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ANALYSIS OF THE COMPLIANCE WITH THE REQUIREMENTS OF ENVIRONMENTAL DIRECTIVES IN METALLURGICAL PROCESSING ACTIVITIES

BY

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Abstract: The paper makes an analysis of the requirements of environmental directives and of the implementation of these requirements in hot working industry. By analyzing the results obtained during experimental measurements, certain practical measures are necessary in order to comply with the limits ELV established by the directives. The focus is on defining the guidelines for the verification of the compliance with the environmental requirements of the European Directives, especially in metallurgical processing activities.

The work procedure aims to obtain certain results which can be compared with emission limit values or discharge limit values established by the directive 2010/75/EU on integrated pollution prevention and control. If the limit values are exceeded, certain improvement measures are necessary in order to comply with the required levels.

Keywords: directive, analysis, evacuation limit values.

1. Introduction

Sustainable development requires restrictions in terms of environmental protection (Massimo, 2005; Wenzel, 1995). The technologies which have activities with environmental impact should comply with the ELV limits

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(emission limit values). In metallurgy and machine building industry the main activities with environmental impact are: developing semi-finished products; casting; preparing surfaces; anti-deposit treatment; pulsed electrical discharge; post deposit treatment.

These activities should strictly comply with the requirements of the environmental European directives. The directives referring to industrial emissions were integrated in Directive 2008/1/EC. This directive merged with Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). The legislation was harmonized by the development of the Law no. 273/2013 (Baciu, 2015; Corăbieru *et al.*, 2006).

2. Aspects Regarding the Requirements of Environmental Directives

The requirements of the environmental European directive integrated in Directive 2008/1/EC and merged with Directive 2010/75/EU aim to reduce water pollution by hazardous substances and to reduce emissions of volatile organic compounds (Corăbieru *et al.*, 2006).

In order to reduce water pollution by hazardous substances, the following aspects are targeted:

a) reducing heavy metal discharges;

b) reducing the amount of pesticide discharges (HCH, indane, DDT, drins);

c) reducing the amount of chlorinated solvents discharged into wastewaters (carbon tetrachloride, chloroform, ethylene chloride, trichloro-ethylene, pentachloroethylene);

d) reducing impregnating agents for wood in water (pentachlorophenol);

e) reducing discharges of chlorinated byproducts into sewers;

f) reducing discharges of priority hazardous substances (Co, Cu, Ba, Be, Mo, Ni, Se, Ag, Ta, Sn, Ti, U, V, dichloroethane, dichlorobenzene, benzene, biphenyls, dimethyl, polyaromatic hydrocarbons, vinyl chloride).

The main technological activities and processes in metal parts industry subject to integrated pollution prevention and control are presented in Table 1.

Tabele 1
Technology Activities Impacting on Water Pollution

Mercury	Hg	● manufacture of batteries
		● steel casting
Cadmium	Cd	● manufacture of batteries
		● galvanization
Hexachlorobenzene	HCB	● industrial rubber processing
1,2 dichloroethane	EDC	● degreasing metals coating activity
Trichloroethylene	TRI	● metal degreasing in coatings
Perchlorethylene	PER	● degreasing metal and surfaces

In accordance with the requirements of the European directives, the solid and gaseous pollutants in the working environment within the departments of metal parts manufacturing should not exceed the levels required by the emission limit values (Bejinariu, 2015; Corăbieru, 2015b). In Fig. 1 we can find emission limit values for the main solid and gaseous pollutants in the working environment within the departments of metal parts manufacturing.

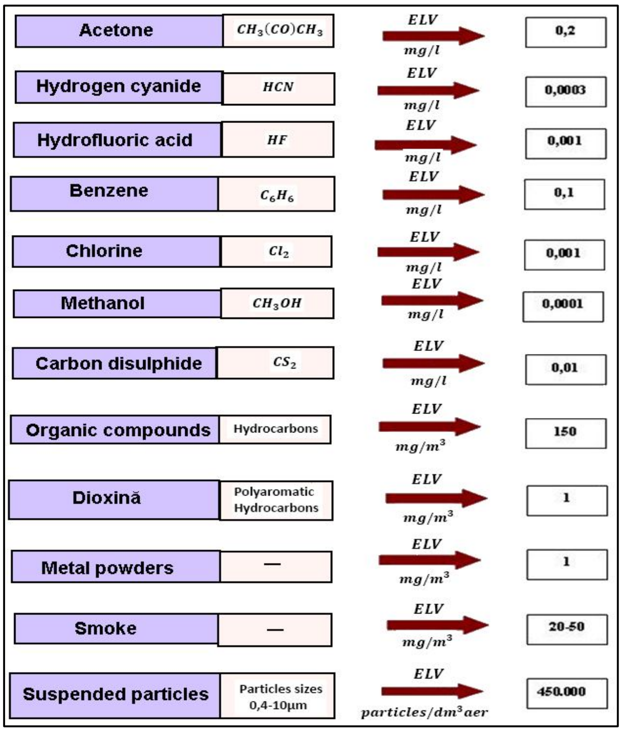

Fig. 1 – Solid and gaseous pollutants in the working environment within the departments of metal parts manufacturing.

The emission limit values tend to be calculated in several ways, namely (Corăbieru, 2015a):

- grams of solvent emitted /m^2 product surface;
- kilograms of solvent emitted / unit of product;
- milligrams of solvent emitted /dm^3 air.

3. The Work Equipment

The work equipment consists of the following experimental devices:

1° *Rotary evaporator* – has the role to concentrate the sample extract at a certain temperature and a determined pressure, obtaining the final sample which will be submitted for analysis to a gas chromatograph. The final sample is a sample piece of up to 2 ml of the sample. The rotary evaporator evaporates any unwanted traces of organic compounds present in the organic solvent.

2º *Gas chromatograph* - Konik HRGC 4000 B: determines the organic compounds in the aqueous solutions which can be formed or made into aqueous solutions from samples taken from water, air or soil.

3º *Atomic absorption spectrometer GBC 932 AB PLUS*, is used for the analysis of metal ions in the solution (for solid materials, a preliminary mineralization is carried out). Each metal element forms an atomic absorption spectrum, at a characteristic wavelength.

4º *Spectrophotometer GBC Cintra 5 UV-VIS*, is used to determine the concentrations of anions and cations (cyanide, phosphates, nitrates, sulfites, hexavalent chromium) in aqueous solutions, based on the staining intensity of the complex formed between the element to be analyzed and a specific organic compound. The used technique is molecular absorption spectrometry which allows us to measure absorption at a wavelength specific to each formed complex.

4. The work procedure

The work procedure used for the experimental determinations includes the following stages:

- we collect for analysis samples of 1 liter of process wastewater, discharged into the production department sewers;
- the collected water is extracted into the organic solvent (hexane) by repeated extractions (of 3-4 times with rates of 20-25 ml/hexane). Hexane serves as blotting paper in order to extract the organic part from one liter of process wastewater;
- all the extracts are collected and brought into contact with an amount of Na_2SO_4 (solid) → it absorbs the traces of water remaining in the collected extract;
- the resulted extract is concentrated by a rotary evaporator at a certain temperature and a determined pressure → finally, we obtain sample pieces of 2 ml (it evaporates any unwanted traces of organic compounds present in the organic solvent);
- the final sample is a sample piece of 2 ml which is subject to gas chromatograph analysis;
- before analyzing the sample pieces of 2 ml, we plot the calibration curve of the device, which is obtained due to certain standard solutions of known concentration (usually, 5 standard solid solutions are prepared);

- the gas chromatograph has an autosampler (the device automatically introduces the sample for analysis);
- the sample taken by the autosampler is injected into a detector at 270°C;
- from the detector, the sample goes through a capillary chromatographic column of almost 30 m;
- depending on the affinity of the organic compounds on the chromatographic column, different compounds will be absorbed (on the surface) at different retention times, usually starting from low molecular weights and ending with high molecular weights;
- the answer of the chromatographic column is sent to the device software and thus we will obtain a chromatogram which will include all the organic compounds in the corresponding sample;
- the result is expressed in nanograms/liter and it is compared with the maximum limits permitted for the organic compounds present in process wastewater, discharged in the sewers.

5. Results. Discussions

Following the interpretation of the chromatogram for the sample collected from the process wastewater of the production department, we determined the pesticides and trihalomethanes.

Pesticides total = 0.829 μg/l

Trihalomethanes total = 0.253 μg/l

After analysis on atomic absorption spectrometer GBC 932 AB PLUS were obtained the following results:

Tabele 2

The Content of Heavy Metals in From Sampling at the Technological Water

No. crt.	Sample	Element, [μg/l]				
		Pb	*Zn*	*Cu*	*Ni*	*Cd*
1	*P1*	1000	810	1200	100	162,00
2	*P2*	980	810	1180	78	96,50
3	*P3*	960	800	1100	46	95,80
4	*P4*	950	800	1000	47	96.50
5	*P5*	940	805	980	46	94,90
	Media	*966*	*805*	*1092*	*63,40*	*109,14*

The interpretation of the results by comparing them with the discharge limit values highlights the exceeded emission limit values for lead, copper, zinc:

- Pb 966 μg/l > ELV = 200 μg/l;
- Cu 1092 μg/l > ELV = 100 μg/l;
- Zn 805 μg/l > ELV = 500 μg/l.

Certain measures are necessary for the improvement of the manufacturing technologies, in order to comply with the levels required by the emission limit values. To this end, the focus will be on the following aspects:

- equipments and technologies for identifying and preventing pollution;
- provision of real time multi-detection systems and appropriate methodologies for recording, analysis and control;
- separation technologies for reusable and recyclable materials;
- methods for storing, handling and disposing waste;
- removal of hazardous substances;
- including the principle of total quality - European concept (own laboratories accreditation, staff certification).

5. Conclusions

According to the determinations, the following conclusions are outlined:

a) the process for reducing the noxious and polluting residues begins with designing the metal parts, as follows: choosing the material, depending on the technical and economic considerations; choosing the hardening process;

b) the main measures for compliance with the ELV are: cleaning the surfaces of the metal parts before quenching in oil; permanently controlling the level of toxic gases; cleaning the surfaces of the metal parts after quenching; washing down the heat-treated metal parts; permanent cooling of the quenching oil; controlling fuel combustion; eliminating gas leaks; using fans for ventilation and drying; providing filters for collecting metal suspensions; permanently controlling the air by means of a particle analyzer; providing desulphurization and nitrification plants;

c) viable solutions for the EU: upgrading the existing process flows in order to comply with the environmental European directives, promoting environmental technologies, developing hybrid parts manufacturing (combining the advantages of two power sources);

d) the tendency will be to replace the EC directives with the UNECE regulations (United Nations Economic Commission for Europe).

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ANALIZA RESPECTĂRII CERINȚELOR DIRECTIVELOR DE MEDIU ÎN CADRUL ACTIVITĂȚILOR DE PRELUCRĂRI METALURGICE

(Rezumat)

Se realizează o analiză a cerințelor directivelor de mediu şi al implementării acestor cerințe în activitatea industrială de prelucrări la cald. Prin analiza rezultatelor obținute în cadrul măsurătorilor experimentale se impun măsuri practice de încadrare în limitele VLE stabilite în cadrul directivelor. Se pune accent pe trasarea liniilor de verificare a respectării cerințelor Directivelor Europene de mediu în special în cadrul activităților de prelucrări metalurgice.

Procedura de lucru urmăreşte obținerea unor rezultate care pot fi comparate cu valorile limită de emisie sau cu valorile limită de evacuare trasate de directiva 2010/75/UE cu privire la prevenirea şi controlul integrat al poluării. În cazul depăşirii valorilor limită se impun măsuri de îmbunătățire în vederea încadrării în nivelurile impuse.

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SAFETY – THE 6th S OF LEAN MANUFACTURING

BY

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Abstract: Realizing a Lean environment in a workplace could be a success only if the employees are motivated to involve and if there is a good management. The 5S method (Sort, Set in order, Sweep, Standardize, Sustain) is the basis of an effective Lean implementation, being one of the most effective tools of Lean manufacturing. The development of Lean Manufacturing imposed, in the last years, the change of 5S to 6S (5S+Safety). In this paper, the authors described the Lean Manufacturing system and why Safety is a must in every one of the 5S steps. It was described that 6S is the foundation for all improvement programs: waste reduction, cleaner and safer work environment, reduction in non-value added time, effective work and visual workplace vision.

Keywords: safety; 5S; 6S; Lean Manufacturing.

1. Introduction

In the most basic definition, Lean Manufacturing is the systematic elimination of waste by focusing on production costs, worker involvement and product quality and delivery.

In the 1950s, Taiichi Ohno, the one that developed the Toyota “just-in-time” Production System, created the modern intellectual and cultural environment for Lean Manufacturing and waste elimination. He defined waste as “any human activity which absorbs resources but creates no value.”

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(U.S. EPA Contract # 68W50012, 2000). Largely, Lean Manufacturing represents the fundamental change from traditional “batch and queue” mass production to production systems based on product aligned “single-piece flow, pull production.” Whereas “batch and queue” involves mass-production of large inventories of products in advance based on potential or predicted customer demands, a “single-piece flow” system rearranges production activities in a way that processing steps of different types are conducted immediately adjacent to each other in a continuous and single piece flow (U.S. EPA Contract # 68W50012, 2000). The purpose is that, a shift in demand can be accommodated immediately, without the loss of inventory stockpiles associated with traditional batch-and-queue manufacturing.

Lean Manufacturing, at his apparition, was embraced by the Japanese manufacturers as their biggest hope in recovering effectively from a war torn economy in the 1950's. In present, the companies embrace Lean Manufacturing for three fundamental reasons: 1) the highly competitive, globalized market of today requires that the companies lower their production costs to increase capacities and/or decrease prices through the elimination of all non-value added aspects of the enterprise; 2) meeting rapidly changing customer “just-in-time” demands through rapid product mix changes and increases in manufacturing velocity; 3) goods must be of high and consistent quality (U.S. EPA Contract # 68W50012, 2000).

2. 5S - Base of Lean Manufacturing

The five primary elements that must be taken into consideration when applying the improvement by organizing the contents of the work using Lean Manufacturing tools are: manufacturing flow, organization, process control, metrics and logistics (Feld, 2003). These elements represent the variety of aspects needed to sustain a successful Lean Manufacturing implementation program. As a result, the Lean Manufacturing program may be, mistakenly, viewed as a failure for applying 5S within a business in the early stages of implementation (Cunningham & Real Numbly, 2003). The more successful the implementation is, the more rapid the reduction rate of waste (David & Kumar, 2006).

The approach of Lean Manufacturing is in direct opposition to traditional manufacturing approaches that are characterized by economic order quantities, high capacity utilization and high inventory (Feld, 2003). It is necessary to base on the five pillars of 5S in Lean Manufacturing plus a separate pillar that provide the employees with answers to these questions so that they become more engaged in the process.

Lean identifies the seven forms of waste/muda and the way they affect the safety: overproduction (overburdening of employees), unnecessary transportation (and actions of employees), inventory, motion and efforts, defects (producing defective goods, unused creativity), over-processing, waiting (Anvari *et al.*, 2011).

It also give solving, by applying tools and techniques to optimize the systems: workplace organization (5S), Kanban, Just-In-Time (JIT), Total Quality Management (TQM), Total Preventive Maintenance (TPM), standardization of work, point-of-use-storage etc.) (Gapp *et al.*, 2008). These wastes are commonly referred to as non-valued activities and to Lean practitioners they are known as the Eight Wastes. Taiichi Ohno (co-developer of LM) suggests that these account for up to 95% of all costs in non-LM environments.

After identification of any of the seven forms a waste, it is necessary to have a repeatable method for eliminating waste. That process or method is known as 5S.

