreement with the manager.
3. Breaks caused by the nature of work – all the interruptions caused by the work method. For example, it is waiting for the machine to finish the work operation, waiting for materials, etc.
4. Established breaks – breaks set by the management. In addition to daily rest, there can be breaks for refreshments (“coffee breaks”). Studies have shown that the introduction of several new established breaks reduces the number of spontaneous covert breaks.

Figure 4.14 shows the loss in performance in continuous work and work with breaks.

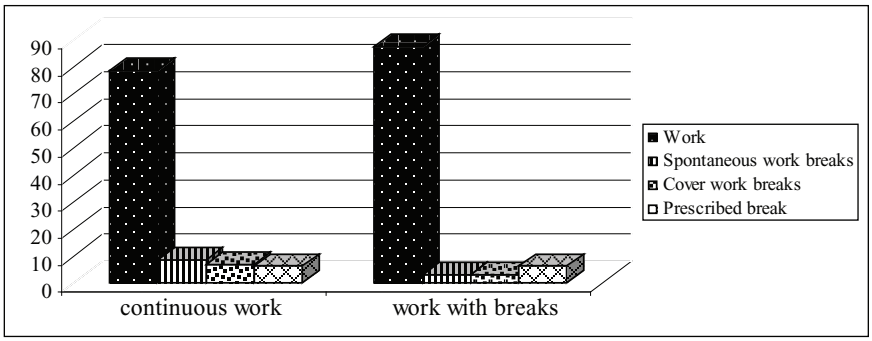

Figure 4.14 The loss in performance in continuous work and work with breaks (%)

All kinds of breaks should take about 15% of the total working time, because breaks should increase productivity. According to Boris Petz (1985), more research has indicated the principle that starting a break should not be in the moment when the fatigue has reached its culmination but at the beginning of fatigue. Instead of a general rule applicable in connection with this principle, in order to determine the optimal start of the break, various tests and monitoring the development of fatigue during work hours for each specific work situation are recommended. This can be achieved by making the effect graphic, which will show when, during work, the performance begins to decline and when it begins to decline when the work is continued after the first break, after another pause, and so on. Locating the beginnings of pauses in the moments of initial fatigue, i.e. the initial decrease in performance, enables preventing further development of fatigue.

Eating big meals during breaks temporarily "disable" continuing the work, so the breaks for eating must be either longer or separated from the breaks intended for rest, or the meals during breaks should be light and adapted to the needs of the organism for a given type of work.

The lengths of the workweek and workday are associated with accidents, i.e. the increase in the workweek proportionally increases the number of accidents at work. The shorter the workweeks are, the smaller the number of accidents is. The study by Boris Petz (1985) shows that most accidents happen on Monday, and the smallest number of accidents occurs on Tuesday and Wednesday. After Wednesday the number of accidents slowly increases until the end of the week, probably due to fatigue. He believes that the main cause of the increasing number of accidents on Monday is the way weekends are spent (rest, going out, alcohol). Figure 4.15 shows the working ability of a man during the week.

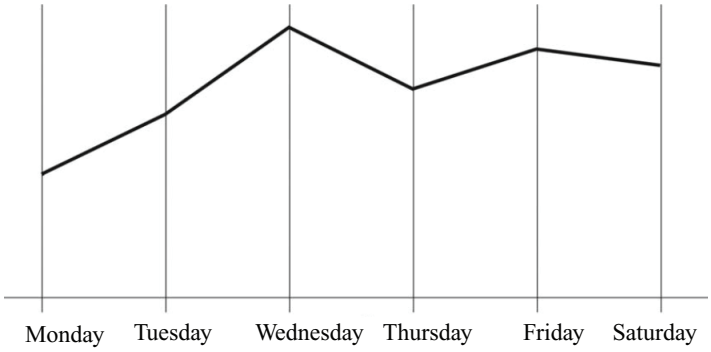

Figure 4.15 The working ability of a man during the week

Many studies have showed that most of the accidents of workers happen in the morning and afternoon, and the number of accidents reduces at the end of the shift. According to Vernon Horace Middleton (1870–1951), the largest number of accidents occurs just in the last hours of the day.

Managers must take care of the working ability of a man during the year and determine the time for vacations based on that. Figure 4.16 shows the working ability of a man during the year.

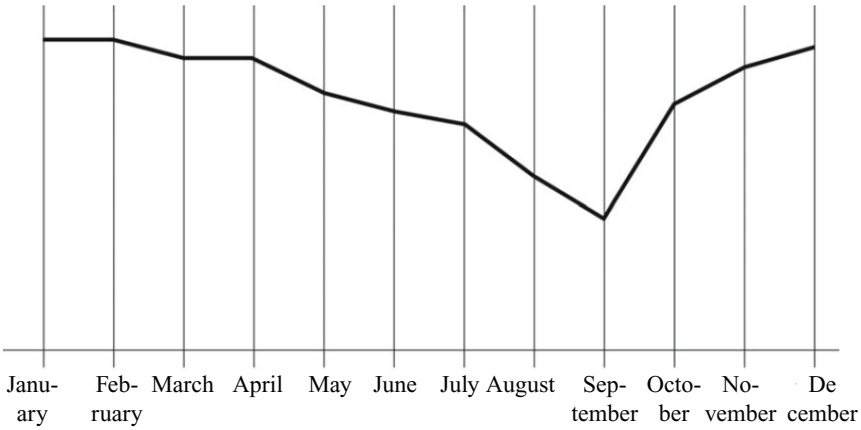

Figure 4.16 The working ability of a man during the year

All these facts point out the great importance of working time management. Effectively planned work organization and working time allows managers:

1. the preparation of work
2. the implementation of the necessary replacement of workers (absence from work)
3. the optimization of resources

4. cost reduction
5. finding a way through unforeseen events and
6. the humanization of work

4.4 Ergonomic principles in handling material and tools

One of the most important tasks of ergonomics is to determine the difficulty of work, with the objective to determine the limit of load that will not lead to adverse human health effects. Table 4.6 shows the ratio of fatigue when sitting or standing with handling tools and subjects of work.

Table 4.6 The ratio of fatigue when sitting or standing with handling tools and subjects of work.

	Loads to be mastered in N							
	to 49	49–98	98–147	147–196	196–245	245–294	294–343	343–392
Ratio of fatigue	0.11	0.13	0.15	0.17	0.20	0.23	0.26	0.29

During allocation of equipment and tools to the workplace the following rules should be taken into account:

1. Working equipment should be clearly and neatly arranged in the workplace, so that the movements at work should be as small as possible and should not last long.
2. Working equipment should be close to the workers to allow the worker to use both hands.
3. Working equipment should always be located in the same place so that the worker can find what he needs without wasting time. Schedule should be standardized in order to eliminate the time for searching and selecting tools (to help younger workers get accustomed to a standardized schedule the outlines of individual tools where they need to be disposed of can be drawn).
4. Schedule of equipment should be such that it suits the flow of technological operations so as to reach the automation of work, to perform the work quickly and effectively.
5. All working equipment should be placed opposite to the workers in the reach field of his hand, in the normal operating area.
6. Two or more tools should be combined whenever possible.

Lifting and carrying loads are the most difficult works that burden the body and adversely affect the heart, spine, joints and muscles, especially when

working in small spaces (stairs, ladders). Long-term lifting and carrying loads cause changes in the joints of the legs more than when doing jobs in other body positions during work.

Figure 4.17 shows the body positions when carrying loads.

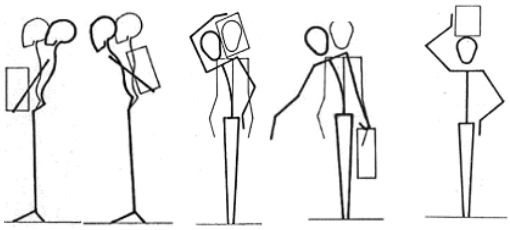

Figure 4.17 Body positions during carrying loads

In the US, a quarter of all registered occupational injuries are injuries of the lower back. Of these, 75% of the injuries occurred during lifting of loads and 20% when pushing or pulling loads. In the UK, more than a quarter of registered industrial injuries were caused due to handling, transporting or holding the loads. The proportion of injuries is as follows:

- back 45%
- hands 22% and
- arms 13%

The approximate values of ergonomically acceptable weight loads are shown in Table 4.7.

Table 4.7 Approximate values of ergonomically acceptable weight loads.

Table 4.8 shows the ratio of fatigue during lifting or lowering of loads from various heights.

Poor work habits are as follows:

i. Unsafe reach of loads
ii. Improper lifting and lowering of loads
iii. Manipulate with very heavy loads
iv. Failure to use personal protective equipment

There is an increased burden on the spine when lifting or carrying higher loads or when handling loads with the spine in a curved or rotated position, because the muscles must support the weight of the body with the additional burden of arms. The forces on the spine also increase with the increase in horizontal distance between the load and the spine. According to the European Agency for Health and Safety at Work, the risk of back injury increases during lifting, carrying, pushing and pulling loads, if the load is:

Table 4.7 Approximate values of ergonomically acceptable weight loads.

Activities	Men				Women			
	Below 50		Over 50		Below 50		Over 50	
	Periodically	Often	Periodically	Often	Periodically	Often	Periodically	Often
Lifting with two hands; compact burden; close to the body	300	210	240	140	180	130	140	100
Lifting with one hand; compact burden; close to the body	200	140	120	80	120	80	70	50

Table 4.8 The ratio of fatigue during lifting or lowering loads from various heights.