5-S refers to the first letters of five words or phrases used to describe a repeatable process used to identify and eliminate all forms of waste. The five S's are Japanese terms, loosely translated as:

a) Seiri/Sort – remove unneeded materials from the workplace, eliminate distractions and confusion;

b) Seiton/Set-in-order (straighten) - make it easy to visually find things that are needed including parts, tools, information, aso;

c) Seiso/Shine – introduce a regular system for cleaning the work area, also focusing on inspecting the workplace for equipment needing preventive maintenance;

d) Seiketsu/Standardize – establish methods to maintain cleanliness;

e) Shitsuke/Sustain (self-discipline) – implement methods to sustain the process, including continuous improvements.

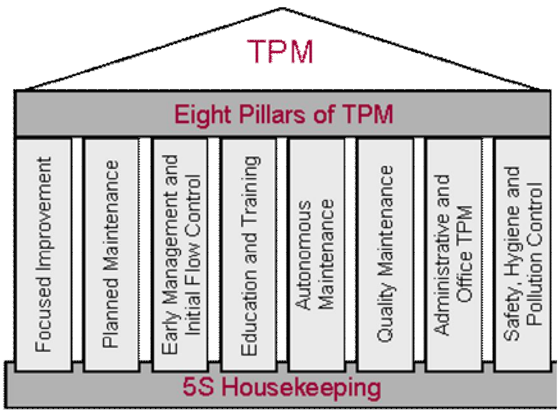

Fig. 1 – TPM (Total Preventive Maintenance) House.

Many consider that 5S is the method to obtain neat, clean, well-organized work places. Even if the typical result of 5S implementation is an organized, visually attractive workplace, the real purpose of 5S is to impose a fundamental understanding of how to identify and eliminate waste. As it can be seen in Fig. 1, 5S is at the base of all actions needed to implement and maintain a lean system.

3. Introducing the 6th S – Safety

Safety and lean should to be considered concurrently rather than separately. In many cases a common optimum can be developed. The challenge for a good management is to develop a work environment where safety and lean are addressed concurrently to yield the best throughput at lowest risk and waste (Main *et al*.,2009).

By organizing a work area and eliminating waste, safety is automatically improved. Standardizing the approach in a work area – using tool shadow boards, for example – not only improves the efficiency of an operation, but also allows the employee to utilize the proper tool for the job. How often does an operator spend five minutes searching for a specific wrench, only to find the wrong one, incorrectly adjust a machine and cut his hand on the machine frame?

Fig. 2 – Definition of the 6S elements (Leff, 2011).

6S (5S + 1S = Safety) is a method used to create and maintain a clean, orderly and safe work environment. 6S is based on the five pillars of 5S in LM, plus a separate pillar for safety (see Fig. 2) (Anvari *et al*., 2011).

The first five of these elements were taken from the Toyota Management System (TMS) but the sixth 'S' was added by Universal Coordinated Time to emphasize safety in the workplace (Schmidt, 2007). Besides, 6S is often the first method companies implement in their Lean journey because it serves as the foundation of future continual improvement effort (EPA, 5-9-2008).

This system allows workers to be able to know and find tools easily, file the tasks conveniently and save time spent on looking for things. The six pillars work together to support improvement efforts in a company. They help reduce defects, make accidents less likely, reduce costs and increase productivity. Also, 6S sustain a culture of continual improvement (as the base of the PDCA cycle: Plan-Do-Check-Act) and employee engagement that is essential for successful implementation of Lean.

Moreover, 6S often makes it easier to implement other Lean methods such as cellular manufacturing, one-piece flow and JIT (just-in-time) production. Finally, the visual impact of a 6S event makes the improvement and this creates a real sense of achievement and pride that can form the beginning of a more significant cultural transition (Roll, 2008).

As a consequence, 6S is a tool of Lean Manufacturing whose value is readily grasped and the concept of "a place for everything and everything is in its place” is easily understood. Also, another great quality of 6S is that it is doubly enabling for employees: it enables people to be free of aggravations that derange their work and it is a positive way to involve people in improving their own work settings (Roll, 2008).

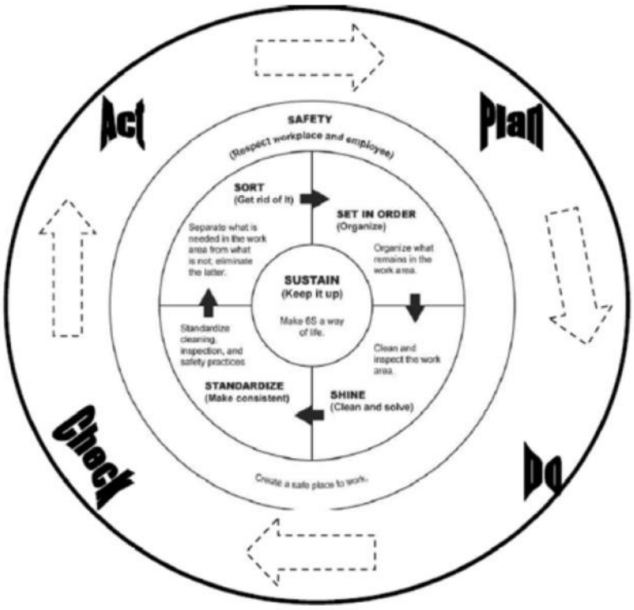

Fig. 2 – Combination of the Six Pillars of 6S and PDCA Cycle (Main et al.,2009).

4. Conclusions

As presented above, the Lean principles relate directly to safety. Every Lean implementation plan is specific for the environment that will be improved and should be tailored to fit individual company operations. By focusing on the seven types of waste, implementing a 6S process, improving ergonomics and optimizing process flow, safety improvements will follow closely behind.

The 6S process simplifies the work environment, reduces waste and non- value activities while improving quality efficiency and safety. 6S helps to get production staff involved in identifying needs and developing safe work procedures as part of the work instructions process.

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SECURITATEA LOCULUI DE MUNCĂ – AL 6-LEA S DIN LEAN MANUFACTURING

(Rezumat)

Realizarea unui mediu de lucru *lean* într-un loc de muncă poate deveni un succes numai dacă angajații sunt motivați să se implice și au parte de un bun management. Metoda 5S (Sort, Set in order, Sweep, Standardize, Sustain) reprezintă baza unei implementări efective a sistemului Lean, fiind una dintre cele mai eficiente metode a Lean Manufacturing. Dezvoltarea acestei filosofii a impus, în ultimii ani, trecerea de la 5S la 6S (5S + Securitatea locului de muncă). În acest articol, autorii descriu sistemul Lean Manufacturing și motivul pentru care Securitatea este necesară în realizarea fiecăruia dintre cei 5S. A fost prezentat faptul că 6S este elemental de bază al oricărui program de îmbunătățire: reducerea pierderilor, mediu de lucru mai curat și mai sigur, reducerea timpului adăugat.

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PERSONAL PROTECTIVE EQUIPMENT AND OCCUPATIONAL STRESS

BY

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Abstract: Legislation and technical regulations on the design, manufacture and use of personal protective equipment aim at providing the worker's safety and health during work, so they focus mostly on the technical performance of the personal protective equipment design parameters and less on the equipment as a stress factor if not selected and used appropriately, although one of the basic requirements taken into account refers to comfort and efficiency during wearing. Consequently, lately there has been a constant concern to correlate the protection characteristics with those of comfort during use, as in certain circumstances it can be an important factor against work stress.

The aim of this paper is to present the main stress factors that can occur when designing or using the personal protective equipment, as well as solutions to be adopted in order to control stress at work with the help of the personal protective equipment.

Keywords: personal protective equipment; comfort; efficiency; stress; risk level.

1. Introduction

The personal protective equipment has to meet the essential safety and health requirements applicable to the specific type of product, specified in GD

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(Government Decision) no. *115*/2004 with its further completions and modifications in order to be placed on the market and used to fulfill its basic function that is to provide the safety and health during productive work. Such statement eventually applies to specific requirements to provide user's safety and protection against risks caused by the presence of chemicals in the work environment, protection against thermal or fire risks, etc. All personal protective equipment shall meet the essential general safety and health requirements, specified in section 1 of annex 2, respectively, of GD *115*/2004. The requirements specify that the personal protective equipment shall be designed and manufactured to provide the necessary level of protection for its meant area of use and not result in a dangerous factor for the user's health.

The present paper actually deals with the way in which the personal protective equipment meets the essential safety and health requirements "1.2. Innocuousness of PPE" and "1.3. Comfort and efficiency", meaning that each personal equipment must:

a) be appropriate for the implied risks and not lead to an increased risk;

b) be appropriate for the existing working environment;

c) take into account the ergonomic requirements and the worker's health state;

d) fit correctly the wearer after all necessary adjustments.

Taking into consideration such principles related to personal protective equipment the paper aims at identifying why the personal protective equipment can be a stress factor or a factor to control occupational stress. Further on, it is important for those involved in the manufacturing and selecting process to, besides the performance levels of effective protection, consider aspects related to:

- thermal state and underwear microclimate, especially for the protection clothing, according to the characteristics of the working environment where is to be used, as well as the energetic consumption and effort needed to develop work;
- construction design that has to provide dimensional correspondence with the wearer size and degree of freedom to allow the technological movements at the work place;
- stability of product at the environment factors and during maintenance processes, as well as the weight of the personal protective equipment and its period of use;
- rigidity of joints and their strength to strains during the work process;
- artistic design as for the composition and colour of the pattern (as both influencing factors of psycho-motor parameters and improving technical and organization indicators of work discipline and productivity).

2. **Personal Protective Equipment and its Induced Stress**

The design and manufacturing of personal protective equipment has gone beyond the stage of making performing models which provide the protection parameters for different types of protection to the stage in which more and more researchers and specialists in the area of personal protective equipment are preoccupied with studying different effects on users when wearing a PPE model, as studies have proved that there is a significant percentage of refuse to wear PPE, especially on the criterion of "discomfort". An example would be a study carried out in a car factory showing that 96.2% of employees use one or a combination of PPE, and they appreciate the comfort in wearing as it follows:

a) 8% consider that respiratory protection equipment is comfortable;

b) 30% consider that the respiratory protection equipment is tolerable;

c) 62% consider that the respiratory protection equipment is uncomfortable;

d) between 32% and 52% consider that the personal protection equipment (other than the respiratory protection equipment) is comfortable and 30% that is acceptable/tolerable.

As for types of protective equipment the percentage referring to comfort sensation during wearing is the following:

- 52% protective clothing (overalls, combination suits or aprons);
- 51% goggles;
- 42% rubber protective gloves;
- 36% earplugs.

The main stress factors mentioned by users that are the object of ample studies on PPE use are:

2.1. Heat, thermal control of body temperature during the use of respiratory protective devices (Honings, 2000). The study mentions that whenever using the respiratory protective devices the heat excess generated by the human metabolism and eliminated by nasal and oral respiration, together with the heat transfer of the environment (*e.g.* radiant heat) can develop a stress during the use of respiratory protective masks. The study takes into consideration various types of respiratory protective masks (full masks, semi masks, etc.) of various materials (rubber, plastic, special materials) with or without filtering devices. The most frequent complaint about the use of respiratory protective masks refers to the discomfort due to accumulation of facial heat that, through sweating, leads to irritations that with time can result in local dermatitis which is difficult to cure.

2.2. Heat and work in hot environment or in the presence of risks determined by heat and fire. This is a major risk factor taken into account especially for the protective clothing (Kinney & Wiruth, 1976), especially when choosing appropriately the protective clothes used in open air at temperatures over 30^{o}C in the presence of solar radiations or in hot work environments (metallurgy, welding, food industry, etc.) or in firefighting operations. Choosing and using the protective equipment shall correlate the intrinsic characteristics of materials related to comfort parameters (air permeability, water vapour permeability, resistance to evaporation) to the level of protection that needs to be provided against different forms of heat (of convection, radiation or contact). For example, the Fig. 1 shows the variation of the thermal transfer index of convection heat to various materials according to air permeability.

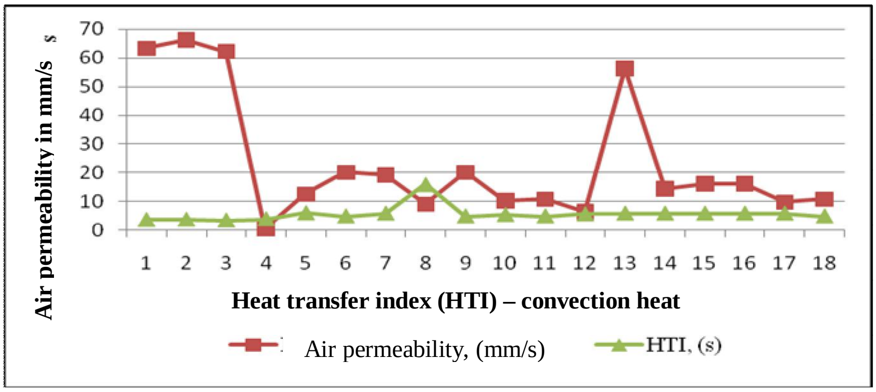

Fig. 1 – Variation of heat transfer index HTI (convection heat) according to air permeability.

Ample studies developed for protective clothes used in hot environments and for firefighters show that, if not taken into account the physiological factors of the materials used at manufacturing this type of clothing (at least air permeability and evaporation resistance) the stress can be major during use due to several effects on the user's health, namely:

a) thermal stress caused by body overheating and bringing over tiredness, excess sweat, nausea, headaches, dizziness, cricks, etc. Such symptoms due to heat can be the first signs of severe, sometimes even fatal health disorders, as dehydrations or strokes caused by heat;

b) scalding or serious skin injury due to the fact that the interface between the user's skin and clothing is partially permeable or even impermeable and accumulates water vapours from sweating that can reach very high temperatures caused by heat and induce user's scalding or skin injuries;.

2.3. Stress can be induced by the use of personal protective equipment against chemical risks (clothing, goggles, gloves) as such types of equipment are leak-proof to chemicals. In this case (Moraru & Băbuț, 2010) wearing the personal protective equipment affects the thermal regulation system of the human body, and can cause cardiovascular stress and dehydration as direct effect of the increase in heat temperature. Thus, in accordance with the type of personal protective equipment used and the level of protection that needs to be provided various measures must be adopted to prevent stress, from artificial ventilation systems that maintain constant temperature and humidity within the equipment to specified duration of use and breaks that need be made to restore the thermal balance.

There are numerous examples of studies made on the use of personal protective equipment and correlation of protection performance parameters with the requirements on product innocuousness and requirements of comfort and efficiency so that stress and especially refuse of wearing are avoided. Such facts must not lead to the idea that the personal protective equipment is a causing factor of stress during work, but in many cases it is the only solution to prevent the risk of accidents or occupational diseases and its choice and use based on correct principles can result in beneficial effects on the psychical state of workers and work productivity.

3. Use of Personal Protective Equipment to Control Stress

As the materials of personal protection equipment are continuously improving their performances the users impose new requirements that must ensure:

a) technical characteristics according to the protection requirements against cumulated actions of risks in the work environment according to level, intensity and exposure time;

b) comfort characteristics that maintain the user's health state and his psycho-physiological and motor characteristics, that is, the way in which the user can make the movements needed in the work process, as well as their precision and coordination;

c) a reasonable life duration, taking into account that in most work places the main risks (heat and/or fire, chemicals, biological risks, etc.) are associated with mechanical risks (abrasion, crushing, penetration, cutting) that lead to rapid wear of the personal protective equipment.

To be accepted and actually worn, the personal protective equipment has to demonstrate its effectiveness in the real conditions of the work place and also provide the necessary comfort for the user in the specific environment it is used in, that is to meet both the requirements related to the risk level for which the protection is needed and the requirements providing the comfort and hygiene qualities necessary to ensure and protect the user's health.