	The load that should be lifted or lowered in N							
Ratio of fatigue	to 49	49–98	98–147	147–196	196–245	245–294	294–343	343–392
to 0.40 m	0.24	0.25	0.27	0.30	0.33	0.36	0.40	0.44
0.41–0.80 m	0.18	0.20	0.23	0.26	0.30	0.34	0.38	0.44
0.81–1.20 m	0.15	0.17	0.20	0.24	0.28	0.33	0.39	0.46
1.21–1.60 m	0.15	0.17	0.20	0.25	0.30	0.37	0.44	0.54
1.61–1.80 m	0.17	0.19	0.22	0.27	0.34	0.42	0.52	-

- Too heavy – There is no precise weight limit that is safe. Weight of 25–30 kg is tough for most people, especially if the loads are handled several times per hour. Pushing or pulling loads creates smaller burden on the body than lifting or carrying.
- Too big – One of the basic rules for lifting and carrying loads is to keep the load as close to the middle of the trunk of the body as possible. In order to keep a wide load close to the body a worker has to spread his arms to catch and hold it. When the arms are outstretched the arm muscles cannot generate the strength as efficiently as when the arms are held closer to the body. Therefore, the muscles will get tired faster during handling, which demands widespread or outstretched arms to hold a large, huge load.
- Difficult to catch – When the load is hard to catch then the load can slip or move suddenly. Catching the load is more difficult with gloves than with bare hands.
- Placed in a way that it can be handled only with outstretched arms or by bending or twisting of the body. Lifting the loads with arms outstretched requires more muscle power/strength. If when lifting the load the trunk bends or twists, back injuries can easily occur.
- Sharp edges or the shape of the material can injure workers, especially in case of a crash.

When handling loads one must abide by the laws prescribed in that country. At the international level the standard ISO 11228-1, Ergonomics - Manual handling - lifting and carrying applies. Directive 90/269/EEC - manual handling of loads provides health and safety requirements for the manual handling of loads where there is a risk of back injury for workers. The Directive sets out the following general obligations of the managers:

7. avoiding the need for manual handling of loads
8. taking necessary organizational measures to reduce the risk unless manual handling can be avoided
9. enabling workers to receive adequate information on load weight and
10. providing appropriate training and accurate information about the proper handling of loads

The basic rules for handling loads are as follows:

1. Before lifting the load the condition of the load and the weight of the load should be checked.
2. The position of the foot should allow a stable posture.
3. Choosing the best position and do not change it during transport.
4. Heavy loads should be carried by two workers or use transport.
5. Women and young people should not lift loads over 15 kg (Table 4.9).

Table 4.9 Allowable load weight according to the age of employees.

Age of employees (years)	Maximum allowable load weight (kg)	
	Men	Women
from 15 to 19	35	10
from 19 to 45	50	25
more than 45	40	15

6. When carrying long loads on the shoulder the front part should be lifted in the air so as not to injury other workers.
7. Workers should be lined by height if carrying long loads on the shoulder.
8. Lifting of loads should be done from a crouch.
9. The loads should be accepted as close to the body as possible.
10. Lifting loads heavier than 4.5 kg in the sitting position is not advisable.
11. Lifting loads heavier than 20 kg in the standing position is not advisable.
12. None should be allowed to carry loads heavier than 55 kg.
13. It is necessary to avoid movements of twisting the spine, especially when the load is balance-deployed.
14. When carrying loads keep the spine in an upright position whenever possible, without bending and distortion.
15. It is necessary to break the operation of carrying into simple movements with short stops (more short breaks to 1 min) between two movements.

Figure 4.18 shows ergonomic of carrying loads (bundles) by lifts in the appropriate trolley.

Figure 4.18 Carrying loads in lift

Pushing a load requires about 15% less energy than pulling it behind (Fig. 4.19). A trolley should always be pulled a little sideways. Hands on a trolley should be about three feet above the ground and about 4 cm in diameter (Fig. 4.20). A trolley should have to lower the center of gravity and be as close to the axis as possible, to keep the balance and minimize the hand load.

Figure 4.19 Transport

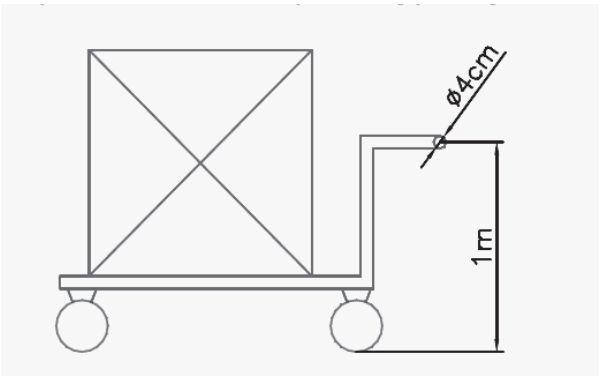

Figure 4.20 Trolley

Characteristics of environments can particularly increase the risk of injury or diseases of the spine during manual handling, if:

a. There is not enough space to perform the job, especially if the space is of insufficient height.
b. The floors or the surfaces of work are uneven, due to which there is a danger of tripping or are slippery in relation to the shoes an employee uses.
c. Workplace or working environment prevents the safe load position in relation to the body of an employee or the position of the body of an employee.
d. There are differences in the level of the floor or the working surface because of which manual handling of loads is performed at different heights.
e. The floors or work surfaces are unstable.
f. The conditions of the work environment are inadequate.

4.5 Ergonomic principles in designing environment

Ergonomic principles in the designing environment are as follows: microclimate, light, noise, vibration, color, music, and hygienic conditions.

4.5.1 Microclimate

A man in a work process can be exposed to more or less adverse climatic and microclimatic conditions of the working environment. The term microclimate includes conditions in a small area, usually around the workplace, and all the factors these conditions vary upon (humidity, temperature, air movement, heat

radiation, etc.). They have been modified under the influence of local factors such as the heating of rooms, evaporation of liquids, and ventilation.

The factors of microclimate are mainly affected by the quality of artificial air-conditioning in the rooms and a technological process of production itself. Therefore, the microclimatic factors (air temperature, relative humidity, the amount of fresh air, air velocity, the impact of the sun, the amount of dust around the workers, gas concentration around workers, etc.) must be taken into account in the phase of designing facilities and technology. The optimum microclimate conditions include the temperature, humidity and air velocity within the limits, which, when having a prolonged effects on humans, ensure a normal functional and thermal condition of the body in order to maintain a high level of working capacity.

Unhealthy climate of work often leads to health problems of employees. The causes of inadequate working conditions are the presence of harmful substances in the air, various types of radiation, etc. Suggestions on reducing side effects consist of frequent ventilation of premises, avoiding the use of unsafe materials and devices, testing a new office building before use (usually using ventilation tubes), a careful analysis of objections and feedback of employees.

Two major factors affect air saturation:

(a) air composition (presence of dust, vapours, microbes and bacteria concentration, disorders in air composition)

(b) organizational measures to ensure the proper composition of the air, which include:

    1. preventing air pollution and

    2. providing the change of polluted air

The necessary amount of fresh air is provided by ventilation. Natural ventilation is the cheapest means, but it is difficult to control it due to frequent changes in external weather conditions. Hence, additional or entirely artificial ventilation using a device for ventilation is often introduced. It is recommended to provide air movement always in the same direction, because intersecting air currents in a room is not good. The speed of air in the rooms should not exceed 15 m/min (0.25 m/s) in the periods when the rooms are heated. Faster air speed is recommended in summer, but it should not exceed 45 m/min (0.75 m/s). Ventilation, at the same time, takes away the dust, fumes and gases generated in the work process. Figure 4.21 shows a typical ventilation system.

Figure 4.21 Ventilation system

Climate modifications in a small space can be of such intensity that it is more important for health and the overall working capacity of people who live or work under these conditions. This implies specifying the value of certain microclimatic factors aiming to possibly reduce them to optimal values for the human body. The conditions under which people work affect their working capacity. Performing a physically hard work is much easier in conditions of lower temperature and a decrease in relative humidity. Easier jobs cannot be done mostly while sitting in a cold room. When the work is carried out in an overheated environment, the heart and lungs have two primary objectives:

- Transferring energy into muscles.
- Transferring the heat from inside the body to the surface, i.e. to the skin.

In hot, humid conditions, workers can lose heat and cool down naturally in a number of ways:

- by evaporation – by sweating
- by radiation – by increasing blood flow and the temperature of the skin surface; it needs cooler objects nearby for this method to be effective
- by convection – exchange of heat between the body surface and the surrounding air; it needs air movement to be effective
- by conduction – direct exchange of heat between the body and cooler, solid objects

Table 4.10 Values as a function of the type of work.

Vrsta rada	External air temperature								
	to + 5ºC			From + 5ºC to +15ºC			Above +15ºC		
	Temperature (ºC)	Relative humidity (%)	Air velocity (m/s)	Temperature (ºC)	Relative humidity (%)	Air velocity (m/s)	Temperature (ºC)	Relative humidity (%)	Air velocity (m/s)
Easy work – no physical effort	18–28	max 75	max 0.3	18–28	max 75	max 0.6	max 28	28ºC 55 26ºC 60 25ºC 65 < 24ºC 73	max 0.5
Medium work – easy physical work	15–28	max 75	max 0.5	15–28	max 75	max 0.6	max 28	28 C 55 26ºC 60 25ºC 65 < 24ºC 73	max 0.7
Hard work – heavy physical work	15–28	max 75	max 0.5	15–28	max 75	max 0.6	max 28	28ºC 55 26ºC 60 25ºC 65 < 24ºC 73	max 1.0

The temperature in the workplace depends on the outside temperature and the type of work. If the outdoor temperature is up to + 5°C or in the range of + 5°C to +15°C or more than +15°C, the temperature of the working environment should be from 15°C to 28°C depending on whether it is an easy work (no physical effort), medium work (easy physical work) or difficult work (heavy physical work) (Table 4.10).

Increased or lowered temperatures may have different effects on the human body. Some of the bad effects of high temperature are as follows:

- Reducing the concentration of workers, which leads to more accidents. Boris Petz (1985) believes that the increased number of accidents at a low ambient temperature is explained by the disturbances of psychomotor precision (especially fine fingers mobility), whereas the increase in accidents in a too warm environment leads to sleepiness and sluggishness of the body, which often accompany high temperatures.
- Dehydration caused by the lack of fluids can cause headaches, cramps, fatigue and accidents at work.
- Heat stress, with the symptoms of nausea, extreme fatigue, dizziness, sweating, rapid pulse, and swoon, reduces concentration and tolerance.
- Heat stroke, which can occur if the blood temperature is higher than 39°C, leads to confusion, incoherent speech, muscle contraction, organ damage, and possible death.

Air humidity affects the health and physical fitness of employees, and this is reflected in the effect of the work. The high degree of humidity in the working environment can be a result of the nature of the technological process, or organizational weaknesses. On the basis of the research it was found that 75% relative humidity mostly suits workers in the space in which they live and work. This value is given as a function of the type of work.

Examining microclimate in summer is carried out when the outer temperature is above 15°C, and in winter when the outer temperature is below 5°C, in conditions when all technological facilities are operating (machinery, equipment, installations, etc.) along with the devices for heating the rooms. Microclimate elements are measured at 1.2 m above the floor.

Table 4.11 shows the necessary rest time if weather conditions are unfavorable.

Temperature of work place	Minutes of rest per hour
30°–32°C	10
32°–35°C	15
35°–37°C	30
Above 37°C	work stoppage

General limit for 8h of work is a thermal load of 180 kcal, air temperature of 27°C, body temperature of 38.3ºC, working pulse of 130–140 and sweating at 1100 ml. All these indices should be adjusted for 2ºC if it comes to women's labor force, due to the specific metabolism.

Measures to protect health and safety related to the microclimate at work are as follows:

- separation of thermal radiation sources
- mechanization and automation of production processes
- normalization of conditions with the help of air conditioners that maintains the desired normal temperature, humidity, and velocity of air
- ventilation and heating
- applying personal protective equipment for safety and health at work
- appropriate clothing
- curtains on the windows, shades
- additional breaks
- adequate food and non-alcoholic drinks or water

4.5.2 Light

Keeping in mind the fact that eyesight is very important in all work activities, lighting is an important factor in the work environment and a necessary condition for performing work processes. Inadequate lighting has a negative impact not only on eyesight but also on the psychological state of a worker, the productivity at work, and occupational injuries. The condition under which it is best to place a work process is in daylight, and if it is not always possible to achieve it, artificial lighting must be used.

The lighting in work rooms, depending on the source of light, can be:

- Natural – achieved through windows, vents, and luminaries
- Artificial (thermal, luminescent, and laser sources of light)
- Combined

Table 4.12 Indication of some typical light levels.

Light levels	lux
Very bright sunny day	up to 100000
Overcast day	30000–40000
Dusk	1000
Shady room in daylight	100

To ensure favorable light, adequate attention should be paid to:

1. strength
2. consistency and
3. uniformity of light

When lighting workplaces with daylight it is necessary to adhere to certain rules due to higher utilization of daylight, such as:

a. Sunlight should not fall directly onto the workplace because it can damage eyesight and this light can have adverse effects on the materials used in the manufacturing process.

b. During the organization of workplaces, if conditions allow, daylight should come from the north because it is most diffuse and with the smallest oscillations.

c. Daylight reaches the workspace through the windows. The amount of daylight depends not only on the total window area but also on the relation between that area and the dimensions of the room and the distance of the windows from the workspace.

d. Daylight that penetrates directly into the workspace must be balanced with the light that is reflected from the surrounding walls.

e. At one-storey buildings the best results in daylight utilization can be achieved in so-called "sawroofs.

f. At multi-storey halls the windows are placed on the outside. In this case, the best results in the utilization of daylight are achieved when the ground-floor halls are projected in such a way that the top edge of the windows reaches the ceiling of the workspace; the lower part of the window should not be put below the level of the work area; daylight lighting effect will be much better if diffuse glasses are used and it is best if daylight comes from the left side, if possible.

Lighting needed in the workplace ranges between 10 and 2000 lx for jobs without any special requirements in terms of accuracy of 50–100 lx.

1. for jobs in workshops and offices with high demands regarding precision of 100–300 lx
2. for performing highly accurate and precise jobs of 300–2000 lx

Figure 4.22 shows artificial lighting in a sewing room.

Figure 4.22 Artificial lighting in a sewing room

Proper lighting of workspace should:

- protect eyesight
- reduce fatigue of eyesight and nerve-muscle tension
- provide high accuracy at work and reduce the number of errors
- increase productivity in all activities and
- reduce the risk of injuries

Different lighting at work results in a different frequency of occupational injuries. It was found that as it gets dark, at the end of the day and before a fully artificial lighting, the frequency of accidents increases. Some experts think that about 20% of all work-related injuries can be attributed to an accident or a dark environment, which leads to incorrect operation or reaction. The higher incidence of accidents at work in the night shift occurs only when the lighting is insufficient. Poor lighting especially contributes to eye strain. If artificial lighting in the night shift is good, Vernon Horace Middleton found that the frequency of accidents at work is 17% lesser than in daylight. However, if the lighting is poor in the night shift, the number of injuries and damages to eyes increases.

Measures of safety and health protection at work:

1. isolation of objects and devices that are the abnormally strong sources of light by fitting tinted glass walls, nets, and other similar solutions
2. application of appropriate combinations of painted surfaces to mitigate or enhance the effect of lighting and

3. the usage of equipment for personal protection and safety of health at work

4.5.3 Noise

Noise is any unwanted sound that disrupts, disturbs and damages psycho-physiological functions of the organs of the human body. The unit for measuring the intensity of noise is decibel (dB).

Division of noise in urban areas:

(a) Noise in the workplace
- the noise generated by a device (machine) on which the employee works directly
- the noise generated by other devices (machines)
- the noise from the so-called non-production sources (e.g. apparatus for ventilation and air conditioning) and sounds from the environment (e.g. traffic)

(b) Noise in the environment
- traffic noise
- the noise heard from industry and
- the street noise of various origins

Human ear feels changes of sound pressure level in the range of 2×10^{2} to 2×10^{-5} and within these boundaries the limits of sound intensity change. As the sound intensity increases, so does the intensity of the pressure, i.e. the force by which the pressure acts upon the receiver or the eardrum. Threshold or minimum intensity of sound that the ear can hear is about 10^{-12} W/m², i.e. from 0 to 80 dB. Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS) impairment arises from about 80 dB to 140 dB (the threshold of pain 10 W/m²) and at prolonged exposure. It is believed that 16 hours of recovery are needed after a noise exposure of 85 dB for a period of 8 hours.

According to the permitted noise levels in the workplaces, the communication between people is still possible with the noise from 50 to 60 dB, at a frequency of 1000 Hz at a distance of 1–2 meters, considering the fact that smaller distances are given for the higher noise level (e.g. 0.4 m at 70 dB). The permissible noise level is in the range of 35–85 dB (physical work, which indicates the noise made by the real work tool, the device handled by the worker) to 35–40 dB (mental work – the noise made by the appliances for ventilation or air conditioning, street traffic, etc.).

According to the available data in the US, over 50% of the working population in the workplace is exposed to noise levels higher than 80 dB, and less than 20% of the working population to the levels above 90 dB. In Europe, more than 30% of the working population is exposed to noise levels at work hazardous to health.

Noise measurement is carried out in the following way:

– If an employee changes the place of work during working hours, the noise is measured at all locations where he works and the equivalent noise is calculated.
– If the same group of machines (e.g. the sewing machine) is in the room where the noise exceeds the permitted level, the noise analysis is carried out at the workplace in the center of each such group of machines and at each machine with the noise level at least 3 dB higher than the noise of the surrounding machines.
– Noise is measured in work areas with doors and windows closed and the air conditioning system turned on. If the room is often used with open doors or windows, noise measurements should be repeated under such conditions.

Health problems due to noise include the following:

1. difficulties in communication and concentration (difficulty in hearing, the lack of concentration, fatigue, uncertainty, the lack of confidence, irritation, misunderstanding)
2. stress and irritability
3. problems with sleep
4. cardiovascular problems
5. deterioration of hearing (tinnitus)
6. psychological disorders (anxiety, aggression)
7. reduced work efficiency (productivity) and
8. social behavior

Table 4.13 gives the allowable noise levels depending on the type of work, where: a – the noise made by a machine or device that is directly handled by the worker; b – the noise made by a machine or device that is not handled by the worker; c – the noise made by non-production sources (device for ventilation or air conditioning, other factories, street traffic, etc.).

Table 4.13 The allowable noise levels depending on the type of work.