For an optimum protection, it is important for those involved in the manufacture and selection of personal protective equipment to have in view, besides the performance levels of effective protection, aspects referring to:

- thermal state and underwear climate related to the characteristics of the work environment where it is to be used and also the energetic consumption related to the effort needed to develop the work activity;
- constructive design providing dimension correspondence with the wearer's size and degree of freedom needed for the technological movements at the work place;
- product stability at the environment agents and during the maintenance processes, as well as the weight of the personal protective equipment and its duration in use;
- rigidity of joints and their strength at strains during the work process;
- artistic design as model composition and characteristics (on the one hand as influence factors of psycho-motor parameters, and on the other hand, as indicators of technical and organization improvement of work discipline and productivity).

After many years in which the colour of the personal protective equipment was chosen in toneless colours to be dirty resistant, today there is a true revolution in the usage of PPE, the selection being based on:

- necessity to represent the brand company, both for advertising the product or services provided by the company (the majority of oil extraction and processing companies use clothing of orange or combination of orange and blue colours, etc.) and making the difference between workers of similar companies (for example Coca-Cola company uses the red colour for the bottling and delivering section in all zones of the world and Pepsi Cola company uses blue);
- differentiation of personnel having special duties so that they can develop their activity in appropriate conditions (for example the rescue or intervention teams);
- necessity to signal the presence of workers to avoid accidents (for example workers working on public roads, rescue teams, etc.);
- necessity to implement the order and discipline rules within the company to prevent unwanted events: work accidents, product contamination, ill health and others.

Moreover, besides the above mentioned, when choosing a colour especially for the protective clothing (that has a larger surface than other categories of personal protective equipment) knowledge and studies of colour influence on human psychic are also taken into consideration. Thus, application of such studies has led to protective clothing of colours that reduce the stress effect at work or the total effects of the work environment on human psychic. For example, when working in confined spaces, such as ducts or channels, protective clothes make use of colours or combination of colours that stimulate the human psychic (green, yellow, light blue, etc.). Such colours are used to stimulate the workers' metabolism and also to make their presence visible in poor visibility conditions and in case of unwanted event workers are easily and rapidly tracked and rescued. The secondary effect of an increased visibility is a better safety perception, a stimulating factor of the work capacity, as the worker who feels safe has a higher work capacity than the one psychologically stressed by the possibility of a catastrophic event.

Another indicative example is the yellow or orange colour that has been lately used for the protective clothing against bad weather or water drops used by workers working on fishing vessels and pleasure boats.

Regulating the use of a certain colour or such colour used in combination chosen for the representation of a company has a significant contribution to increase discipline within the company. Consequently, more and more companies choose a distinctive colour, *e.g.* grey, but the protective equipment, especially the protective clothes have several elements (collars, yokes, slots, etc.) of other colour, for example blue for the management staff, green for the maintenance personnel, etc. so that there are avoided acts of indiscipline of personnel circulating in restricted areas, leaving the work place to do other activities or carrying out work for which they do not have the necessary qualification, etc.

Fig. 2 – Examples of personal protective equipment.

4. Conclusions

The considerations presented above clearly show that the personal protective equipment has a vital importance both in the risk prevention of occupational accidents or diseases at the work place, and also to ensure the maintenance of the worker’s health state and by adopting appropriate measures in choosing and using it can be a decisive factor in controlling stress at work.

The researchers and specialists in the area play an important role so that the protective equipment meet such requirements, implying them even in the design stage to scientifically and aesthetically combine every element leading to the development of a performing model, from the selection of the necessary materials and accessories and continuing with the operational and aesthetic elements necessary to carry on the work activity and maintain the worker's physical and mental health.

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ECHIPAMENTUL DE PROTECȚIE ŞI STRESUL OCUPAȚIONAL

(Rezumat)

Legislația şi reglementările tehnice în domeniul proiectării, fabricării şi utilizării echipamentului de protecție individual are ca scop asigurarea siguranței şi sănătății lucrătorului pe timpul lucrului aşa încât se concentrează în special pe performanța tehnică a parametrilor echipamentului de protecție şi mai puțin pe echipament ca factor de stress dacă nu este ales şi folosit corespunzător, deşi una dintre cerințele de bază ce trebuie luate în considerare la alegere se referă la confort şi eficiență în timpul purtării.

Prin urmare, în ultimul timp a existat o preocupare costantă pentru corelarea caracteristicilor de protecție cu cele de confort în timpul utilizării deoarece în anumite circumstanțe acestea pot fi factori importanți împotriva stersului în muncă.

Scopul acestei lucrări este de a prezenta principalii factori de stress care pot apărea atunci când proiectarea sau utilizarea echipamentului de protectție individual cât şi soluțiile care trebuie adoptate în scopul controlului stresului în muncăcu ajutorul echipamentului de protecție individual.

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RANKING RISK ASSESSMENT TOOLS: USE AND ABUSE

BY

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Abstract: In practical terms, a risk assessment is a thorough analysis of the workplace, having as goal to identify those factors, situations, processes, etc that may cause harm, particularly to workers. After identification is made, it is evaluated how likely and severe the risk is, and then decided what measures should be in place to effectively prevent or control the harm from happening. In Romania and, also, worldwide, a great variety of assessment tools are employed with special target towards risk ranking, which is - if properly implemented - a sound practice in the field of occupational health and safety risk management process. Unfortunately, our experience confirms the misuse and, even, the abuse of such simple methods, leading to inadequate managerial decisions. This is the main reason why, in this paper we aim to systematise and highlight the weaknesses, limits or drawbacks of such tools. To achieve this goal we analyse, discuss and interpret a widespread used method in this category, admitting the hypothesis that the conclusions drawn stands valid for other similar risk assessment techniques.

Keywords: risk assessment; risk management; occupational health and safety; ranking tool.

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1. Introduction

There is already a significant time lapse since the resort to the Kinney method, and also to other similarly structured methods, self - denominated as risk "quantification" methods, is done on large scale in the field of occupational health and safety, the goal being to rank and prioritize the risks identified in working place/job.

Presently, more and more experts in the field are developing a criticism in relation to the limits, "drawbacks" and disadvantages of this category of methods, which are increasingly considered as uncompleted, non - reliable and detaining a strong subjective character (Cordeschi *et al*., 2013; Moraru *et al*., 2014). Other specialists are refining their opinions, suggesting the resort to this kind of methods only as complementary or informational tools (Shojafar *et al*., 2015).

For the purpose of our study we are taking into analysis the largely employed more than two decades Kinney-Wiruth risk assessment method, considering that it is highly comparable to other tools applied very often.

The Kinney method was firstly introduced in U.S.A. in 1976, being proposed by G.F. Kinney and A.D. Wiruth in a technical document of Naval Weapons Center in California.

Initially aimed at explosion risk prevention in military industry, the method was rapidly adopted in Europe, with immediate success. Most of the specific literature sources in the field are qualifying it as a risk analysis method. We argue that, indeed, the method can be used in the risk analysis stage, but, considering the specific estimation pattern, it rather evaluates and ranks the risks in order to have a prioritization of them.

Even in this posture, as a evaluation and ranking tool, the method continues to be a "market leader" in several European Union member states. *E.g*. in Belgium the method is almost universally employed, both in big companies and in small and medium - sized enterprises (Koob & Malchaire, 2003).

2. Basics of the Kinney Risk Assessment Method

The risk (R) assessment, after Kinney, is done considering three parameters (Kinney & Wiruth, 1976): the probability (P) of an accident or damage occurrence, the exposure at risk frequency (F) and the gravity (G) of the induced consequence.

The probability of the damage occurrence during the exposure to a risk factor describes the accidental, stochastic and uncertain character. Kinney have defined seven probability classes, to whom he allocated certain numerical values (see Table 1).

Table 1
The Kinney Method: Numerical Values for the Probability

Probability (P)	Description (qualitative)
0.1	Virtually impossible
0.2	Practically impossible
0.5	Plausible, but unlikely
1	Improbable, but possible at boundary conditions
3	Unusual, but possible
6	Possible
10	Predictable

The exposure frequency expresses the time lapse in which the worker is exposed to the risk factor action; this component is estimated by one of the six classes described in Table 2.

The size of damages is expressed by five gravity classes, highlighted in Table 3.

Table 2
The Kinney Method: Numerical Values for the Exposure Frequency

Exposure frequency (F)	Description (qualitative)
0,5	Very rare (less than once per year)
1	Rare (yearly)
2	Monthly
3	Occasional (weekly)
6	Regular (daily)
10	Permanent

Table 3
The Kinney Method: Numerical Values for the Gravity

Gravity (G)	Description (qualitative)	Consequence type	Damage (financially expressed)
1	Low	Injury without work capacity loss	< 250€
3	Significant	Injury with loss of work capacity	250€ - 2,500€
7	High	Invalidity	25,000€ - 100,000€
15	Very high	One fatality	125,000€ - 250,000€
40	Catastrophic	Several fatalities	> 250,000€

A value must be allotted to each of the three factors. This designation is not the result of an inspirational moment. Normally, the process should start upwards, by defining for each working task, of the hazards and for each hazards of the risks related. Only after this hazard and risk identification phase (*e.g.* based on a check - list) the quantification can be initiated.

However, if the process is done by a single individual, the process will be a fake, while it offers the unique perspective of a person. Therefore we can state that the need for a multidisciplinary team is obvious.

Afterwards, but only after the completion of this first identification phase, will be imagined and developed the risk propagation scenarios. Based on the context setting, the numerical values will be assigned to probability, frequency and gravity; the risk level will be obtained by multiplying these three factors. The value obtained allows then to frame the risks into 5 levels, according to Table 4.

Table 4
The Kinney Method: the Risk Ranking Scale

Risk level (R)	Risk class	Required action
< 20	Very low	Acceptable risk: no measure required
20 - 70	Possible	Monitoring
70 - 200	Significant	Measures to be taken
200 - 400	High	Immediate improvement
> 400	Very high	Activity cessation

If the method is applied by a working team, it is strongly recommended that all the R values are retained, an average value to be computed, discussed and interpreted within the group session.

3. Identified Drawbacks

There are several drawbacks, outlined in literature, to whom the users of these methods may be confronted (Honings, 2000).

Drawback 1: The resort to "Kinney - type methods" can create a false feeling of safety, induced by the fact that the risk was identified and assessed. But, it is not enough to know and quantify the risk; this means not that risk vanished. While risk analysis is a continuous, dynamic process, assigning some numerical values can not be a goal in itself. On the contrary, this stage should be the starting point for new actions. The actions and measures taken should be differentiated so that they consider the individual features of the exposed workers, while it is known that certain groups are requiring special care and attention (such as pregnant women, nursing mothers, young workers or workers with disabilities).

Drawback 2: It was often observed in practice, that the users of these methods are having the tendency to regroup the various scenarios they should develop in order to identify risks. Consequently, only a risk level computation is carried out, for several differing scenarios: this is not a correct approach.

The working places and situations should be clearly differentiated. Also, the fact that the consequence could be a fatality or invalidity imposes to carry on two different analysis, even if the exposure and probability values are identical. Finally, while we are dealing with inductive methods, it will be always necessary to use as a support for the analysis, the accidental scenario.

Drawback 3: The use of "Kinney - type methods" should be avoided if the risks are cumulative, while the exposure time is not considered here, at least not in the meaning from the occupational illnesses.

Drawback 4: Frequently, when computing the risk level, it comes that the existing prevention measures in the system, not to be considered. If this is acceptable in the case of a first assessment, it is compulsory in a second stage, in order to better and realistic assess the effectiveness and impact of measures on the risk level, to check the compliance of the protection level according to the working context and the technical updating process of the employed protection measures.

It is very important to establish if risk analysis is done with consideration given to the existing control measures. As in other risk management fields, there is no unique answer to this question. Generally, the following recommendations can be made:

a) if the scope concerns a new system, where control measures are not yet implemented, probability and gravity will be estimated admitting the lack of control measures hypothesis;

b) if the scope concerns an operating system, with "adequate" safety measures, probability and gravity will always be estimated, with consideration given to the existing control measures.

4. The Quantitative Character of Ranking Risk Assessment Tools: Pros and Cons

Moving one step forward it can be considered that, apart from the drawbacks emphasized in the previous paragraph, the validity of Kinney - type methods is interpretable when the wellbeing risk assessment of workers is to be carried out. The quantitative character of the approach itself is disputable. Moreover, this category of risk assessment methods isn’t technically correct, while different users can apply it each in his manner, without any guarantee of a comparable result when a new exercise is carried out in the same working place (Moraru *et al*., 2010). Kinney - type methods are not fulfilling a precondition which is specific to any risk assessment exercise, both quantitative and qualitative, namely the rigorous conception of the measuring scale. Generally speaking, the measuring scales can be: reference scales, interval scales, ordinal scales and nominal scales.

The *nominal scale* offers to an object, in this case to a risk, an attribute allowing his differentiation with respect to another risk (*e.g.* risk 1, risk 2, etc.). The Kinney - type methods do not make appeal to such a scale.

In a *reference scale* it is assumed that the point of "zero" is an absolute value. This scale has as feature the fact that the unit can be freely chosen, but the reference point is a fixed one. In other words, a 10 factor risk should be twice higher than a 5 factor risk.

The *interval scale* offers the feature to measure simultaneously the rank and the distance between the individual values. Both the interval and the reference point can be freely selected, as in our hourly system. Even if it is possible to set the difference between two hours, between them there exists no connection. Therefore, the Kinney - type methods can not be considered nor an interval scale based methods categories.

The *ordinal scale* allows the establishment of the rank. The resulting information is more extensive that in the nominal scale; it will be known not only the category to whom the subjects or objects do belong, but also the ways in which they are linked. So, risks can be classified from 1 to 10, and the 10 level risk will always be higher than the 5 level risk. Meanwhile, this scale is not exclusively expressed in numerical values; it can also be depicted by symbols (++, +, − or − −). Kinney - type methods do have the features of an ordinal scale: risks are classified in growing order, but it isn't possible the summing of risk scores.

It can, therefore, be concluded that Kinney - type methods do not have a quantitative character, because the probability, frequency and gravity values are expressed through numerical values extracted from preset tables, but the risk values can not be nor summed, nor multiplied. These methods can be considered as subjective and qualitative risk assessment tools, based on ordinal scales expressed by preset tables.

5. Discussion

The use of the Kinney - type methods can offer seriously differing results, for the same working place or system, if the individuals composing the team are different from a case to another. Kinney and Wiruth are considering that the risk levels are allowing the assessment "of realistic priorities regarding the safety measures". On the contrary, the practical use of Kinney - type methods indicates that a misuse can lead to a variable risk factor list and diverging scores, according to the competency and expertise of the assessor. It follows that the emphasized priorities can be completely different from an individual to another.

On the other hand, even if the figures obtained can be useful in increasing the awareness of an organization's top management, the quantification is limited. It gives only the appearance of a mathematical evaluation, without really having the rigour of such an approach.

As shown before, the Kinney - type methods are allowing both the assessment of the prevention measures effectiveness and the trend estimation of a certain risk, as a function of the preventative measures implemented with time. Table 5 comparatively illustrates the advantages and limitations of Kinney - type methods.

Table 5
The Kinney Method: Advantages and Limitations

Advantages	Limitations
Numerically	Random data
Simple in use	Cost
Risk ranking	No guarantee for risk identification quality
Allows to assess the prevention-protection measures efficiency	Subjective method (high variability of results)
Risk acceptability evaluation	Unable to council the extremely diverging risk scores
Establish if measures are required	Confusion hazard: P, F and G unaccurately defined
Education, information, reflection	False safety feeling
Employer or financial manager persuasion	Lack of rigour: how the scores differences are interpreted?
	Applicable just for certain risks (not psychosocial or occupational illnesses, etc.)