Type of work	The allowable noise levels on workplace (dB)		
	a	b	c
Physical work without requiring mental strain and perception of environment by hearing	90	84	80
Physical work focused on accuracy and concentration; periodical monitoring and environmental control by hearing; driving of means of transport	80	74	70
Work that is done by frequent voice commands and acoustic signals; work that requires constant monitoring of environment by hearing; routine work mainly of mental character	-	70	60
Routine work mostly of mental character that requires concentration	70	64	55
Mental work focused on the control of work of group of people who perform mostly physical work, work that requires concentration or direct speaking and telephone communication	-	60	50
Mental work focused on the control of work of group of people who perform mostly mental work, work that requires concentration, right speaking and telephone communication; work exclusively related to talks over the means of communication	-	55	45
Mental work that requires large concentration, exclusion from the environment, precise psychomobility or communication with a group of people	-	-	40
Mental work related to great responsibility, communication to deal with a group of people	-	-	35

According to the Occupational Safety & Health Administration (OSHA), depending on the amount of noise to which a worker is exposed, here is the established and allowed time of exposure to a certain noise level (Table 4.14):

Allowable noise levels regarding the possibility of direct agreement through speech are shown in Table 4.15.

Measures to reduce the impact of noise can be the following:

Table 4.14 Maximum permissibility of noise exposure.

Time spent in a noisy environment	Noise level in dB
8 hours	90
6 hours	92
4 hours	95
3 hours	97
2 hours	100
1.5 hours	102
1 hour	105
30 minutes	110
15 minutes	115

Table 4.15 Allowable noise levels regarding the possibility of direct agreement through speech.

	Distance in meters	
dB	Normal speech	Loud speech
45	7	14
50	4	8
55	2.2	4.5
60	1.3	2.5
65	0.7	1.4
70	0.4	0.8
75	0.22	0.45
80	0.13	0.25
85	0.07	0.14

1. use of machines and tools that make little noise
2. proper arrangement of machines
3. regular maintenance and repair of machinery
4. rotation of workplaces
5. maximum possible removal of the workers from the source of noise
6. physical fencing of workplaces from the source of noise
7. sound insulation of floors, ceilings, walls, wall partitions and windows

8. using curtains in front of the windows
9. suitable substrates and surfaces
10. using personal hearing protection devices (like ear plugs and ear muffs)
11. using plants that protect from noise, such as Viburnum rhytiphyllum

4.5.4 Vibration

Vibrations are oscillations at low frequencies that usually occur with infrasound and spread through direct contact.

Vibrations that are examined from the standpoint of safety and health at work are called humane vibration and are examined at places where touchable working tools the worker is in contact with vibrate and are tested in the range of 1–100 Hz. Short-term exposure to vibration can cause back pain, headaches, nausea, fatigue, insomnia and slow reactions. Prolonged exposure produces serious damage to the spine and can cause Hand-Arm Vibration Syndrome (HAVS), whose symptoms are pain in the joints and muscles, sensitivity to cold, the loss of the sense of pain and touch in fingers (tingling fingers; Vibration White Finger) or, in more serious cases, muscle atrophy.

Symptoms of exposure to vibrations that are dominant at frequencies from 1 to 20 Hz are shown in Table 4.16.

Table 4.16 Symptoms of exposure to vibrations.

Symptoms	f (Hz)
Feelings of discomfort	4–9
Disturbances in the head	13–20
Trembling of the lower jaw	6–8
Impact on speech	13–20
“Lump in the throat”	12–16
Chest pain	5–7
Pain in the abdomen	4–10
Shortness of breath	4–8
Muscle contraction	4–9

Security measures of occupational health protection from vibrations are as follows:

1. constructional changes with the application of plastic materials
2. extraction of the machine or device that produces noise and vibration

3. installation of plastic shims under the machines and devices that produce vibrations
4. installation of partition walls or covering the walls with materials that do not block sound waves, etc.
5. the usage of personal protective equipment for safety and health at work

The mostly widespread standards that sanction the vibration phenomenon are:

- ISO 2631 applies to whole-body vibrations
- ISO 5349 refers to the system of hand vibrations
- ISO 8041 regulates how the measuring equipment should be designed and classified

4.5.5 Color and music

Color surrounds us and affects us every day. Color affects people psychologically, physiologically and economically. Color can encourage thinking, it can move people and cause different reactions. It can irritate or soothe, raise blood pressure or reduce the appetite. It is estimated that up to 60% of the acceptance or rejection of a product or service is associated with color. People use colors to communicate and to influence their moods and feelings.

Psychology of colors is a part of psychology that studies the emotions and reactions of observers to certain colors because about 87% of all sensory feelings one gets through colors. It has been proved that people react differently to certain colors, thus causing different emotional states, behaviors and moods.

The choice of colors in a working space plays an important role. Colors affect work in the following ways:

1. Physiological effect of colors: colors affect the general condition of the operator, his working ability, responsiveness, fatigue, etc. Accordingly, red color contributes to accelerating reactions, yellow color does not affect speed, green color slows down a little and, purple color causes a noticeable slowdown of reactions. Bright environment stimulates muscle activity, but interferes with mental work.
2. Psychological impact of colors: colors affect the character of the activity of operator (exciting and calming colors), the colors that cause the feeling of coldness or warmth.

3. Biological effects of colors: colors affect the biochemical processes of the operator. Thus, blue color reduces hormonal activity, lowers blood pressure and slows down speed. Red color increases blood pressure, heart rate, and nervous tension of the operator.

Table 4.17 The impact of colors on human feelings.

Color	Basic feeling
Blue, orange, red, yellow-green	feeling the heat
Blue-green	feeling cold
Bright, cold, diffuse color	sense of "current effect"
Green, blue like sea	soothing feeling
Bright colors	snug feelings
Dark colors	heavy feelings

Colors have an impact on the reflection of light in the surface, and the reflection coefficient should be between 25% and 60% (except the ceiling). The ceiling should be painted white (psychologically neutral color, the reflection coefficient of 80–90%). The upper part of the walls should have a reflection coefficient of 40–60% (if the floor and equipment are dark) or 50–70% if most of the space is in bright colors. The floor should have a reflection coefficient of 20–40%. Equipment should have a reflection coefficient of 25–40% and should be brighter if the floor is brighter and darker if the floor is darker.

The color in the workplace environment affects the brightness and the sensation of pleasure. The color of the rooms affects the perception of temperature. According to surveys, people experience rooms with cool colors (blue, green) to be 3.3–5.5°C cooler than its actual temperature. Warm colors (red, orange) have a 3.3–5.5°C warmer effect.

In order to avoid the reflection of light that comes mostly from the upper side, machines and the lower parts of walls should be painted in dark colors. Light blue and green are recommended for machinery and equipment, because they do not bother the eyes. The intensity of light reflected by the colors is as follows: white 84%, yellow 60.5%, green 54.1%, blue 53.6%, red 14.4%, and black 1.12%. The color recommended for the walls in the workspace is a yellow-green, with the addition of white.

The colors of work objects also affect an employee. According to Klarin and Cvijanovic (2005), the harmony of colors is shown in Table 4.18.

Table 4.18 Harmony of colors.

Colors of work objects	It agrees with the background color
Red	White and red
Green	White and yellow
Blue	Red, green, blue
White	Black

Researches in the field of work physiology and psychometrics have shown that certain colors, usually warm ones such as red, orange, and yellow, seem exciting and stimulate any activity, whereas cool colors such as blue, green, gray and purple have a calming effect. Bright red colors seem irritating, so neutral combinations of red color, e.g. rosy, are mostly used for stimulating purposes.

Psychophysical studies have shown that yellow color is stimulating to the eyes and the whole nervous system, and is used for darker rooms and corridors due to the high level of reflection. Blue color, as the color of the sky, causes the images of wide open space and has a calming effect, reduces muscle tension, decreases blood pressure, pulse rate and the number of breaths, and is used for a place to rest. Green color, as the color of vegetation, seems cold and is used in rooms where the temperature is raised, as well as for sunny rooms. Considering the fact that it is best for eye-rest, it is used for the surface of the desk.

Colors in the work environment contribute to easier and faster orientation, proper lighting, space harmony, safety at work, optimization of the visual nerve-function of the operator, feeling of comfort, concentration, general improvement of the working environment, and work satisfaction.

Music is often used in rooms where work is performed in order to eliminate the negative effects caused by noise. Music at work, if properly applied, can be an important tool to increase productivity, depending on the work rhythm and the noise in the plant or in the office.

Music affects physiological processes (e.g. heart rate), mobility activities, moods, emotions and cognitive processes (memory). According to many studies, music at work eliminates the fatigue of workers, reduces monotony, increases the willingness to work, contributes to the better mood of workers, reduces anxiety, etc.

The optimal duration of music is 25% of the total working time (about 2–2.5 hours during shifts) and at intervals of 12–20 minutes.

The choice of music is very important – it should not be modern tempo or traditional music. Music should not disturb the employees, so that they stop their work and enjoy it. It should not be too quiet or too loud. Music has to be louder by 7–10 dB than the noise in the workspace. Music in the offices should be louder by 3–4 dB than the usual noise.

4.5.6 Hygienic conditions

Hygiene protection includes the measures of hygiene aiming to protect the health of workers and their being in good shape, and to eliminate potential causes of possible diseases workers are exposed to regardless of the nature of their job.

Cleaning and routine maintaining of hygiene in production buildings are carried out according to the needs of workers (daily, weekly, monthly) when the employees come to work and when they leave the workplace. Cleaning includes vacuuming and washing hard and soft floor coverings, cleaning work and office equipment (desks, computers, copy machines, sewing machines, cutting knives, irons, etc.), emptying waste baskets, cleaning the toilets, washing glass surfaces, removing cobwebs and other dirt from the walls and ceiling.

Figure 4.23 shows a non-hygienic workplace in the sewing room.

Figure 4.23 Non-hygienic work place in the sewing room

The task of maintaining good orderliness in the workplace consists of creating a safe, clean and orderly arrangement, which provides a workplace for everything that is necessary and eliminates everything that is not necessary.

Clean and tidy workplace and work space are the basis for a successful business. It is also the basis of the 5S method.

General hygiene measures should ensure the hygienic conditions in:

(a) Workspace

- The size of the rooms. Under normal operating conditions the rooms should be at least 3m high, and if the room is heated the height should be at least 3.5 m.
- The surface of the rooms – A room surface depends on the nature of the technological process, machine scheduling and number of working places. Around 10–12 m3 of free space is enough for a worker under normal work conditions.
- The walls, floors and ceilings – They should be made of a material that provides daily washing and cleaning and should prevent the absorption of toxic substances.
- Air-conditioning facilities – It needs to be resolved in such a way that the optimum temperature of a unified level is obtained.
- Workspace – The rooms should be designed to provide optimal natural conditions of work: light, temperature, humidity, and clean air. If there are deviations from optimal conditions, the conditioning of the working environment should be provided by artificial means.

Figure 4.24 shows the work room with optimal hygienic conditions.

Figure 4.24 Work room with optimal hygienic conditions

(b) Ancillary rooms

Surface area and volume of ancillary rooms (corridors, stairways, toilets, restaurants, kitchens, and social rooms) must match the surface of the rooms and be proportional to the number of workers.

(c) Water and sewage equipment

Water network (reservoirs and proper water sources) should be designed so that the possibility of pollution is excluded, as well as the possibility of freezing in winter. The sewage system is to ensure proper drainage.

(d) Yards

Yards should be tidy, with green and water oases, with benches, paths that are paved or concreted. The space should be improved and planted with flowers. Yards should be cleaned regularly and garbage and waste material should be removed.

Measures for the preservation of personal hygiene in PBS are as follows:

(a) Providing work clothes and shoes – Clothing plays an important role in the protection of labor and in maintaining personal hygiene. Work clothes and shoes must be appropriate for the operating conditions and provide hygiene protection (Fig. 4.25)

Figure 4.25 Work clothes in a sewing room

(b) Providing and arranging wardrobes in which work clothes are hygienically stored and put away. Figure 4.26 shows the space required for movements of the workers in the wardrobe.

(c) Bathrooms are designed with a sufficient number of sinks and showers with hot and cold water, liquid soaps, and clean towels.

Depending on the building and plants, sanitary facilities should be located next to the wardrobes and restaurants or offices in which workers rest and eat. There are different rules, such as:

- according to the DIN 18 228 standard, maximum distance from the workplace to the toilet is 100 m
- one shower per five workers (heavy sweating, odours, dust) and the smallest shower must be 0.9 × 0.9 m
    - one faucet per 50 employees (administrative staff and related activities)
    - one faucet per 20 workers (dirty hands, sweat, dust)
    - one faucet per 15 workers (dirty hands and bodies or sweating)
    - one faucet per 10 workers (harmful substances, odours)

(d) Health training is one of the main tasks of the staff for sanitary protection of workers. This applies to occasional lectures on hygiene, exhibitions with the theme of health and hygiene, organizing hygiene weeks, organizing competitions between various departments and facilities on hygiene and arranging the premises, consultations regarding health and others. Health education will be more efficient if cooperation with medical institutions is established.

Many studies on cleanliness in the workplace show that employees form their opinion about co-workers on the basis of their looks and neatness of their desks. Thus, 45% of workers assess their colleagues whose desks are neat as positive, 33% believe that messy workers are also very lazy, and up to 73% believe that neat employees are more productive.

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5

Ergonomic design of workplace in garment industry

Abstract: If the work environments in the garment manufacturing industry are unhealthy and unsafe for workers, it might result in several health problems. Therefore, it is important to analyze each workplace in the production of garments and find a way on how to reduce the health problems of workers to a minimum with maximum increase of productivity.

Key words: storage, preparation workplaces, cutting room, sewing room, finishing room, warehouse, clothing store

5.1 Ergonomics in the storage of textile materials

Warehouse is the space for the storage of textile materials where they can be taken in and saved from various physical and atmospheric influences until they are delivered into production or a cutting room. The storage of textile materials is a very responsible operation because improper storage, weather conditions, negligence or improper manipulation all lead to ruining and destroying supplies. Textile materials are large investments for garment manufacturers and bad storage might result in big losses.

Conditions in various parts of the world vary widely with regard to humidity, heat, or cold and to the presence of insects. Such conditions must be taken into account when storing and protecting materials. The following ideal storage conditions should be attained as nearly as possible:

- A dry room with a temperature of 20°C.
- Absence of direct sunlight.
- A storage room construction that affords protection against insects and mice.
- Air conditioning or some other method of humidity control (humidity 30–50%).

Depending on the size, location (distance in relation to the cutting room), automation, and conditions in the storage of textile materials, workers have different operating conditions.

Figure 5.1 shows poor conditions in the storage of textile materials.

Figure 5.1 Poor conditions in the storage of textile materials

Floor surfaces in the garment industry may become slippery as a result of lubricant spills, wool grease, dust, and other substances settling on surfaces. In addition, cracked and uneven floor surfaces may increase the force when an employee is moving a trolley or tubs.

Figure 5.2 shows a roll of cloth being picked from a storage rack. It shows the difficulty of balancing and supporting the weight of the roll at a shoulder height, as well as restricted and insecure footing.

Figure 5.2 Handling of rolls in a storage

Figures 5.3 and 5.4 show the organized, systematic and ergonomic transport of textile materials.

Figure 5.3 Transport of textile materials into the Company Laguna Clothing

Figure 5.4 Ergonomics workplace

Fabric inspection is an important aspect followed prior to garment manufacturing to avoid rejections due to fabric quality and being faced with unexpected loss in manufacturing. Fabric control workers must work in suitable and safe environment with enough ventilation and proper lighting (fluorescent bulbs above viewing area and backlight can be used when needed).

Figure 5.5 shows the posture of workers when controlling materials (fabric inspection).

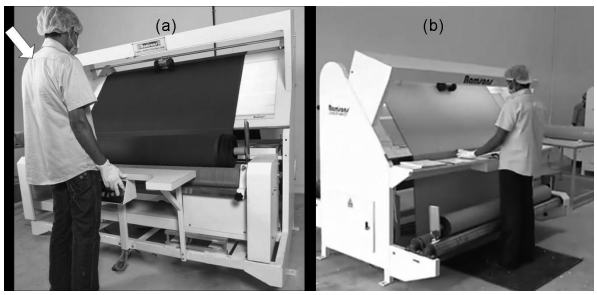

Figure 5.5 The position of the body in fabric inspection (a) improper, (b) proper

5.2 Ergonomic workplaces in garment manufacture preparation

The task of preparing the production is to determine all the circumstances of production so the process can be carried out normally, with no improvisation. Preparation of production includes constructional, technological and operational preparation. Technological preparation includes determining the technological process, the selection of machines, tools and determining the material quality. Operational preparations include developing plans for individual production facilities, determining the amount of material, determining the time of manufacture, the production of necessary documents and so on.

Besides the technological preparation, operational preparation has very important roles in the overall construction output in the garment industry. The operative preparation usually consists of the following tasks: determining the capacity of production, production planning, production monitoring, planning the necessary quantities of materials, launching work orders, scheduling of production, and assembly of data for plan calculation.

Jobs in production preparation are the jobs that are now increasingly carried out in offices on computers, using Computer Aided Design (CAD) systems (for design, garment constructions, making cutting layout) and software for production planning (production planning, technical and technological documentation) (see Chapter 2).

Workers on computers tend to keep their body in a fixed position for long periods of time in order to maintain a continuous physical relation with the equipment. For example, a worker must maintain a fixed spatial relation between his shoulders and the keyboard so that he could use the proper key each time, without looking. Owing to the non-physiological position of the shoulder, they often keep the neck in a fixed position too as a result of continuous looking at the text to be typed or at the computer monitor. These workers feel fatigue and pain in the neck, upper back, shoulders, arms and wrists, especially when they use the computer for long periods of time. They also have problems with eyesight due to long hours of looking at the computer monitor.

Figure 5.6 shows the workplace of a fashion designer.

Figure 5.6 Workplace of a fashion designer

A person who works on the computer is exposed to prolonged and motionless sitting and uses only his fingers, hands, eyes, and the mind. He sits at the workplace for a long time without a break, increasing the risk of

overstrained muscles and wrist stiffness. The consequences of sitting at the computer for a long period of time may vary, from fatigue, stiffness and discomfort to some serious health problems. The display of health problems and their manifestation in the work with the computer is given in Table 5.1.

Table 5.1 Display of health problems and their manifestation in the work with the computer.

Category	Manifestation
	- Stress, fatigue, and inflammation of the eyes
	- Irritation, dryness, and burning
Eyesight	- Conjunctiva
	- Blurred eyesight
	- Problems with differing colors
Hearing	- Growing deaf
	- Hearing loss
Hands	- Spasms in the hands
	- Pain and loss of strength
	- Stiffness of joints
	- Fingers numbness
Neck and back	- Overstrain and neck pain
	- Stiff neck and shoulders
	- Pressure in the head and neck
	- Back pain
	- Damage to the spine
Muscular system	- Loss of power and energy
and bloodstream	- Overstrain of certain muscles
	- Muscle swelling and spasms
	- Disorders in the bloodstream
Psyche	- Loss of concentration
	- Depression, stress, frustration
	- Nervousness, irritability
	- Mental fatigue
	- Disorders in the ability to work
	- The tendency to incapacitating devices and programs

(*continue*)

Table 5.1. (*continue*)

Category	Manifestation
Other	- Skin rashes and other allergies
	- Burning and itchy skin
	- Headaches, insomnia
	- Pain
	- Epileptic seizure

Serious medical conditions can result from:

(1) Frequent injuries – cumulative trauma disorders (CTD).