Paradoxical, one of the most important advantages of the Kinney - type methods is meanwhile a handicap: we are arguing about a numerically expressed risk assessment. Of course, an approach based on figures allows prioritization, but will not be able to consider certain major aspects, such as ergonomics and psychosocial risks. The Kinney method, initially aimed at explosion risk prevention in military industry, is quite simple to apply for such an undesired event, but does not fit for events like fall from a ladder, incision with a cutter, etc. The method is difficult to apply, or even impossible, for chronic intoxication risk assessment, mental or physical (cumulative risks) fatigue assessment, etc.

However, Kinney - type methods do possess some advantages, such as accessibility, simple in use and fitted for training and learning the workers basic concepts, such as probability, frequency and gravity, in a qualitative manner. It comes that, these methods can be ideal sensibilization tools for the workers and staff members. This pedagogical trump is counterbalanced by the involved costs, in terms of time (structured procedure) and in financial resources required (education, enrolment, external consultancy).

5. Conclusions

It can be concluded that the main drawback of Kinney - type risk assessment methods is their subjective character. The results, expressed in figures, have a quite low representativity and do not allow the user to compare different working places or enterprises.

However, as far as certain aspects are not disregarded or neglected, these methods are preserving their goal and reason to be. Firstly, these qualitative methods remain very useful to provide the prevention measures implementation monitoring. On the other hand, they are participatory and, consequently, didactical methods. Employed on teamwork basis the Kinney - type methods can be valuable tools, while they are not complex and can facilitate a thorough analysis of elementary risk constituents. If the participatory risk assessment starts from a known working situation, the Kinney - type methods, through their deductive nature can be considered as complementary methods.

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Shojafar M., Javanmardi S., Abolfazli S., Cordeschi N., *FUGE: A Joint Meta-Heuristic Approach to Cloud Job Scheduling Algorithm Using Fuzzy Theory and a Genetic Method.* Cluster Computing, 2015.

METODE DE IERARHIZARE APLICATE ÎN EVALUAREA RISCURILOR: UZ ŞI ABUZ

(Rezumat)

În termeni practici, o evaluare a riscului este o analiză amănunțită a locului de muncă, având ca scop identificarea elementelor, situațiilor, proceselor etc., care pot provoca prejudicii, în special lucrătorilor. După identificare, se evaluează probabilitatea şi gravitatea riscului, iar ulterior se adoptă decizia privind măsurile care ar trebui implementate pentru a preveni sau controla în mod eficient riscul şi daunele potențiale asociate. În România şi, de asemenea, la nivel mondial, sunt utilizate o mare varietate de

instrumente de evaluare, majoritatea vizând în mod special ierarhizarea riscurilor. Dacă sunt aplicate în mod corespunzător, aceste instrumente permit un management adecvat al riscurilor în domeniul securităţii şi sănătăţii ocupaţionale. Din păcate, experienţa noastră confirmă utilizarea eronată şi chiar abuzul de astfel de metode simple, ceea ce conduce la decizii manageriale inadecvate. Acesta este principalul motiv pentru care, în această lucrare, ne propunem să sistematizăm şi să evidenţiem punctele slabe, limitele sau dezavantajele unor astfel de instrumente. Pentru a atinge acest scop este analizată, discutată şi interpretată o metodă utilizată pe scară largă, care se încadrează în această categorie, admiţând ipoteza realistă conform căreia concluziile obţinute sunt valabile şi pentru alte tehnici similare de evaluare a riscurilor.

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THE IMPORTANCE OF HAZARDS IDENTIFICATION FOR WORKSTATIONS AT A HEIGHT

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Abstract: Dangerous by its nature, the work at height often leads to serious injury, disability or death, having a negative impact on the worker, the company and on the society as a whole. Because the workstations at a height often differ in configuration and working conditions, identifying and assessing the risks remain as primordial in choosing the appropriate safeguards. The study conducted article aims to emphasize the importance of identifying related risks associated with both level difference and wrong selection of personal protective equipment.

Keywords: working at height; hazards; risks; personal protective equipment.

1. Introduction

The accidents due to falls from height are a major issue for health and safety both in Europe and worldwide. Every year, tens of thousands of people absent from work for more than three days, because of injuries suffered due to falls from height. Whether it's a fall from 2 m or a height greater than 2 m, it is not without consequences. In general, the severity and nature of the damage range from bruises, sprains and broken arms and legs, rib fractures, head trauma, diseases of the internal organs to death.

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2. Causes and Economic Effects of Occupational Accidents by Falling from a Height

The occupational accidents and deaths due to falls from height is not only suffering for workers and their families, but also a financial burden for employers (*e.g.* by working days lost profit or loss, negative effects on the image of the company, etc.) and workers (sick leave) and society as a whole (*i.e.* costs caused by production losses and other costs for different resources and human costs).

Although at national scale are recorded cases of accidents due to falls from height in the absence of data the cost of the consequences that they have on stakeholders can not be expressed. In this case it can pull an alarm signal regarding the importance of identifying all existing hazards at work and decisions on the choice of appropriate protective measures.

However, to have a picture for the numbers of accidents at work which are due to falls from height below are some data that was taken from studies conducted in countries such as France and Spain.

The 2012 statistics showed that in France falls from height led to 71 925 accidents (11.2% of workplace accidents), 52 deaths (approx. 9.3%) and 6,033,760 days of leave medical (representing approx. 16% working days lost), this risk placing second cause of death in the workplace and the third leading cause of permanent invalidity and termination of employment (1). In Spain statistics show that annually, over 500 people have suffered from accidents at work. 18% of these die after falling from a height, and costs due to a work accident falls from height, disabled soldier stands at 377,000 €. Add to this the cost of healthcare costs suing their employer (2).

In generally, whether in terms of employer costs are relatively easy to quantify, for victim costs are unimportant because of the pain and suffering, and employment repercussions of the accident can not quantify. The expression of the cost of human suffering and damage to health is not an easy task but depends on a combination of methodological assumptions and the severity of the accident. The incidence of occupational accidents caused by falls from height being most often correlated with the level of activity within the workstation, can be considered an indicator that draws attention to the fact that whenever the workload is high safety tends to receive less attention.

Although a large part of the overall data on occupational accidents caused by falls from height are available, there is little information that could identify the exact nature of the cause of the accident. In most cases it was found that they occur not only because of the difference in level, but also to factors such as:

- the workplace configuration (3) (4) (5);
- the nature of the impact surface;

- the user position during the fall;
- the behavior and attitude at work (6);
- the worker experience (3);
- the health (7);
- the working environment (6);
- the personal protective equipment (hereinafter abbreviated PPE) against falling used (8).

EIP can cause an accident by falling from a height by:

- selection, improper choice;
- misuse;
- careless regarding attention in terms of anchoring characteristics;
- unsatisfactory performance / quality inadequate;
- premature deterioration, unexpected by the action of harmful factors specific to the workplace.

It can be said that often the origins of the causes of accidents are found long before the time of the accident and often can be caused by the action of two or more overlapping causes and effects amplify the effects of another one, such as:

• **the trigger for fall risk due** to insufficient adhesion of the shoe; dizziness; blindness (due to bright objects); lack of visibility; hypodermic shock or heat stroke; rapid temperature drop;

• **the specific risk related to the type / task work:** mechanical (sharp edges, sharp tools, falling objects, etc.) (5); heat (sparks, open flame, etc.); chemical; electric;

• **risk due to atmospheric conditions** (9) - wind, rain and ice over walkways, etc.

This draws the attention of both the importance of identifying all existing hazards in the workplace and synergistic effects of risk factors present in the workplace.

3. The Need to Identify all Existing Hazards for Workstations at a Height

Because of the continuous changes taking place in the labor market and that the dangers facing workers are alarming, the health and safety at work are essential components of quality of work. Therefore, the creation of secure jobs that ensure maximum safety and health of workers is one of the main objectives of social policy at European level.

On national level, the law establishes measures to encourage improvements in the safety and health of workers is the Law 319/2006 - Health and Safety at Work Act (national transposing framework Directive 89/391/EEC on personal protective equipment). In order to ensure working conditions similar to those existing at the European level, the law establishes that the risk assessment in the workplace, which means identifying all hazards and assessing all existing risks at workstations in order to adopt optimal measures to protect workers at work.

As in the case of activities at height, exposure to the risk of falling from height can occur during access to the workstation (with or without equipment or materials) or during work, the hazard identification can be consider as the most important stage of the process of risk management, as it depends on making the right decisions regarding the choice of appropriate protective measures. It is important to identify the hazards associated with:

- work to be carried out (construction, inspection, maintenance, etc.);
- equipment to be used;
- the location where the activity will take place - such as those generated by the presence of overhead power lines power, presence of openings, etc;
- working environment - such as those generated weather conditions (rain, sub-zero temperatures, etc.), lighting;
- the condition and stability of the existing work surfaces (fragile surfaces, inclined, slippery);
- physical capacities of workers (health, fatigue, etc.).

In terms of working at height, protective measures may be taken either in the design phase (by providing handrails, anchorages, etc.) or following risk assessment, when identifying collective protective measures. If by arranging a scaffold of proper railings or other similar safety devices the risk of failure can not be removed in order to minimize the distance and consequences of failure have to use the appropriate PPE as protection for working at heights supplemented with other measures, such as surveillance instruction and training.

4. General principles for the selection of personal protective equipment for working at height

Defined as "equipment designed to be worn or held by the worker to protect against one or more hazards likely to endanger his safety and health at work" (10), the EIP serves either be mechanical barrier preventing hazard action on the body or deforming it interacts with it or destroying it partially, thus preventing damage to the body.

In the case of risks related to the drop from height the user protection is ensured by a system made up from an assembly of components (a body support device is connected by a connecting means with or without absorber, at a resistant anchor) and elements with different operational characteristics and protection, whose role is either to prevent falls from height, fall arrest or rescue idle (11).

Regardless of components is achieved, PPE against falls from height are highly complex and highly specific function not only in his role, but also for the specific work (workplace configuration, fixing possibilities, positions needed during work, the burden of work performed, etc.). Given that the specific configuration of the workplace hazards, work and on environmental factors present in the workplace can have a cumulative effect, the need is primary in choosing their appropriate PPE for work at height.

So depending on the configuration of the workstation and its formed components, systems of PPE against falling from height can be:

- Fall prevention – they are used when working on horizontal or slightly inclined; prevent the user to enter free fall (they support during work) (11);

- **Fall arrest** – they used when working on vertical surfaces or surfaces where there is danger of falling from height; they prevent user to hit the ground, a structure or another obstacle during free fall (serves to brake and thus to lessen the shock) (11);

- Rescue – it provides emergency rescue or save another person, thereby avoiding free fall (11).

If for works carried out on horizontal or inclined slightly selecting the appropriate PPE for work at height is considering:

- the nature of the work area;
- ability to withstand the required task area;
- the nature of which is planned to be conducted;
- the environment in which it operates;
- work equipment used at work;
- the existence and strength of the anchorages;
- the need to move from one height to another;
- the number of workers who have access to the work area of work and their training and experience, regarding activities on vertical surfaces, things are more complicated.

In this case, in addition to the dangers mentioned above must be considering:

- the height of fall;
- is the workplace (position workstation to edges and openings failure to signal the presence of structures in the trap);
- the presence of sharp edges;
- the simultaneous action of various factors dangerous;
- the load sent by the body belt in case of a fall;
- the suspension of the worker body fall arrest equipment and time spent in this position.

5. Conclusions

Because labor accidents caused by falls from height are classified into the category with very serious consequences, which often have irreversible effects on workers' health, it was concluded that only the correct identification of hazards followed by a proper assessment risks, accompanied by the choice of appropriate measures would represent the path to safe and healthy jobs.

Considering the fact that according to the law, every moment of work, the exposure to risk should be minimized, use of PPE for working at height must be carried out only if:

• risk assessment has shown that the work can be done as safely possible and the use of other, safer work is not possible;

• user and a sufficient number of available persons have received adequate training specific to the operations envisaged, including rescue procedures.

Regarding the selection of PPE against falls from height this is based on identifying all existing hazards in the workplace, simultaneously considering their synergistic action.

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IMPORTANȚA IDENTIFICĂRII RISCURILOR PETRU STAȚIILE DE LUCRU LA ÎNĂLȚIME

(Rezumat)

Pericolos prin natura sa, lucrul la înălțime conduce adesea la vătămări serioase, dizabilități sau moarte, având un impact negativ asupra muncitorului, companiei şi societății în ansamblu. Deoarece stațiile de lucru la înălțime diferă adesea prin configurație şi condiții de lucru, identificarea şi evaluarea riscurilor este primordială în alegerea măsurilor de prevenire potrivite. Articolul are scopul de a scoate în evidență importanța identificării riscurilor asociate cu diferența de nivel cât şi cu alegerea greşită a echipamentului de protecție.

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CHEMICAL RISK ASSESSMENT AT WORKING PLACES FOR SUITABLE PREVENTION AND PROTECTION OF WORKERS

BY

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Abstract: Several technological processes contain in their exploitation an implicit risk. Thus, in the chemical industry and not only, are being used dangerous materials and chemical substances, which, by their flammable, toxic, corosive and explosive nature induce some degree of inherent risk asociated to the technological processes. Function of chemical properties, various substances used in the working process become risk factors for workers health and safety.

The use of suitable work equipment in accordance with legislation plays an important role in the prevention and protection activity carried out within the company.

The European Union initiated the Council Directive 89/686 / EEC on the harmonization of the Member States legislation concerning the personal protective equipment, in order to ensure safe products throughout the European Union.

In this respect, in the laboratories of INCD INSEMEX Petroşani were implemented technologies regarding the determination of personal protective equipment resistance to dangerous chemical agents.

Keywords: risk assesement; prevention and protection; chemical hazard; personal protective equipment; compliance.

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1. Introduction

The technology development resulted in solving numerous aspects of industrial hazard. Nevertheless, new hazards arise and a number of risk factors are represented by chemical hazards. This is important due to the gravity of the consequences (professional disease hazard) and the influence over the social relationships and over the indirect cost of the finit product. Increased production of chemical products determined the increase in the number of units where may occur these risks during the manufacturing, storage, handling or transport. The risk assessment of such products, the health hazards and their consequences is necessary both to protect workers and the environment.

The starting point for the optimization of prevention activity of work accidents and occupational diseases into a system is represented by the risk assessment of that system.

Risk assessment is the key to a proper health and security at work and the effective prevention can be achieved by the following steps:

a) the hazard identification and those at risk;
b) assessment and prioritizing risks;
c) establishing the preventive and protective measures;
d) achieving the prevention and protection measures;
e) monitoring and verification of compliance and efficiency measures.

The risk assessment involves the identification of all risk factors from the analyzed system and quantifying their size based on the combination of two parameters: the severity and frequency of maximum possible consequence on the human body.

Identifying the sources of risk must consider both normal operation (source of regulatory risk) and accidental situations (source of occasional risk).

The inventory of sources of risk requires a good knowledge of plants, but also of the amount and properties of substances with a high potential of danger, circulated on the technological flow.

The systematic identification of sources of risk is essential to the success of risk analysis. Omitting from the inventory of sources of risk means exclusion from analysis of a hazard which could have extremely serious consequences.

1.1. Professional Risk Characterization

Risks to human health are related to exposure to occupational pollutants that are harmful factors existing at certain jobs and that can threaten the health of workers, unless protective measures are taken.

Such emissions are: smoke, particulate matter (dust), gases and fumes, high temperature, cold, ionizing radiation or caloric, noise, etc.

Winding up or neutralizing the pollutants, using collective or individual means of protection, is a central concern of the leadership of businesses and state inspections for hygiene and safety in our country in order to reduce the morbidity due to occupational disease.

The occupational diseases for the purposes of of Law 319/2006 on Safety and Health at Work, represents diseases that occur as a result of the exercise of a trade or profession, caused by physical, chemical, biological or psychosocial harmful factors job characteristics and also by overloading different devices and systems of the body in the course of work process, regardless of the type of employment contract existing between employer and employee.

In most cases, the effects are both physical and chemical type, characteristic situation to the diseases or conditions that occurs from exposure in the industry.

The aggressiveness of pollutants is conferred by their characteristics such as chemical structure, aggregation state, volatility, dispersion, solubility, etc.

The ways of entering the body is of particular importance to the toxicity of pollutants on the body have, movement in the internal environment, biotransformation their body's ability to block the toxic effects storage body structures and finally eliminate them in various ways.

The entering of the pollutants in the body can be made on the respiratory way, skin and digestive system, but also by placenta or mammary, but the most important of all is respiratory way, because the link between the external environment and the blood is made directly.

The circulation of toxic substances in the body takes place in several stages: the distribution of the substance in the blood; some organs relative orientation of certain affinities, so-called target organs; accumulation of substance in different tissues. The elimination of toxic substances in the body has great importance in reducing the risk.

1.2. Chemical Hazard

The chemical risk is the name that is assigned to any danger associated with chemical substances, toxic, corrosive, flammable, explosive, carcinogenic, radioactive, mutagenic that come in direct contact persons who perform the work activity which may cause them any of the following effects: burning, chemical poisoning / asphyxiation and contamination.

Hazardous substances means any liquid, gas or solid, presenting a risk to the health or safety of workers. They can be found in almost all workplaces.

If the risks of using dangerous substances are managed properly, health workers may be affected in a variety of ways, with effects ranging from mild ones such as irritation of the eyes and skin to serious ones like asthma, reproductive problems birth defects even cancer. This can happen either through a single short exposure, or multiple exposures and long-term accumulation of substances in the body.

The chemical risk assessment due to hazardous chemicals should take into account of certain information related to: the chemical properties of the substances, the concentration level, conditions for work carried out in the presence of such agents, duration of exposure to hazardous chemicals action, etc.

In accordance with the Decision no. 1218 of 6 September 2006 the employer must ensure that the risk to health and safety in the work process induced a hazardous chemical agent is eliminated or minimized.

The employer must ensure that personal protective equipment to chemical risk jobs complies with the laws applicable to the design, production and delivery, having regard to health and safety.

Romania, as an EU member country, took into national law Council Directive 89/686/EEC of 21 December 1989 by Government Decision no. 115 of 05 February 2004 on establishing the essential safety requirements of personal protective equipment and conditions for placing on the market.

Personal protective equipment may be placed on the market and put into service only if they comply with all the essential health and safety requirements apply.

2. Technologies Regarding the Testing on Individual Protection Equipment for Hazardous Chemical Agents

In accordance with the chemical risks identified by the employer for its jobs, one must select the appropriate personal protective equipment. Ensuring compliance with the requirements of personal protective equipment Council Directive 89/686/EEC of 21 December 1989 that the Government Decision no. 115 of 05 February 2004 in accordance with the intended use implies conducting specific tests permeation and degradation of chemical hazards.

In the present paper are presented experimental stands for the implementation of core technologies developed under Project PN-7:45 1:27 "Technologies on resistance, permeation and degradation of personal protective equipment against chemical agents to assess their compliance", namely:

1º Determination of resistance of materials to penetration by liquids.

2º Determination of resistance to permeation and degradation of safety footwear.

3º Determination of resistance to permeation of gloves to chemical products.

In order to determine the resistance of materials to penetration by liquids was used by the SR EN ISO 6530:2005 "Protective clothing. Protection against liquid chemicals. Test method for resistance of materials to penetration by liquids", which specifies a method of test for measuring indices of penetration, absorption and rejection for the protective clothing materials against splashes of liquid chemicals of small volume, low pressure and higher and was reaised an experimental stand shown in Fig. 1.

In order to determine the resistance to permeation and degradation of safety footwear was used the european standard SR EN 13832-1:2007 "Protective footwear against chemicals. Part 1: Terminology and test methods" and were made in accordance with this experimental stands shown in Figs. 2 and 3.

In order to determine the permeation resistance to chemical products of the gloves was used the standard EN 374-3: 2004 "Protective gloves against chemicals and microorganisms. Part 3: Determination of resistance to permeation by chemicals" and was made an experimental stand shown in Fig. 3.

Fig. 1 – Experimental stand for resistance to penetration by liquids materials.

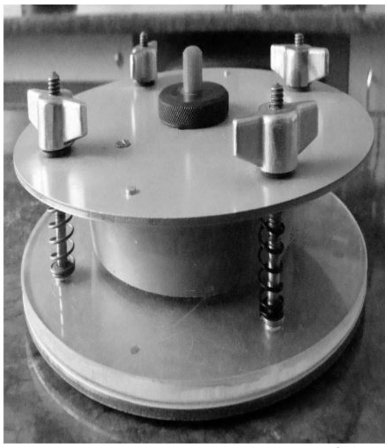

Fig. 2 – Experimental stand for resistance to degradation.

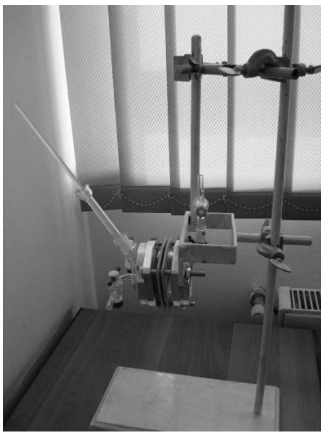

Fig. 3 – Experimental stand for resistance to permeation.

The technologies developed have been used for the testing of samples of materials used in the manufacture of antistatic protective clothing, the footwear for the oil industry and the constituent materials of the gloves.

As test liquid was used in solution of 96% concentration ethyl alcohol - distilled water in a ratio of 1: 1 and the product oil (crude oil).

The results showed conformity of samples tested, ensuring adequate level of protection from chemical risks, namely:

a) protective clothing materials indices of penetration, absorption and rejection were within the parameters specified;

b) the gloves, the permeation flow is adequate;

c) for shoes, permeation flow and degradation are in specified parameters.

In the industries on which have been identified chemical risks at the workplace and that studies evaluating the risk of accidents and professional diseases led to the plan of measures of prevention and protection to be given personal protective equipment resistant to chemical agents dangerous manufacturers of such equipment are available test facilities in line with European standards referred to respectively EN 374-3:2004, EN ISO 6530/2005 SR, SR EN 13832-1/2007 under INSEMEX NRDI Petroşani.

3. Conclusions

The risk assessment involves the identification of all risk factors analyzed and quantify their size system based on the combination of two parameters: the severity and frequency of maximum possible consequence on the human body.

The chemical risk is the name that is assigned to any danger associated with chemical substances, toxic, corrosive, flammable, explosive, carcinogenic, radioactive, mutagenic that come in direct contact persons who perform the work activity which may cause them any of the following effects: burning chemical poisoning / asphyxiation and contamination.

In accordance with the Decision no. 1218 of 6 September 2006 the employer must ensure that the risk to health and safety in the work process induced a hazardous chemical agent is eliminated or minimized.

The employer must ensure that personal protective equipment to chemical risk jobs complies with the laws applicable to the design, production and delivery, having regard to health and safety.

In the present paper are presented experimental stands for the implementation of core technologies developed under Project PN-7:45 1:27 "Technologies on resistance, permeation and degradation of personal protective equipment against chemical agents to assess their compliance", namely:

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EVALUAREA RISCULUI CHIMIC LA LOCURILE DE MUNCĂ ÎN VEDEREA PREVENIRII ŞI PROTECȚIEI CORESPUNZĂTOARE A LUCRĂTORILOR

(Rezumat)

Numeroase procese tehnologice conțin în exploatarea lor un risc implicit. Astfel, în industria chimică şi nu numai, sunt utilizate materiale şi substanțe chimice periculoase care, prin natura lor inflamabilă, toxică, corozivă şi explozivă, induc un anumit grad de risc intrinsec asociat proceselor tehnologice. În funcție de proprietățile chimice, diverse substanțe utilizate în procesul de muncă devin factori de risc pentru securitatea şi sănătatea în muncă a lucrătorului.

Utilizarea unor echipamente de muncă potrivite şi în conformitate cu legislația în vigoare are un rol important în activitățile de prevenire şi protecție desfăşurate în cadrul întreprinderii şi/sau al unității.

Uniunea Europeană a inițiat Directiva Consiliului 89/686/CEE privind armonizarea legislației statelor membre referitoare la echipamentul individual de protecție, în scopul asigurării de produse sigure în întreaga Uniune Europeană.

În acest sens, în laboratoarele de specialitate ale INCD INSEMEX Petroşani au fost implementate tehnologii privind determinarea rezistenței echipamentelor individuale de protecție la agenții chimici periculoşi.

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THE CAUSALITY AND DETERMINATION LINKS BETWEEN THE PSYCHOSOCIAL RISKS AND WORKPLACE SUFFERING

BY

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Abstract: The paper refers to the main factors that can generate psychosocial risks, the causality and determination between psychosocial risks and suffering at work and the benefit of psychosocial risks prevention for workers, their families, the organizations, their leaders and society.

Keywords: psychosocial risk; stress at work; psychological harassment; violence at work; suffering at the workplace.

1. Introduction

Every few minutes, someone loses their life in the European Union from work-related causes. Moreover, every year hundreds of thousands of workers are victims of work accidents, while others have medical leave to deal with psychosocial risks, excessive workload or other work-related diseases.

Besides the traditional workplace risks (chemical, mechanical) due to general working conditions, psychosocial risks (risks emerging) that bring new challenges to the health of workers at work are determined by:

- changing the type of work;
- changing the role of the workers;

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- changes in the organizations and companies;
- globalization;
- free market economy;
- new IT technologies;
- economic crises and recessions.

Currently, the most popular psychosocial risks, which may affect the physical integrity but also the mental health of employees, are:

- work related stress;
- psychological harassment at the workplace;
- violence at work.

In the European Union, work-related stress is the second health problem related to work after dorsal affections. It affects 28% of EU employees, which represents 40 million.

Work-related stress is the most commonly cause of illness reported by workers. On average, an estimated one million workers are absent one workday because of stress.

In Romania, in recent years, about one in five individuals felt very or extremely stressed.

Any employee may be the victim of psychological harassment in the workplace. According to the results of an investigation at EU level, 2.9% of European employees, meaning 12 million people, said they were subjected to psychological harassment in the workplace over the period of 12 months, and a 4% of the working population says they were the victim of physical abuse from people outside the workplace. A higher number of employees have suffered threats, insults or other forms of psychological aggression from people outside the workplace.

2. Definitions and Terms

2.1. Psychosocial Risk

The most frequently encountered *definition* is stated as "*the interaction between psycological and social factors*"**.**

The *psychosocial domain* refers to the psychological aspects of the social life at the workplace.

Psychosocial disorders (stress, violence, harassment) occur when there is an imbalance in the system consisting of a man and his working environment.

Psychosocial disorders are encountered at the person level, but also in that person's entourage in extremely various, and often misleading, forms.

The phrase "*health and safety risk*" refers to the risk of harm to the physical or mental health of an employee.

The concept of *psychosocial risk* must be understood as "*the probability of a psychosocial disorder, caused by the working environment, to appear*".

2.2. Work-Related Stress

Stress is currently a generic term used by everyone to describe very different situations, referring to both the causes and effects: health condition, individual feelings, explaining the situation at work. Stress has an individual character, multifactorial and cumulative interlocking the private and professional spheres. The definition from the European Agency for Safety and Health at Work: "*A state of stress occurs when there is an imbalance between the perception a person has vis-a-vis the constraints imposed by the environment in which he works and the perception that he has about his own resources to cope with those constraints*".

Although the evaluation process for the constraints and resources is purely psychological, the effects of stress are not only psychological.

Stress is a defense reaction, that individuals exhibit to excessive pressures or other types of requirements that addressed them. Stress can be caused by profesional pressure, some extra-professional ones.

Work related stress occurs when the demands of the working environment exceed the capacity of the employees to meet them or keep them under control.

A pressure state of mind can improve performance and provide some job satisfaction by achieving the objectives. But when demands and pressures exceed certain limits, they lead to stress.

STATISTICS:

a) Up to 90% of the visits to the family physician are related to stress.

b) Up to 80% of industrial accidents are because of stress.

c) Over 50% of lost working days are related to stress.

d) 14% of all workers say stress caused them to quit or change jobs in the last two years.

e) 43% of adults suffer adverse health effects from stress.

2.3. Psychological Harassment at Work

There is no single definition accepted at international level for psychological harassment. An example of definition is: "*psychological harassment in the workplace is an irrational behavior, repeated to a worker or group of workers, which has the purpose or effect the degradation of working conditions, able to harm the employee's rights or dignity, affect his physical or moral health or to jeopardize his professional future*".

Within this definition:

a) by "*irrational behavior*" we understand the behavior that a reasonable person is considering it to victimize, humiliate, discredit or threaten, taking into account all the circumstances;

b) the term "*behavior*" includes individual or group actions. A labor system can be used as a means of victimization, humiliation, disparagement or threat.

Psychological harassment in the workplace may involve::

i) a wrong exercise of a position or abuse of office function against whom persons concerned may find it difficult to defend

ii) verbal and physical aggression, and more subtle actions, such as discrediting the work of a coworker or his social isolation;

iii) a phenomena of physical and psychological violence.

There are two types of psychological harassment:

1. harassment as a consequence of an increased interpersonal conflict.

2. if the victim was not involved in the conflict, but is accidentally in a situation in which it becomes subject to aggression exercised by harassment (*e.g*. psychological harassment: the transformation of a person into the "scapegoat").

2.4. Violence at Work

The best definition of violence itself that best suits the subject is “the assembly of physical or mental disorders caused by external violent factors”

Violence at work can manifest itself in different ways:

a) fizicly: aggression ...;

b) psychologicly: domination, persecution, humiliation, ...

Violence in the workplace can be:

1º External – generally occurs in the exercise of professional relationships and refers to workers exposed to external aggression from contact with people or activities that generate hazardous situations.

2º Internal – refers to relations between employees - several combinations are possible: between two colleagues, one individual and one group, two groups, ...

The concept of “external violence” at work includes insults, threats, physical or psychological aggression exerted by people from outside the organization, which constitute a danger to health, safety and welfare of the workers who undertake work load.

Acts of aggression or violence can manifest as:

- acivic behavior - lack of respect for others;
- physical or verbal aggression - intention to injure or offend;
- attack - intention to harm another person.

Violence tends to expand also to institutions that “symbolicly” represent society, and more recently in the exercise of a profession or function of inspection, control or "authority" in general.

2.5. Suffering at Work

The suffering - psychological, social, physical - has its origins in work organization which removes the individual or systematically denies its identity, its own conception of the work, his values, his hopes and dreams. Suffering at work can sometimes be difficult to recognize. If suffering from work reaches the worker then it affects its potential of his resources: mental health, life experience, professionalism, culture etc.

Work is an essential place for building identity, personal development and establish social relations.

3. Factors that May Cause Psychosocial Risks

In their daily work, employers must take into account the mental effort of each employee, depending on the ratio of professional variables (requirements, working conditions, occupational risks existing in the workplace) and individual variables (individual professional capabilities). This report reflects the different level of solicitation (subsolicitare, optimum solicitation, maximum solicitation, oversolicitation) of the body, its various systems, functions, capabilities (sensory perceptual, cognitive, psychomotor) including emotional factor.