(2) Injuries caused by stress due to frequent repetitions of the same movements – repetitive stress injuries (RSI), such as Carpal Tunnel Syndrome (CTS), tendonitis, and Tennis elbow.

Around 15% of users whose full-time job includes working at the keyboard suffer from CTS. The hand is capable of performing six types of movements, each involving a different muscle group. Typing covers only one of these groups, and its prolonged usage leads to a certain type of stress due to the unbalanced use of the other muscle groups. The most common symptom is the feeling that the whole hand becomes numb (actually only the thumb, index and middle finger get numb), dropping things from the hand or the feeling of impulse from the wrist into the hand. Figure 5.7 shows the arm area affected by CTS.

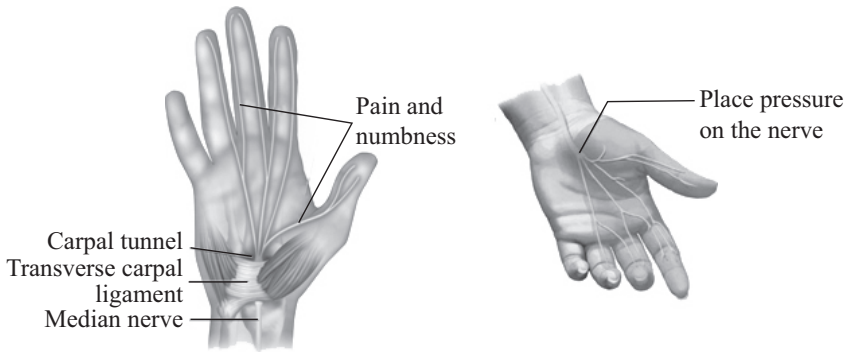

Figure 5.7 The arm area affected by the Carpal tunnel syndrome

About 25% of all the people who work at a computer suffer from CTS and it is estimated that this percentage will increase to 50% within five years. Women suffer twice as much as men. Owing to CTS, employees are mostly absent from work (30 days or more).

Tendinitis is an inflammation or irritated condition of the tendon – the tissue that connects muscles and bones. This condition, which causes pain and discomfort around the wrists, usually occurs around the shoulders, elbows and knees or around any wrist of the body. The dimensions of an ergonomic chair and leg space at a desk are shown in Fig. 5.8.

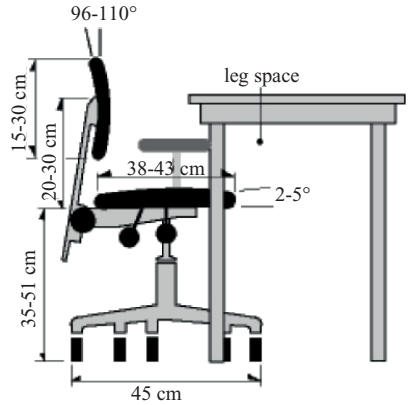

Figure 5.8 Dimensions of ergonomic chair and leg space

Tennis elbow is an inflammation of the tendon-bone joint (Fig. 5.9). It is a condition when the outer part of the elbow becomes painful and sensitive, usually as a result of strain, over-training or a direct blow.

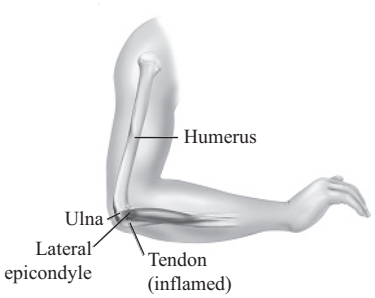

Figure 5.9 Tennis elbow (Lateral Epicondylitis)

The problem is often the space, its size, lighting, ventilation and humidity. Many, especially old, offices were designed to work with papers and are not eligible for ergonomic computer work. Setting up the screen in front of a window or in front of very shiny surfaces can cause direct dazzling of the computer screen. Reflections on the screen caused by the position of windows, lamps or other shiny surfaces can cause a reduced contrast on the screen.

Microclimatic parameters of the working environment for computer work are

(1) minimum brightness of 300 lx

(2) humidity in a room from 40% to 60%

(3) room temperature from 20°C to 24°C and

(4) noise in the room up to 60 dB (the average noise of the computer is 35 to 50 dB)

Recommendations for the amount of light that should be available for the type of work for office work or in a garment factory:

- general tasks 500 lx
- more detailed work 750 lx
- very fine work 1000 lx

Illumination values for the CAD system range between 300 lx and 600 lx.

The electrical system in the offices must also be taken into an account because of work safety (Fig. 5.10). The measures for protection against indirect and direct contact with electrical parts must be taken. Cables must be installed in such a way that they are not pressed anywhere, do not go over sharp edges or movable parts of the furniture where they could be damaged.

Figure 5.10 Electrical cables in the offices

Apparatus and devices in the offices (phone, copy machines, coffee makers, etc.) must be ergonomically designed because they contribute to productivity and user satisfaction. Therefore they must be constructed to be safe for the health and life of users (mechanical hazard, risk of electrical current, hazardous materials, radiation, and noise).

Many garment manufacturers in the world still operate in the old way with the technical and technological preparation carried out in the offices

without computers, and constructional preparation without using CAD systems. Traditional constructional preparation is a very difficult mental and physical work. Figure 5.11 shows the posture of workers in the construction of garments.

Figure 5.11 The posture of workers in the construction of garments

When cutting paper for patterns, workers often hurt the skin on their fingers because of the excessive use of scissors. This leads to the swelling of fingers. Many workers wrap the handles of the scissors with a piece of cloth/cotton to reduce the friction of the metallic handle on the muscles, resulting in fatigue.

In manual marker making, marking is done around each pattern (Fig. 5.12). Work should be organized in an easy and natural rhythm.

Figure 5.12 The position of fingers in manual marker making

5.3 Ergonomics in cutting room

In the technological process of clothes cutting, lifting, transferring and putting of textile bundles on the cutting tables or on the machine for laying of cutting layers are considered to be the most difficult physical tasks.

Lifting and carrying loads are among the most difficult works that burden the body; hence, textile materials must be transported by trolleys into the cutting room (Fig. 5.13).

Figure 5.13 Transport of textile materials into the cutting room

Spreading (fabric layering) is the process of unwinding large rolls of fabric onto long, wide tables (Fig. 5.14) in preparation for cutting each piece of a garment.

Figure 5.14 Cutting tables and overhead electrical cords

Parameters for cutting tables are as follows:

- Length – variable, depending on the size of the room and the length of the lay.
- Width – 120 cm (maximum width of fabric).
- Height – 117.3 cm for men; 108.9 cm for women.

Workers' load at certain points in the cutting room is an imminent danger of causing serious damages to the spine, which can cause permanent disability.

Inappropriate position of the body is seen through the increased fatigue ratio of the worker and more time to carry out a technological operation in the appropriate position of the body. In the standing posture, the worker's center of gravity is high and the pressure is increased, thus affecting blood circulation at the ends of extremities.

Figure 5.15 shows the work on the automatic spreading machine.

Figure 5.15 Ergonomic workplace on the automatic spreading machine

Safe operating on cutter machines requires electrical cords to be intact and the correct power switch. Electrical cords should not be conducted along the places where employees move, or, if it is not possible, the places where cables are set should be secured and marked so as not to be a threat for the employees when moving. When cutting, workers are required to wear a protective metal glove (Figs. 5.16 and 5.17).

Figure 5.16 Cutting with a protective metal glove

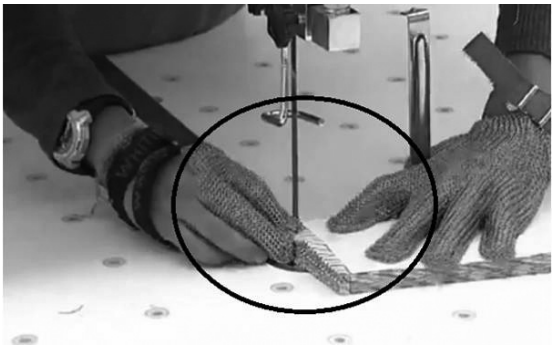

Figure 5.17 Maximal hand protection when cutting

In performing an operation, the posture applied should require minimum energy consumption. Figure 5.18 shows the incorrect posture of a worker when cutting.

Figure 5.18 Incorrect posture of a worker when cutting

Owing to the continuous use of cutting machines, workers often have headaches because of vibrations. Breathing difficulty is caused by dust and loose fibres in the cutting room, causing allergies.

Another factor that has a significant impact on health is the effect of chemicals the fabric is treated with. Some fabrics are treated with resins so that when cutting or ironing the formaldehyde, which causes many respiratory diseases, can be released, followed by various allergic reactions. The use of personal protective equipment should be made mandatory wherever threat to workers' health and safety is anticipated.

Simpler, faster, better and safer workers' performance is observed at a CAM system for cutting (Fig. 5.19).

Figure 5.19 CAM system for cutting

Workers in the cutting sections should be encouraged to use dust protectors in the form of fine-mesh cloth material worn over the face and the nose. Figure 5.20 shows workers with personal protective equipment (working cloths, dust masks, gloves, and caps).

Figure 5.20 Workers with personal protective equipment

The fusing process requires the use of machines with comfortable working conditions for operators at unheated loading stations (Fig. 5.21).

Figure 5.21 Work on a fusing machine

Separated garment components are numbered to ensure that when stitching, all the components from the same layer are stitched together. Between the cutting and sewing processes cut components may pass through other processes like printing and embroidery.

According to the production system (progressive bundle or one-piece flow system), cut components are sorted. As for production line requirement, a certain number of pieces with all components are tied together (bundling). Each bundle is marked with a bundle number, style name, size number, and quantity of pieces in that bundle. Figure 5.22 shows the tables for stacking bundles in a cutting room.

Figure 5.22 Table for bundling

5.4 Ergonomics in sewing room

Sewing involves repeated movements of the shoulder and arm, a static position of the spine and lower extremities, as well as the inclination forward while the job is done throughout the working hours.

Proper ergonomic design of each workplace, along with finding suitable methods of work with the appropriate time standards, ensures better structure of technological operations with the increased efficiency of sewing machines. Working posture at sewing machines should allow mobility of the limbs, an ergonomically favorable arrangement of working and visible zones and a stable, balanced state when performing the work process. Technological processes of sewing clothes are performed on production lines with a large number of technological operations where each technological operation does not last long and has a significant psychological, physical workload for each worker.

The material that goes through the process of work, due to its physical-mechanical characteristics, requires careful handling when taking, assembling, positioning and putting it aside. Therefore, the structure of technological operations is mostly (65%) related to the handling of materials within support-

hand technological grips. The very processing on a machine (sewing grip) is performed during the machine or machine-hand time (25%), whereas 10% of the time is used for non-production work. When designing workplace in the process of sewing it is necessary to achieve dimensional harmony of the human–machine system of inter-phase transport, with the correct physiological posture of sitting, which allows rapid and accurate movements of the motor when switching on the machine and processing the work object, a high level of coordination of movements, a correct position of the spine and good position of the head. The posture of the body of workers, the complexity of the structure of individual movements within the performance of technological operation of sewing and the level of muscular and visual control of the worker depend on the type of technological operation, the type of sewing machine, its technical equipment, machinery and the layout system of workplaces.

According to Anderson and Gaardboe (1993), *being a sewing machine operator for more than 8 years had a cumulative, permanent and deleterious effect.* Poor ergonomic conditions in combination with adverse psychological and social circumstances can cause various diseases, such as:

- Emotional symptoms – psychological tension, uncertainty, anxiety and depression.
- Psychosomatic diseases – respiratory, gastrointestinal, cardiovascular, the loss or the increase in appetite and sleep.

If the height of the table, including the sewing machine, is too low, the worker must hunch forward in order to properly view the sewing needle. In such a position it is difficult to operate the treadle. The sewing machine operators in the apparel manufacturing industry typically sit with sharp forward flexed torso, which places them at risk of musculoskeletal disorders. Prolonged sitting in unnatural postures is common and is often accompanied by seats that have no back rests (Fig. 5.23).

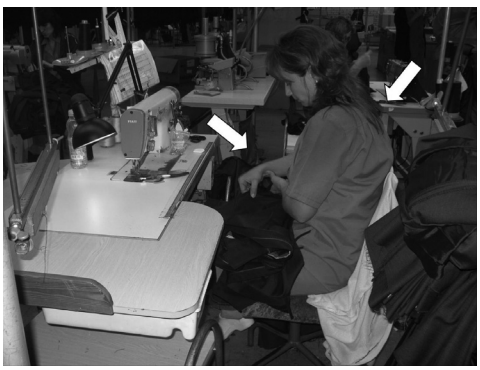

Figure 5.23 Unnatural body and hands postures

Sewing machine operators have shoulder and neck problems. Up to 30% of operators in some garment plants report symptoms of musculoskeletal disorders, such as tingling in the hands and fingers and aches and pains in the arms, shoulders and neck. Mahone (1997) noted that 70% of sewing machine operators using foot controls report back pain, 35% report persistent low back pain, 25% have suffered a compensable cumulative trauma disorder and 49% of workers experience pain in the neck. So hand sewing and trimming are stressful to all the upper limbs, stitching tasks are associated with pain in the shoulders, wrist and hands, ironing by hand is associated with elbow pain, garment assembly tasks are associated with cumulative trauma disorder of hands and wrists and foot-operated sewing associated with pain in the back.

When sewing, the following problems mainly arise:

(a) A table that is too low forces workers to hunch forward, which strains the neck, back, and shoulders. When the table is too high, workers must raise their shoulders unnaturally, which tires the neck, shoulders, and the upper back.

(b) Reaching into the distance to access, position or move material strains the shoulder and elbow joints and the back.

(c) Resting forearms or wrists on sharp edges of tables blocks circulation and pinches the nerves, increasing the risk of injury to hands and arms.

(d) Poor lighting requires workers to strain their eyes and bodies in order to position themselves to maximize illumination. It is recommended to have a minimum illumination of 1000 lx in the sewing area.

(e)Sitting or standing in awkward positions or for long periods of time is tiring and contributes to strain on legs and back.

(f) The operation of sewing machine pedals contributes to musculoskeletal disorders of the feet and legs (Fig. 5.24). The worker's foot should be able to easily operate the treadle. The angle of the knee should be slightly greater than 90º and the thighs should be horizontal.

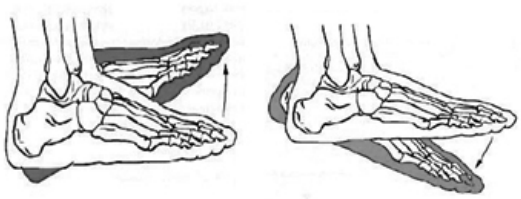

Figure 5.24 Foot movements on the pedal (flexion) when sewing

Better ergonomic design of workplaces in a sewing room requires the following:

(1) Work should be organized so as to use both hands simultaneously whenever possible.

(2) Hand should be freed from work whenever possible and serving the tools or machines done by feet (work on special sewing machines whenever possible, Fig. 5.25). A study of 132 US apparel manufacturers found that the companies that invested in ergonomic sewing equipment increased both productivity and quality.

Figure 5.25 Work on special sewing machines whenever possible

(3) To make a movement maximally economical, it is necessary to employ adequate muscle masses.

(4) Sewing workplaces are shaped assuming that the worker has good visual skills, i.e. favorable working posture, which consists of a slightly bent upper part of the back with a work line of sight that can include flexible front of the head in a comfortable posture to a maximum of 30° and an additional eye rotation of 10°. This posture allows field of vision with a viewing angle of ± 1°, which achieves high visual acuity required for the accurate management of technological operations of sewing.

(5) This is to specify the height of sitting, the height and the size of desktop machines, pedal position, distance of chairs, with the necessary sight and visual acuity and the ability to perform simultaneous movements of hands, legs and torso.

(6) The procedure of designing the workplace in a sewing room requires determining the angles of kinematic system, whereby a suitable position of the foot on the pedal of a sewing machine is at an angle of 90°–100°, while angles suitable for joints of under knee-upper knee are 90°–110°, and upper knee-torso 90°–95°. This is the way to realize an ergonomically functional and physiologically correct sitting working posture, with the proper arrangement of equipment and means of work, proper angles of vision, distances and heights of sitting.

(7) Ergonomically designed chairs contribute to the adjustability and comfort of the workstation. Sewing chairs need to be adjustable in height and have good back support. Newly ergonomically designed sewing tables have adjustable arm supports where workers can rest the forearm. Figure 5.26 shows new ergonomically designed sewing tables and the position of elbows at work.

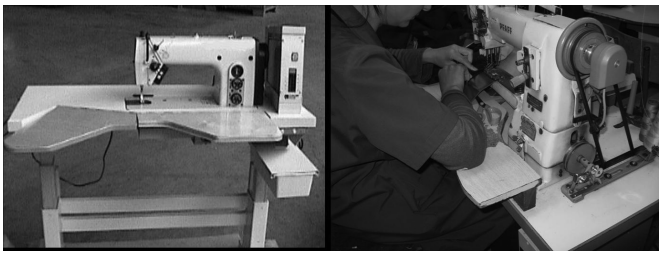

Figure 5.26 New ergonomically designed sewing tables and position of elbows at work

(8) Work surfaces that tilt 10°–15° keep materials in line of sight and reduce awkward arm, neck and trunk postures. Tilting away from the operator helps pull heavy fabric through the machine without a lot of force. Padded or rounded table edges reduce pressure on the wrists and forearms. Pressure-sensitive foot pedals allow activation with just a gentle weight shift. For standing operators, anti-fatigue mats help prevent back and lower extremity circulation problems.

(9) The movement from left to right requires a strain that is partly static (taking and passing a cutting part) and partly dynamic, and each is accompanied by a slight bending and turning of the body in the waist area. Figure 5.27 shows the areas of the reach of hand while working on an overlock sewing machine.

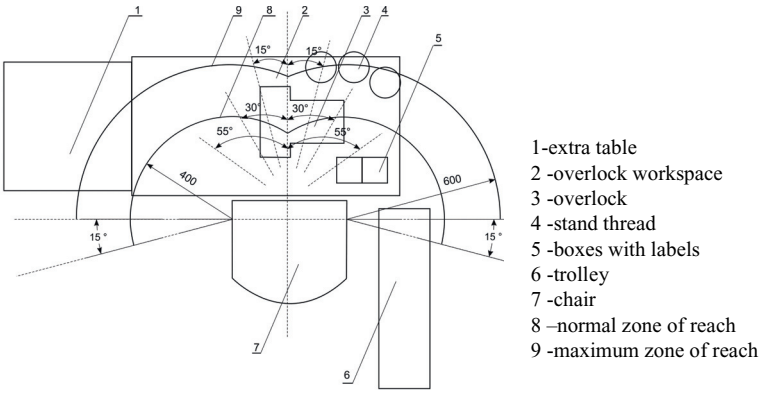

Figure 5.27 Zone of reach on the overlock sewing machine

(10) Adjustable task lights with optional magnifiers allow workers to position lights where they need them and avoid glare, reflections and shadows.