There are many factors that can have a negative impact on wellbeing of workers and may generate psychosocial risks at work such as:

- high quality requirements in work tasks;
- overly demanding work and / or insufficient time for tasks;
- conflicting requirements and lack of clarity regarding the role of the worker;
- the existence of an imbalance between job requirements and the capabilities of the worker - a worker capacity underutilization may be a source as large as its overuse;
- lack of involvement in decisions affecting worker and lack of influence on how tasks are performed;
- individual work done when dealing with members of the public and/or when the worker is subject to the will of a third party which may take the form of psychological harassment, verbal aggression and threats of physical violence or actual physical violence;
- lack of support from management and fellow workers and poor interpersonal relationships;
- psychological harassment in the workplace - victimization, humiliation, undermining or threats received by a worker or group of workers from bosses or colleagues;
- inequitable distribution of work, rewards, promotions or career opportunities;
- lack of recognition and acknowledgment of personal merit;
- ineffective communication and cumbersome operation of communication systems;
- continuous organizational changes (government changes, organizational changes and staff changes) and job insecurity;
- imprecise definition of the task entrusted to the worker;
- difficulties regarding joint commitments at work with those at home;
- lack of equipment and material resources needed to fulfill operational workload;
- introduction of new IT technologies.

4. The Causality and Determination Links Between the Psychosocial Risks and Workplace Suffering

In Fig. 1 it is shown the causality and determination links between psychosocial risks at work and workplace suffering.

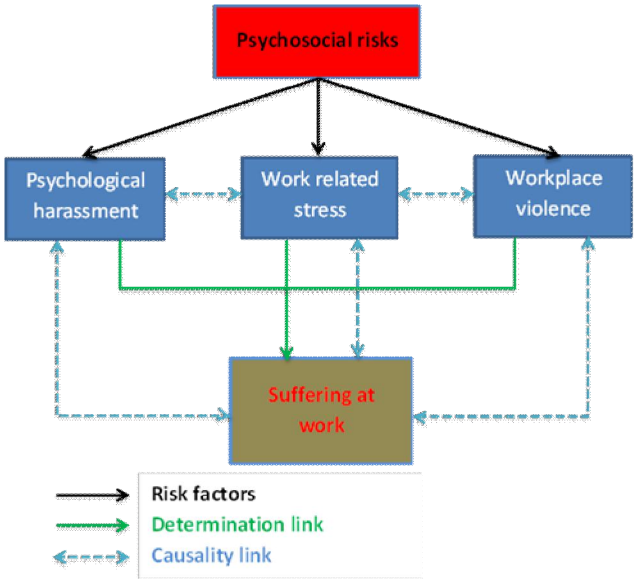

Fig. 1 – The causality and determination links.

Both psychological harassment and violence and stress at work causes suffering at the workplace.

Stress at work can be the consequence of psychological harassment or workplace violence, but it can also generate a workplace violence or psychological harassment.

5. Conclusions

Preventing psychosocial risks must enroll in the prevention of occupational risks. The employer must take action to protect the physical and mental health and safety of his workers. It is an obligation imposed by current legislation. Therefore, as for other occupational hazards, addressing psychosocial risks should be materialize in their evaluation and their inclusion in the plan of prevention and protection.

The advantages for prevention of psychosocial risks are:

- for workers, a high level of well-being and satisfaction in the workplace;
- for managers, healthy, motivated and productive workers;
- for the organization, better overall results, reduced absenteeism, reduced number of accidents and injuries and greater preservation of workers;
- for society, reduced insurance costs in cases of accidents at work and health insurance;
- for workers' families, moral and material support, a better life.

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LEGĂTURILE DE CAUZALITATE ŞI DE DETERMINARE ÎNTRE RISCURILE PSIHOSOCIALE ŞI SUFERINȚA LA LOCUL DE MUNCĂ

(Rezumat)

Lucrarea se referă la pricipalii factori care generează riscuri psihosociale, la legăturile de cauzalitate şi de determinare între riscurile psihosociale şi suferința la locul de muncă şi la beneficiile prevenirii acestor riscuri pentru lucrători, familiile acestora, organizațiile şi liderii acestora şi societate.

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PARTICULARITIES OF THE TRAINING NEEDS IN THE FIELD OF AUTOMOTIVE CASE STUDY

BY

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Abstract: Present study is identifying particularities of the professional development needs, in order to help future programs of implementation of a series of activities for a structured program, flexible and applicable. It aims also to involve employees and increasing interest in training programs.

The subject of the study is to identify the main professional training needs in automotive sector, identifying the particularities of the professional needs and the most affected areas, that need immediate improvements. Also, the purpose is to identify the current level of competence and skill levels perceived by management, in a certain period, on key competences while pursuing their business and strategic development objectives of the company.

Study results are giving important information about the current development needs of engineers in the fields of research and development, but also about career development opportunities and improving the skills of the people from the company. The study can be a source of documentation for future implementation of staff development activities of automotive companies.

Keywords: particularities; vocational training; lifelong learning systems; professional training; professional qualification; professional training program; professional development needs.

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1. Introduction

The issue of the competitiveness of the human resources was reinstated because of the decision priority for short-term intervention in the struggle of Romania to counter the effects of the global economic crisis. The current competitive companies must take care about the existence of a consistent personnel policy that takes into account the quality and competence of staff, as administration efficiency and effectiveness depend on how those working in administration know, understand and fail to fulfill their tasks and duties.

The data obtained through the investigation among key actors in the automotive companies served to shaping an overview on current training system. Participation in continuing training of employees is still low and vary depending on a number of criteria: company size, ownership of its lifespan, development prospects.

The awareness of the importance of vocational training remains relatively low, both for employers and the employees. Responsibility for vocational training is perceived (by employees) that the employer rather than the employee returning and continuing education motivation is extrinsic rather than intrinsic.

Romanian continuing vocational training system is designed and organized according to a specific legislative framework, whose analysis is a prerequisite for effective approaches to various aspects of lifelong learning and the proposal of possible recommendations in this area.

EU policies in the field of training are milestones for the development, by each Member State to regulations, policies and specific action directions. What European documents significant policy gap will be synthesized in the following? Lisbon Declaration (March 2000) establishes a series of goals EU member states to set up a society and economy based on knowledge, which can only be achieved by adapting and improving education and training systems. Memorandum on lifelong learning the Commission European (adopted in October 2000) formulates a number of key messages the orientating future actions in the field: guaranteeing access universal and continuous learning for training and improvement skills; More investment in human resources; encouraging innovation in teaching and learning; valuing learning, non-formal and informal; Rethinking guidance and counseling, focusing the access to quality information and advice on opportunities lifelong learning; Learning near the home, offering lifelong learning opportunities as close to the beneficiaries, their own communities and supported by ICT equipment. "Copenhagen Declaration" (Declaration of European Ministers education and training and the European Commission agreed to November 2002 on strengthening European cooperation in training Professional) establishes the following priorities in developing systems education and training, initial and continuing: size

European, transparency, information and counseling, recognition competences and qualifications, quality assurance in training.

Why professional training is necessary ?

The company that provides training to develop management skills as behavioral or emotional self-control have a double benefit in that it significantly improves the likelihood of developing these skills increase work performance and at the same time, help employees better manage their privacy [Sacara 2008, p. 46].

A particular case preparation, are adults employed by organizations. These, together organization can use training offered by the company for achieving performance, and continuous development.

The training programs of large companies, management are implemented on the initiative or at the request of employees. Regardless of who initiates the process, the programs are designed and tailored to the needs of employees, they manifested in a certain period of time. This means that the organization will continuously collect information on possible shortcomings or improvements submitted by employees. After this stage, analyze their need for vocational training through various methods.

The training may apply:

• To stimulate the development of employees who were evaluated with some shortcomings in recent years. The training will help industries that require deepening awareness and will also motivate employee involvement in their experiment included professional development.

• To facilitate the integration of new employees, giving them useful information packages opportunity to assimilate from experienced colleagues.

• To accelerate the integration of new employees in the workplace, so they quickly familiarize themselves with the tasks, procedures and internal rules. Mentors will guide and integrate new employees into the life and organizational culture, thus the total potential use of the disciple in a shorter time.

• To discover new talent in the organization, prospective new leaders. In this case, mentors will be senior managers who will guide and will train employees who show potential to become leaders in the organization.

Purpose of the professional development :

• Stimulation of labor force employment;
• Raising the level of professional competence;
• Facilitate the employment consistent with labor market trends;
• Adjusting the demand and supply of skilled workers;
• Maintaining and developing professional skills;
• Stimulating labor mobility;
• Increase the chances of (re) professional integration;
• reinsertion of part of labor market training;

• Increasing the level of preparedness to meet the real needs of qualified economic agents.

Training is the procedure to ensure the growth and diversification of professional competencies through initiation, qualification, requalification, training and specialization of persons looking for a job in order to achieve mobility and (re) integrate them on the labor market.

The principles governing the training are: legality, professionalism, efficiency, ensuring equal opportunities in the labor market confidentiality.

Desired Results:

• equipping individuals with the skills necessary to participate more actively in the spheres of social life at all levels of the community, including at European level;

• increasing labor mobility;

• enhanced access to jobs;

• proportions limiting long-term unemployment;

• facilitate (re) integration activity disadvantaged categories of labor;

• increasing investment in human resources;

• develop effective teaching and learning methods;

• improving skills assessment and formal and informal system;

• increasing the efficiency of vocational training courses.

Required facilities: classrooms, Training Equipment, Furniture, Study Materials, supplies, materials for the practical activity, Protective equipment, workshops, tools, installations, audio-visual means.

Personnel involved in the activity: staff training providers, responsible for the course, theoretical and practical training trainers, CEOs of training providers.

The microclimate conditions, facilities and materials used in courses for training is important for the proper development aspects of their as the trainer maintain activity and provide a favorable context for active participation of students. Overall, 70% of employees participating in training formation appreciate "good" and "very good" gauge the comfort conditions that were carried out training activities.

Modern technical equipment does not automatically ensure quality and timeliness of training. Some trainers have the skills (technical) necessary for effective and creative use of technical equipment in their training. Thus, there are situations where improper use of new technologies lead to the adverse effects projected. Although the use of technical equipment must have supporting role learning activity in training, not infrequently the computer is used for reading a text-only format on the screen, which can impact the impression employees to use new technologies for the benefit of training, proven by the average of the responses above.

Table 1
The Level of Appreciation of the Employees Against Material Resources Used in Education Programs

Conditions/ Answer	I totally agree	I agree	I am not agree	I totally disagree	I don't respond	Total	Average
Physical space allowed conduct in good conditions for the courses	40%	20%	30%	10%	0	100%	3.0
The facilities were proper for the course	55%	25%	10%	10%	0	100%	3.1
The learning materials were useful deepening theme	35%	45%	15%	5%	0	100%	2.9

Also, here are some opinions from group interview with employees from automotive companies:

P1: A while ago, classes from trainings were otherwise dull prevail lecture, there were no modern means, but now everything has changed ... I am exciting, teamwork, communicating with trainers, access to a range of variety of means.

P2: I understand that my skin is not enough to bring to our news colleagues, but they must be presented in an interactive way, not courses where the notions abound, but more practical examples, trainer to be opened, ready to answer questions.

P3: It tries increasingly involve students in their own learning through using interactive methods.

P4: Methodology training is often a serious problem of courses offered. I'm surprised anchoring in traditional trainers, who often resort known only to lecture.

P5: I learned from all courses in which I participated, in different ways. I asked many questions related to training, but often not found the expected responses. And it was one of the gains courses that my training considered weak. We learn firsthand what it meansmethod, a style.

So some training are having a lot of benefits and also some training remains deficient in this light, hovering between two extremes: on the one hand, overuse of modern methods, which cause a degree of formalism in their use and has little effect in terms of vocational training; on the other hand, anchoring the traditional strategy, which does not require the active involvement of students in their training and do not support their needs into practice the theoretical knowledge assimilated.

Assessment of employees is an important component of an approach forming multiple roles that it has: highlights the extent to which objectives were achieved; provides feedback on results in the formation of learners and their progress (level assimilation of information, skills acquired, the degree of reflection on new knowledge, forming new attitudes etc.); trainer ensures a image of efficiency and quality of his performance.

Another area watched our investigation refers to impact continuing education programs, a particularly important aspect for a better understanding of current training policies and for substantiation of new specific policies for professional development.

Although most employees appreciate the use of modern strategies in continuing education, they proposed a series of specific measures such as: skill development trainers on the use of methods modern methods of training and adaptation to different learning contexts; training strategies connection and to the specific needs of the target group; focus on methods support the application of theoretical knowledge in practical situations.

Based on existing researches, the following observations regarding the use of tools to identify training needs of the automotive companies:

a) most important way to identify training needs is the proposals by the heads of departments. Equally, an important source of investigation is the need for training and performance evaluation reports employees;

b) significant attention is given and the content of the job, offers submitted by various training providers and recommendations;

c) not given much importance in determining training needs consultation and contract staff based on their questionnaires regularly.

Particularities of the professional training and development are – according to group interviews and according to a study research are:

i) last training course attended by employees of public institutions;

ii) participation over time in various training courses.

For the last training course was considered a number of issues:

a) how to achieve the rate;

b) year in which it took place;

c) type of place that was conducted;

d) institution covered the costs of the training.

To assess the views of central government employees made over time on training activity were taken into account:

a) the courses in relation to certain standards (compliance program distribution training materials, course evaluation by participants at the end of its assessment of the students, etc.);

b) quality of courses supported by various institutions and training service providers;

c) satisfaction of trainees in relation to certain aspects of training (Quality benefits lecturers, thematic courses, held in the location etc.);

d) attendance of training activities within the participants.

2. Conclusions

Offer of continuous training - managers and other categories of employees - includes a variety of courses and forms of organization, which provide some flexibility to continue training system increased possibilities for adapting it to the needs of different categories target. Analysis of this remark offers a number of priority areas training and topics of interest to a significant weight category taken to be analyzed, on the one hand, the changes implemented at work or general labor market and, on the other hand, their personal development needs.

The strengths of the training courses are dotted concrete aspects related to: assessment strategies used (variety of forms and methods used, focusing on identifying and improving the mistakes during the development of training sessions); ways of organization (focusing on the positive valuation as organizing training close to home); duration and placement rates over time; Financial issues (gratuity courses).

As features of professional development, we evaluated the following hypotheses:

- Employees seeking guidance and support personal and professional development.
- The need for professional development varies by seniority being higher for that are in the early career.
- The need for professional development varies depending on the individual's age is higher in younger.
- The need for professional development varies by education level of individuals.
- The need for professional development varies by the individual's learning style – it is greater for those who learn better with others than those who learn better by themselves.

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PARTICULARITĂŢI ALE NEVOILOR DE FORMARE PROFESIONALĂ ÎN DOMENIUL AUTOMOTIVE
Studiu de caz

(Rezumat)

Sunt prezentate informaţii de bază şi câteva particularităţi importante în dezvoltarea unui sistem structurat de formare şi dezvoltare profesională continuă, într-un sistem transparent şi flexibil, cu un nivel adecvat de finanţare şi o puternică

implicare a partenerilor sociali vizând creşterea ocupabilității, adaptabilității şi mobilității forței de muncă.