(11) Most garment factories have a combination of natural and artificial lighting. Recommendations for the amount of light that should be available for the following type of work:

- rough work and assembly: 300 lx
- medium bench and machine work: 500 lx and
- fine bench and machine work: 1000 lx

The main task of the quality control is to monitor the production and determine whether the products meet certain standards, thus preventing certain production errors. The controller should stop the wrong mode and draw the workers' attention to the quality of materials and garments produced (Fig. 5.28).

Figure 5.28 Workplace of controller in a sewing section

5.5 Ergonomics in finishing room

Finishing and pressing are two processes that have the greatest influence on the finished look of a garment. Fusing creates the foundation and pressing puts the final seal of quality on the garment. This process includes checking of garment, measurement checking, ironing, and spotting. After sewing of the garments, all pieces are checked by a quality checker to ensure that garments are being made as per buyer quality standard. Checking normally is done for visual appearance and measurements. Spotting is required to remove stain in

the pieces. In the quality section, there is a lot of stress on the eyes, leading to headache and visual discomfort (Fig. 5.29).

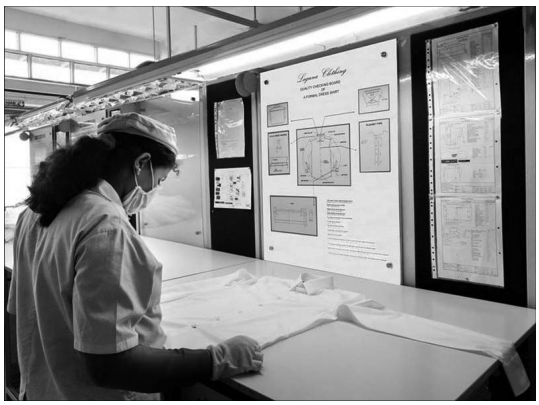

Figure 5.29 Quality section

In the finishing section the following problems arise: skin problem, visual discomfort, neural discomforts, respiratory discomfort, and hearing problem.

For the heavy processes like ironing, which has an energy consumption of 4 kcal/min, the height of the working surface should be 20 cm lower than the elbow height. When it is considered that the elbow height in standing position varies between 99 and 113 cm (+2.5 cm shoe height), the height of the ironing table can be adjustable between 82 and 86 cm. The height of the units around the area that will be used for storing purposes should not exceed 173.5 + 2.5 cm and should not be lower than 70.5 + 2.5 cm in order to prevent bending. (Fig. 5.30)

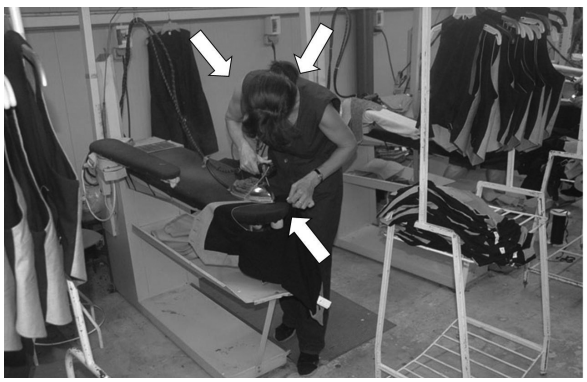

Figure 5.30 Bending on the working surface

Work should be organized so as to use both hands simultaneously whenever possible (Fig. 5.31).

Figure 5.31 Work on press

In workplaces, air needs to be changed between 8 and 12 times per hour and that there should be at least 10 cubic meters of air per worker.

Washing is special finishing to the garments. For light colours garment, washing is carried out to remove dirt and stains. In the washing section, the workers are exposed to chemicals, particularly bleaches and detergents, and are not aware of their health hazards, leading to skin allergies.

The finishing of jeans (prewashed and/or stone-washed, bleaching, batching, crushing, dirty washing, sandblasting denim, painting) with poor equipment and inadequate working conditions is a very dangerous process for the health of workers.

Sandblasting denim is a process used to make denim jeans appear well worn and used. The process involves the use of a machine to produce a pressurized stream of sand onto the surface of a garment. Depending on the amount of silica found in the sand being used, the process can create large amounts of silica dust. When large quantities of silica particles are inhaled they can begin to cause lung problems, including the development of silicosis. Silicosis is a lung disease that causes cough, shortness of breath and weight loss and, depending on the amount of damage done, eventual death. Therefore, it is necessary to use protective equipment as shown in Fig. 5.32.

Figure 5.32 Worker uses sandblasting equipment

New ways of finishing denim garments require special attention and maximum safety of workers by using protective equipment. Figure 5.33 shows paint spatters with a protective mask on a worker's face, and Fig. 5.34 shows dyeing of jeans trousers without the protective equipment (no gloves and masks).

Figure 5.33 Paint spatters

Figure 5.34 Painting without the protective equipment

Packing clothes is the final process in garment manufacturing. Each pressed garment is then folded with tissue or cardboard. Folding varies from product to product and also from buyer to buyer. Hang tags, special tags and price stickers are attached with plastic Kimble or threads. Folded and tagged garments are then packed into poly bags. During packing garments are randomly checked by internal quality controllers to ensure that only quality goods are being packed (Fig. 5.35).

Figure 5.35 Packing garments

Figure 5.36 shows the control and additional ironing of each packaged garment.

Figure 5.36 Final control and ironing

5.6 Ergonomics workplaces in garment warehouse and distribution

The garments should be stored in a cool, dry place. Different types of garments should have different conditions of storage and packaging. The storage area should be as clean as possible so that dust and dirt, the acids present in atmospheric pollution, as well as the presence of moths or other pests do not cause garments to deteriorate during storage.

When an over garment is transported by trucks, it is hung, whereas shirts, underwear, sportswear, etc. are packed in cardboard boxes (Fig. 5.37).

Figure 5.37 Packing clothes in cardboard boxes or trucks

Workers in the warehouse of readymade garments have the same problems as in the raw materials warehouse. Transporting clothes on hangers or in a box is hard work. High force or sustained forces can be required to move trolleys, especially if regular maintenance of wheels, castors and bearings is not undertaken. Poor handle orientation and design can contribute to hazardous manual handling.

Figure 5.38 shows the warehouse with an overhead conveyor, which provides healthier and safer work to employees in the warehouse.

Figure 5.38 Storage with overhead conveyor

During transport, clothes must be under a certain temperature, humidity and ventilation, i.e. under certain climatic conditions. Some microorganisms and mould may occur under the influence of high temperature, and there is a change in physical features of yarn that exceed the clothes created (the loss in strength, elasticity, electrical conductivity, etc.). Clothing made of natural fibre is more sensitive than clothes made of synthetic fibres. Low temperatures reduce the volume of fibres. Convenient transport clothes temperature is from 10° to 30°C, while the optimal temperature is 20° ± 5°C.

Optimal relative humidity for transportation of clothing is from 45% to 70%. The amount of moisture allowed for clothing made from wool fibres is from 8% to 12%, and for cotton fibres from 7.85% to 8.5%.

If garment manufacturers have their own trucks they must take the ergonomics of vehicles into account. The construction of vehicles should be adapted to most drivers and allow individual adjusting considering the size of a driver in order to provide:

(1) Visibility and clarity of the vehicle

(2) Exceeding the comfort

(3) Comfortable seating

(4) Easier driving

(5) Better approach and use of controls and devices

(6) Better sound and heat insulation

(7) Reduced impact of vibration

(8) Reduced fatigue of the driver

The most important role in providing the ergonomics of a vehicle is its seat (Fig. 5.39).

Figure 5.39 Ergonomics of vehicle

5.7 Ergonomics workplaces in the clothing stores

In addition to active sales, the task of a seller is to take care of the products, their receipt, storage, maintenance, classification of goods during the receipt, as well as the presentation of clothes. In smaller shops sellers are also the cashiers, so that they are in charge of the payments. Therefore, they are responsible for all the work at the cash register from the receipt at the beginning of the work to the discharge at the end of the day.

Conditions of work of a seller depend on the size and type of the store in which they work. They usually work in clean, bright rooms (minimum 20 lx per $m^{2)}$ (Fig. 5.40).

Figure 5.40 Clean and lighted retail space

Sometimes the sellers do their job in several shifts, often on weekends. Sellers perform their job while standing or walking, so they often have problems with pain in the legs and spine. Lifting and carrying is a common cause of injury among workers in stores.

The aggressiveness of customers is a usual thing in the retail sector. The attacks can occur when the staff is faced with thefts and raids, troubled people and angry customers. Being aggressive toward staff includes attacks, threats and verbal harassment, which can scare the sellers and cause stress.

5.8 Ergonomics maintenance workplaces

All the rooms in the factory including warehouses, offices and plants should be cleaned daily and machinery and equipment maintained. Workers on these jobs are faced with hard physical labor.

When cleaning it is necessary to use a cleaning kit with long handles and clean when kneeling. It is important that the spine is straight, without bending at the waist.

Kneeling, squatting and bent positions are extremely inappropriate postures and should be avoided or at least reduced to a minimum, and when they are inevitable they should be limited in duration. Of all these postures, the most favorable physiological one is kneeling, but the pressure of the floor often leads to knee pain. When squatting there is a high static muscle strain on hips and legs, and bowed posture heavily burdens the back muscles (in addition to that, deeply bowed posture has 60% higher energy consumption than when sitting).

Tasks such as lifting and moving machinery and tools, working in unnatural postures, working with tools difficult to handle and rapid and repetitive movements can cause us pain. In some circumstances, this can lead to back injuries, and injuries in muscles, joints, tendons and nerves.

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