În ceea ce priveşte particularitățile de dezvoltare profesională, în această lucrare,am evaluat următoarele ipoteze: majoritatea angajaților doresc îndrumare şi sprijin în dezvoltarea personală şi profesională; nevoia de dezvoltare profesională variază în funcție de vechimea în muncă, fiind mai redusă pentru cei cu o vârstă mai inaintată şi mai mare pentru cei care sunt la început de carieră; nevoia de dezvoltare profesională variază în funcție de vârsta individului şi este mai mare în rândul celor mai tineri; nevoia de dezvoltare profesională variază în funcție de nivelul de educație al persoanelor; nevoia de dezvoltare profesională variază în funcție de stilul de învățare al individului - este mai mare pentru cei care învață mai bine în grup, decât cei care învață mai bine singuri.

Echipamentele tehnice moderne nu asigură în mod automat calitatea şi promptitudinea de formare. Unii formatori chiar au competențele tehnice necesare pentru utilizarea eficientă şi creativă a echipamentelor tehnice în formarea angajaților, dar există şi situații în care utilizarea necorespunzătoare a noilor tehnologii duce la efecte contrare celor aşteptate.

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CONSIDERATION OF THE RISK OF FIRE IN THE CONTEXT OF PROVIDING SAFETY AT WORK

BY

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Abstract: Having in view the necessity to ensure a safe working environment, it should not be neglected the importance to ensure an appropriate level of security to fire, in this context it would have to be emphasized the importance of buildings in which various economic and social activities develop. In the context of providing fire safety of the buildings, the risks can be diminished by taking measures to reduce the possibility of fire outbreaks and development (preventive measures) or through the adoption of certain measures to limit the spreading of fire inside and / or outside of the building, as well as to locate and extinguish it quickly, reducing as far as possible its consequences.

Keywords: workplace; fire safety; risk of fire; measures of protection.

1. Considerations on the Risk and Security

According to the provisions of Government Decision no. *1091*/2006, transposing the Directive 1989/*654*/EEC, the first of the minimum safety and health requirements imposed for workplaces, refers to buildings which shelter these jobs.

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From a certain point of view, we cannot talk about the security of a building users who are placed in an unsafe building, in other words, users' security depend in the greatest extent on the safety the building, which shelters them. On the other hand, safety can be achieved only by maintaining the risks within certain limits considered acceptable.

The security of a technical system (as performance) represents the ability of the respective system not to produce any critical event or catastrophic consequences (Bălulescu & Călinescu, 1979). The same as to any other technical system, a certain level of security can be associated to a building.

This level of security may be highlighted by analysing the security as a function of risk, that is $S = f(R)$. It is noticed (Fig. 1) the fact that the technical system will ensure a higher level of security as far as the level of risk associated to it, is smaller.

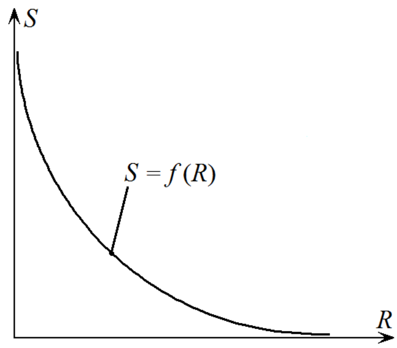

Fig. 1 – Graphic representation of the relation security-risk (Farcaş,1990).

An estimation of the risk in question can be considered as a scientific way of responding to three questions (Flucuş, 2001):

1) What might happen?
2) How bad it would be if it was going to happen?
3) How far as possible is it to happen?

Therefore, the concept of risk involves the association of two components:

a) the probability of producing an adverse event (P);
b) the gravity of its consequences (G).

In other words, the risk (R) could be considered as a potential loss expressed by multiplying the occurrence of an event (P), with the gravity of the event (G):

$$R = G \times P. \tag{1}$$

The materialization of the correlation *probability-gravity* assumes in advance to establish the criteria for assessing the gravity of consequences.

These criteria are established by rules or are negotiated. The graphic representation of the respective correlation probability-gravity highlights two fields of risk: the field of the acceptable risk and the field of the unacceptable risk respectively (Fig. 2).

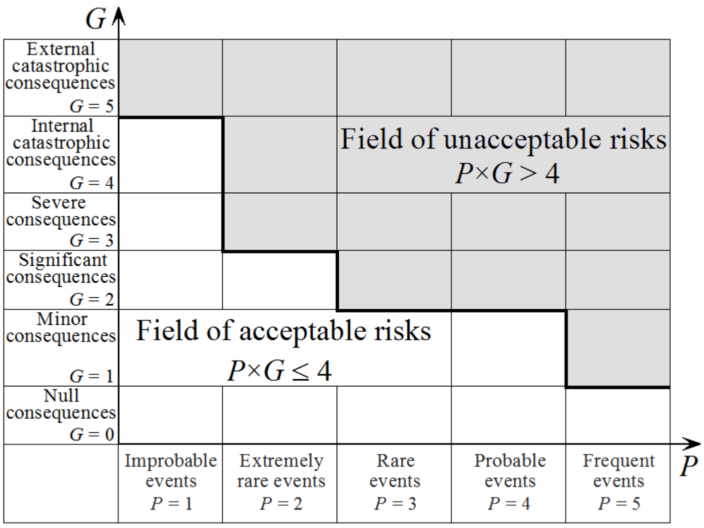

Fig. 2 – Graphic representation of the risk in probability-gravity system of coordinates.

As a general rule, the risks profile is materialized through the establishment of a reference value $(P\times G)_{ref}$ of the product between the value P associated with the probability p (hour^{-1} or year^{-1}) for the production of an unwanted final event and level G of its gravity, expressed according to the scale of gravity assessment. Setting the level of acceptable risk, represents a compromise that should be done and which shall be based on the cost associated to the risk imposed by the measures of security which are to be taken. To be considered acceptable, the product $P\times G$ must at most be equal to the reference value $(P\times G)_{ref}$.

Using the grid / scale probability-gravity and highlighting the area which separates the two fields (the field of the acceptable risk and that of the unacceptable risk) can be emphasized following three variants that allow the passing from the field of unacceptable risks to the field of acceptable risks by:

a) Decreasing the probability of the production of an unwanted event by recourse to preventive measures;

b) Reducing the gravity of its consequences, by adopting appropriate protective measures;

c) Transferring the risk (more exactly its financial consequences), usually to insurers by creating an artificial movement of the separation curve of the fields of risk.

2. The Risk and Safety to Fire

In the particular case, when the adverse event is a fire, the answer to the first two of the three questions mentioned above refers to the potential that a suite of possible events displays by leading to the production of harm to a certain level due to fire-fighting equipment (therefore, to endanger the respective technical system), and the answer to the third question represents the expression of the probability of fire outbreak. Having in view those shown above, the expression of the risk for an event *R* to be produced can be written as it follows:

$$R = A \times B, \tag{2}$$

where: *A* is the factor of activation of the factors of risk which quantify and the probability of fire-fighting equipment; *B* – the extent to which the respective technical system may be put at risk (put in danger).

For a correct approach, in the followings there are mentioned some concepts of events represented by fire.

Fire represents a burning initiated by a well defined cause, deliberately or not, out of control, its consequences being the production of material damages and for its interruption it is necessary a fire fighting action.

Therefore, not any burning constitutes a fire. To define a fire, it is necessary the coexistence of:

- The existence of a burning which has been got out of control;
- The generation of loss of lives or material assets;
- The necessity of intervention through a fire-fighting action by burning interruption or liquidation.

If one of these components is absent, it cannot be said that a burning represents a fire. To initiate a fire, it is required the interaction of:

- *The source of ignition* and, the manner to produce it implicitly, the source which possesses the minimum energy required for igniting the fuel;
- *The existence of the combustible material* (gas, liquid, solid) in sufficient quantity to support the combustion;
- *The existence of certain circumstances determined* to put in contact the source of ignition to the combustible mass.

The means that produce the sources of ignition may be: electrical devices (appliances, means of electric illumination, conductors and other equipments); systems that produce static electricity (storage, handling and transport of liquids or combustible powders); equipment, tools and gears which charge electrostatically; means with open flame (lighters, matches, lamps, medicinal alcohol lamps, candles, torches, flares); fire in open air; cigarette; heating appliances (boilers, ovens, appliances for cooking, stoves, dryers, tools for welding, cutting or bonding with any gas or combustible liquid); tools and actuators (engines, locomotives, machines); metals (materials) which are burning or are causing melted leaks; pipes (channels) for thermal agents, ventilation or products of combustion (downpipes and smoking chimneys); steam heating or technological downpipes or other warming liquids; products which can be self ignitable; products and substances which may cause explosions; thunder struck; bodies overheated by the sun.

The range of materials and substances which are the first to ignite under the action of ignition sources is very broad; they can be under the form of gases (vapours), liquids or solids (including those under the form of powder).

The determined circumstances can be grouped as it follows: electrical appliances under tension, defective electrical installations, improvised electrical equipment; defective heating systems, improvised or unsupervised means of heating; chimneys, smoking downpipes which are defective or un cleaned; ashes, embers or sparks from the heating systems; children's playing with fire; smoking; open fire; welding; self ignition (spontaneous ignition) or chemical reactions; mechanical, electrostatic or friction sparks; leaks (glitches) of inflammable products; technical malfunctions of fitting construction and technical malfunctions of exploitation; organizational irregularities; explosion followed by fire outbreak; technical accident; lightning and other natural phenomena; intentional action (arson).

The classification of fires reported to the causes actually produced, can be made depending on the items mentioned above, but, in most cases, they opt for the classification according to the ignition sources. Therefore, the following categories can be detected: sources of ignition with flame; thermal sources of ignition such as heat; electrical sources of ignition; sources of self-ignition (spontaneous ignition); mechanical sources of ignition; natural sources of ignition; sources of ignition specific to explosives and flaming materials; sources of indirect ignition (the radiation from a fire, the flame of an explosive mixture, etc.).

The type of *arson* fires (intentional fires) (Ivas *et al*., 2001; NFPA Quincy, 2002), increasingly frequent in the current social and economical context are separately treated, due to their distinguished peculiarities, although the used sources of ignition as a rule of flamers are to be found in the previous categories.

3. Risk of Fire and Measures to Reduce it

It can be appreciated that the risk of fire R_f is in the field of acceptable risks if it satisfies the condition:

$$R_f \leq R_a, \tag{3}$$

where: R_a is the accepted risk of fire for the analysed objective type.

In this context, fire safety (S_f) of the building may be considered as being ensured when the condition is fulfilled (NFPA Quincy, 2003; *P 118-99*, IPCT, 1999; *GT-030-01*, IPCT, 2001):

$$S_f = \frac{R_a}{R_f} \geq 1 \qquad \text{or} \qquad S_f = \frac{R_f}{R_a} \leq 1 . \tag{4}$$

Starting from that danger which can be mitigated through appropriate measures, it can be defined the endangering as being the ratio between the potential danger (P) and the ensured protection (M) (*GT-049-02*, IPCT, 2002), according to a scenario of safety (protection concept):

$$B = \frac{P}{M} . \tag{5}$$

The characterization of the respective risk in the context of the applied measures of protection is the so-called *real risk of fire*. By introducing the endangering defined in relation (2), the expression of fire real risks in the context of the implemented measures (R_{fr}) may be written as it follows:

$$R_{fr} = \frac{P}{M} \times A , \tag{6}$$

where: A is the factor of danger activation and quantifies the probability of a possible fire.

A mathematical method, currently used in Romania, is derived from the method used by engineers and architects from Switzerland Association (SIA) where the *real risk of fire* that a building presents for its users and neighbourhood, is determined with the above mentioned relation (6).

To maintain the fire risk within acceptable limits, two main categories of measures can be taken:

- *Preventive measures* that are intended to reduce the probability of fire without increasing the gravity of its consequences;
- *Protection measures* which aim to reduce the risk by reducing the consequences of fire without decreasing the probability for the latter to be produced.

The transfer of the risk to insurers (measure to which quite often it is appealed in the context of the chase for profit), unable effectively to diminish neither the probability nor the gravity of the consequences of a possible fire, do not represent an actual method of reduction of the risk of fire.

In relation (6), its numerator takes into account both the factors of risk arising from fixed and mobile substances and materials (P_1) and the factors of risk derived from the conception of building (P_2), the product of the two categories of factors representing the potential danger (P) which is determined by the relation:

$$P = P_1 \times P_2 , \quad (7)$$

where: P_1 represents factors of risk generated by the used substances and materials:

$$P_1 = q \times c \times r \times k , \quad (8)$$

where: factor q takes into account the thermal load density; factor c takes into account the combustibility of materials; factor r takes into account the danger of smoke; factor k takes into account the potential for toxicity of the burning products; P_2 represents factors of risk resulted from the conception of the building:

$$P_2 = e \times i \times g , \quad (9)$$

where: factor e takes into account the building height, fire department or room; factor i takes into account the combustibility of the building elements; factor g takes into account the shape and the size of the fire compartment.

The numerator of the relation (6) takes into account the protection ensured and reflected through the factor of the measures of protection (M). These measures of protection may be:

a) measures of passive protection provided by the constructive protection;

b) measures of active protection provided by equipping with appliances for fire detection and fire fighting;

c) measures of operative protection which implies organized intervention on fire with forces and special means (*GT 050-02*, IPCT, 2002; MAI Order no. *210*/2007).

The factor of the protection measures (M), which takes into account all the adopted protective measures and / or made to diminish the potential risk of fire, has the following expression:

$$M = F \times E \times D \times I . \quad (10)$$

Factor F (passive protection) takes into account:

a) the degree of resistance to fire, the correlation between the destination and the number of permissible levels, anti fire compartmentalisation and separation of different spaces;

b) finishes combustibility and smoke exhaustion;

c) assurance of people’s evacuation.

Factor E (active protection) takes into account the equipping of the building with signalling and fire fighting systems.

Multiplying factors $D \times I$ represents operative protection.

Factor D takes into account the intervention at the workplace from the objective.

$$D = D_1 \times D_2 \times D_3 , \tag{11}$$

where: we have provision of means of intervention (factor D_1); organizing the staff's intervention in fire and his specialization (factor D_2); the existence of persons for the implementation of the measures contained in the organization of intervention at the workplace and their training level (factor D_3).

Factor I takes into account the ability of intervention of the specialized forces for fire fighting and is estimated based on the relation:

$$I = I_1 \times I_2 \times I_3 , \tag{12}$$

where: I_1 is the factor which takes into account its own civilian fire service category or the service with which it was concluded a convention; I_2 is the factor that takes into account the category of the military firemen subunit that intervenes in case of fire; I_3 is the factor that takes into account the starting time of the civilian fire service intervention or that of the military fire fighters determined by the times of alarming, alerting, moving and entry into action of the concentrated forces.

Normally, there is interdependence between the three categories of measures of protection. Therefore, through a good correlation of the passive protection with the active protection:

a) it allows the increase of the built maximum area of a fire compartment in case of completing the passive protection measures (the constructive ones) with appropriate measures of active protection - up to 100% in case of equipping the buildings with automatic water extinguishing systems and up to 25% in case of equipping the buildings with automatic fire alarm systems (MAI Order no. *234*/2010);

b) it can reduce the limit of resistance to fire for some of the elements of construction;

c) it can extend the field in which the unprotected or partially protected metal structures (by equipping with automatic extinguishing systems that provide cooling water during standardized elements) are admitted.

Correlating the passive protection (accomplished by constructive elements) with the possibilities of operative intervention (the existence, the equipping and the efficiency of fire fighters service, the distance to them, the possibilities of announcement, the operative intervention times, etc.) may be also taken into account by reducing the limit of the resistance to fire of the delimiting structural elements (providing the limitation of fire spreading only until fire fighters' intervention).

When choosing one or another measure of protection, the long-term economic issues should not be neglected.

The adoption of fire protection measures, mostly constructive in nature (the passive protection), may have a higher investment cost which can be compensated by lower operational expenses related to the maintenance of the fires prevention and extinction means.

The protection of a building mainly through active protection systems (automatic extinguishing systems) can lead in some cases to the decrease to some extent of the investment spending, however this short term economy might lead to higher costs in the operation of the building. It should be borne in mind the fact that some beneficiaries, at one time, may abandon (without taking into account the consequences), just in order to reduce the operating costs of construction, the maintenance in running state of the active protection systems which might have as result the inadmissible reduction of the levels of security of the respective building.

The diminishment of fire risk and the increase of fire safety, by establishing its own fire services or concluding agreements which have as subject the intervention in case of fire (the operative protection) might lead to a substantial reduction of the investment costs, but at long term the expenses would be high enough to ensure the safety against fire after commissioning.

We believe, however, that increasing the share of operational protective measures against the other two categories of protection measures should have real economic efficiency in case of the necessity to protect at fire action by an interim arrangement or one with a seasonal functionality that would be obviously unrealistic by raising (for example) massive anti-fire walls or installing complex extinguishing systems with automatic operation.

The assessment of the risk of fire for a building cannot be complete without taking into account the possibility of the deliberate firing (arson). The assessment of Arson risk is complex, requiring a sociological investigation, not only a technical one, which takes into account the social, economic, even political aspects in the area of the objective, the atmosphere of team work, the neighbours' attitude, etc.

The risk of arson is achieved on the basis of the values obtained for the assembly of arson threat and level of protection against arson.

The determination of the risk of arson is achieved by methods scientifically based and involves three steps:

(a) Stage I - the identification and assessment of the danger of arson;

(b) Stage II - setting the level of protection against arson;

(c) Stage III - comparing the calculated risk with borderline acceptable level (according to the process of determining the risk of arson approved by (NFPA Quincy, 2002), the acceptable limit is reached when the danger level R(ii) < 20 and the protector P(ii) > 31) is calculated.

No building is practically perfectly defended by an arsonist. There are also vulnerable buildings: isolated, without public, without intrusion and fire fighting detection systems, without lighted spots, security and access to improperly secured or unsecured, neighbourhoods frequented by children or homeless.

4. Conclusions

In the context of ensuring fire safety in constructions, the risks can be mitigated by measures aimed to limit the power of fire outbreak and its development (prevention) or by adopting measures that allow the limitation of fire spreading within and / or outside the building, and the location and its rapid extinction reducing as much as possible the consequences.

From the categories of protection measures of buildings against fire outbreak, the operational protection measures should not be omitted.

Given the often unsatisfied quality of services offered by some insurance companies from nowadays we consider that it is recommended not to let only in the insurers' care the potential losses due to eventual fire outbreaks, especially in situations in which life may be put in danger and the integrity of the building users as well at least morally, unquantifiable in money.

In the design phase, there should be chosen with responsibility and technically and economically well-founded fire protection measures and their ratio should be determined judiciously as well, so that to ensure an optimal level of fire fighting safety on long term after the commissioning of the building.

During operation there are required to be taken general prevention measures (which necessarily must consider and reduce the risk of arson), such as:

a) physical security of the company or building, particularly at night and on Saturdays and Sundays, fixed posts and mobile security, strict regulation of access, surveillance, and illuminating the entire perimeter, including backstreets. In this context, the functionality and practicality of escape routes in case of fire outbreak should not be affected in any way;

b) providing electronic surveillance systems and certified facilities: central fire detection and intrusion-signalling, extinguishing systems (sprinklers, gas, etc.);

c) limiting to minimum the quantities of combustible materials from the buildings of production (especially raw materials, semi-finished or finished products which must be kept at workplaces in quantities as small so that not to exceed what is needed for a working day);

d) immediate removal of suspicious circumstances: tanks with flammable liquids or combustible materials which are overcrowded in places where their presence is not justified;

e) avoiding concentrations of combustible materials (including archives kept in inadequate conditions) in basements, attics, etc.;

f) immediate removal of defects (cracks in heating devices, unprotected electrical conductors etc.) that can promote fire;

g) knowing and taking into account the mood of the subordinate staff and notifying to the police unit about the threats coming from the part of disgruntled or recently fired persons.

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CONSIDERAŢII ASUPRA RISCULUI DE INCENDIU ÎN CONTEXTUL ASIGURĂRII SECURITĂŢII ÎN MUNCĂ

(Rezumat)

Având în vedere necesitatea asigurării unui mediu de muncă sigur nu trebuie neglijată importanţa asigurării unui nivel corespunzător de securitate la incendiu, în acest context impunându-se a fi evidenţiată importanţa clădirilor în care se desfăşoară activităţile economice şi sociale. În contextul asigurării securităţii la incendiu a

clădirilor, riscurile pot fi diminuate prin luarea unor măsuri vizând limitarea posibilității izbucnirii şi dezvoltării incendiilor (măsuri de prevenire) sau prin adoptarea unor măsuri ce permit limitarea propagării focului în interiorul şi / sau exteriorul clădirii, precum şi localizarea şi stingerea rapidă a acestuia reducând cât mai mult eventualele consecințe.

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RISKS TO THE USE OF TECHNICAL EQUIPMENTS USED IN MECHANIZED HANDLING OF MASSES

BY

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Abstract: In this paper the authors present a point of view on the use of lifting equipment in areas which require manipulation of the masses, so that labor productivity should directly relate to their use. Using lifting equipments is seen as a solution to combat musculoskeletal disorders by replacing the manual handlings with the mechanized handlings. In Europe, musculoskeletal disorders are the most common health problems related to work, affecting millions of workers. There are also presented here the measures taken for the proper use of lifting equipments, measures taken after assessing the risks of accidents and professional diseases at the workplace.

Keywords: masses manipulation; lifting equipments; risks; maintenance.

1. Introduction

Musculoskeletal disorders (MSDs) represent an important health issue involving the professional factor as well. In Europe, musculoskeletal disorders are the most common health problems related to the workplace, affecting millions of workers. Thus, 25% of workers from the EU suffer from backache and 23% report muscular pains. MSDs are caused mainly by manual handling, frequent bending and twisting, heavy physical work. About 40% of the costs of

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compensations allocated to the workers of the European Union are caused by MSDs. They reduce company profitability and increase the social costs for governments.

The European Agency for Safety and Health at Work has launched since 2007 a campaign to tackle MSDs at the workplace, with the theme “Lighten the Load !”, which supports an integrated management approach with three key elements. In this regard, employers, employees and government should cooperate in order to tackle MSDs.

The finality of safety and health activity at work is to reduce the risk related to life, health or physical integrity of those who perform the work. To achieve this goal, the law (Law no. *319*/2006) with its norms (Government Decision no. *1425*/2006; Government Decision no. *955*/2010) and the Framework Directive (Council Directive 1989/*391*/EEC) imposed obligations on employers’ and employees’ duties. The law sets out specialized bodies of state administration units following the way how the workers apply and comply with labor safety. Therefore, the activity of labor security is not left solely to the discretion of operators, but being implemented in all sectors of economic and social life, the state provides the control of its fulfillment as well.

The Framework Law sets out general principles on the prevention of occupational risks, the protection of workers’ safety and health of workers and that of other participants in the process of work, the elimination of the risk factors and accidents, the notification, counseling, balanced participation under law provisions, the training of workers and of their representatives and general directions for the implementation of the above mentioned principles.

Having in view the dynamics of economic activities, it is required the use of lifting equipments in fields which require the manipulation of masses, so that labor productivity should directly relate to their use. Safety and health of operators / users of these systems is an important factor in the overall process and in this context we will address the concept of maintenance of work equipment for mechanized handling of large masses.

We can define *maintenance* as a process of continuous monitoring and verification (the due date as well) of lifting equipments with the implementation of correct procedures of use, systems verification systems and generally for a well functioning, technical intervention itself and proper drafting / completion of documents of surveying in time of equipments, according to the legislation in force.

The maintenance of the lifting systems in perfect operating conditions corresponds to a package of technical and organizational measures reflected directly in the safety of users and the continuity of economic activities, substantially reducing their maintenance costs.

2. Risks in the Operating Activity of Lifting Equipments

Risk assessment helps employers who are obliged, according to law framework, to adopt adequate preventive and protective measures with respect to:

a) prevention of occupational risks;

b) workers' training;

c) workers' information;

d) implementation of a management system to enable effective implementation of measures for labor safety and health at work.

For this purpose we have undertaken a comprehensive approach that includes (Pece, 2010):

a) assessment of the occupational risks;

b) compliance of technical equipments machinery;

c) establishing the procedures;

d) improving the working conditions;

e) staff's selection, training and information;

f) setting out the managerial strategy.

The basic aim of the assessment always consists in the prevention of occupational risks, but the achievement of this goal is not always possible in practice. Where it is not possible to eliminate the occupational risks, these ones should be reduced and the residual risks should be controlled. In the next stages and within a rigorous program of control, residual risks will be reassessed by analyzing the possibility of their supplementary elimination or reduction, following the developments in scientific or technical knowledge.

In this context, the practice should be allowed a minimum risk limit should be allowed, a level of risk which should be different of zero, but low enough to consider that the system is safe, as a maximum risk limit, which should be equivalent to a low level of security so as the system functioning not to be allowed.

The risk is defined according to EN 292-1:1991 as being "the combination of the probability and severity of an injury or attack on health which may occur in a dangerous situation" (Fig. 1).

Risk assessment supposes the identification of all risk factors from the analyzed system and the quantification of their size, on the basis of the combination of two parameters: the probability of the maximum possible manifestation and the severity of the consequence (the most common one) on the human body.

This principle of risk assessment is already incorporated in European standards and underlies various methods with practical application. Therefore, in EN 292-2:1991, chapter 6 states that "the factors that should be considered in the risk assessment are: the probability of injury occurrence or health damaging and the maximum severity of injury or health damage that is expected”.

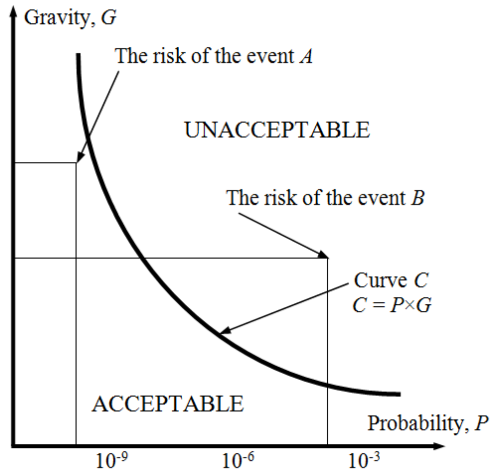

Fig. 1 – The curve of acceptability of the risk.

The curve of acceptability of the risk (CEN 812: 1985) allows the differentiation between the acceptable and the unacceptable risk. Thus, the risk of an event A occurrence, with serious consequences, but with a very low frequency placed under the curve of acceptability is considered acceptable and the risk of the event B, with less serious consequences, but with a higher probability of occurrence of whose coordinates are above the curve, is unacceptable.

Gravity is assessed according to standard MIL-STD-882 E: 2012, by the assessment of the worst accident that could have caused that risk factor. The probability is, according to the same standard, the frequency of undesirable event and may be described as the potential occurrence per unit time or reported to population, item or situation.

If we refer to commercial activities that require the use of lifting equipments, especially where storage areas coincide with sale areas and in addition to the employees involved in the work process there are also persons who interact occasionally with the working environment, the sphere of working procedures widens involving special security rules that make reference to the following issues:

a) acoustic and visual movements of lifting equipments;

b) areas isolation by delimiting them with signaling items that indicate the restricted access area in the moment of lifting and lowering operations of the masses (Fig. 2).

Fig. 2 – The way of restriction areas delimitation.

To perform correctly the risks assessment we must use the machines security standards (EN 1050: 1996; ISO 12100: 2010). For each component of the work system (means of production, work environment, work tasks, executor) there were analyzed the identified risk factors, their harmful action on the human body and the seriousness of the immediate consequences on the operator (Table 1).

Table 1

The Risks Identified in the Assessed Work System

Work system components	The identified risk factors	Concrete form of risk factors manifestation (description, parameters)
Means of production	Mechanical risk factors	F1. Hit made by the technical equipment (pallet truck, forklift)
		F2. Crushing of the parts of the body with the passage of wheel forklifts, pallet trucks over the feet, hands, etc.
		F3. Automatic launcher or counter indicated automatic blockings of the functional movements of the supplied technical equipment
		F4. Movements under gravity: sliding, rolling, rolling on wheels, rear-freefall
		F5. Underwater propulsion effect: deviation from the normal trajectory, balance, recoil
	Physical risk factors	F6. Traffic accidents
		F7. High air temperature in summer (it is enclosure temperature (work environment refers to room temperature, not to the external temperature). Cold microclimate labeling and storage spaces non-food items in the area at reception in winter

Table 1
Continuation

Work system components	The identified risk factors	Concrete form of risk factors manifestation (description, parameters)
Means of production	Physical risk factors	F8. Noise over 87 dB in sections of reception
		F9.Air flow through forced ventilation
		F10. Low level lighting in some dimly lit areas / flickering phenomenon
	Biological risk factors	F11. Micro-organisms in air suspension, air conditioning devices (Legionella). Macro-organisms (insects / rodents)
Work environment	Chemical risk factors	F12. Gases, vapors, toxic aerosols, allergens or irritants at work with washing solutions
	Physical-chemical risk factors	F13. Dust, powders in suspension
	Ergonomic risk factors	F14. Working positions (prolonged standing, prolonged sitting position, other forced / vicious positions
		F15. Repetitive movements
		F16. Intense rhythm of work
		F17. Extended work schedule
		F18. Work in alternating shifts
	Organizational or psychosocial risk factors	F19. Improper alternation of the actual work time and breaks / breaks giving up
		F20. Routine / monotony
		F21. Interpersonal relations: employer-employee, employee-subordinate employee, employee-hierarchical chief, employee-supplier, employee-client
Work tasks	Inappropriate content	F22. Transmission of work tasks through intermediate
		F23. Wrong operations, rules, procedures
		F24. The absence of operations
	Psychical overstrain	F25. Stress caused by the intense rhythm of work, short and quick decisions on short term and negotiations
		F26. Short-cycle repetitive and complex tasks
		F27. Static effort / exercise
	Wrong actions	F28. Making contingency operations: moving with potential danger from the same level; disrupting or slipping on wet surfaces without adhesion

Table 1
Continuation

Work system components	The identified risk factors	Concrete form of risk factors manifestation (description, parameters)
Executor	Wrong actions	F29. Use of lifting equipments without mandatory verification at starting the work
		F30. Information on accidents
		F31. Carrying out operations outside the work tasks, movements and halts in dangerous areas: in the area of the operation of the fork-lift of the load taken out from the ground, etc.
		F32. Starting to run the lifting equipment (forklifts) without verifying the existence and functioning of the provided means of protection, provided, leaving the machine and letting it running state
		F33. Use of forklifts without taking its control and verification on shift
	Omissions	F34. The omission of some operations for labor security
		F35. The unused of means of production (chains for forklifts)
	Factors that depend on human body	F36. Exercise / training
		F37. State of health and sickness
		F38. Negative / positive emotions
		F39. Fatigue
		F40. Individual psychical particularities / features
		F41. Nourishment
	Factors that are part of worker's social status	F42. Transportation domicile-workplace-domicile
		F43. Consume of alcohol

The level of risk of the 43 identified factors is shown in Fig. 3.

The share of the identified risk factors is shown in Fig. 4.

To reduce the overall risk value when assessing the risks of accidents and professional diseases for the use of lifting equipment were implemented a series of measures.

The Authorization of lifting equipment operation shall be issued by ISCIR (State Inspection for Control of Boilers, Recipients under Pressure and Lifting Equipment) based on the technical regulations on safety in running state. The technical verification of the lifting equipment is performed by CNCIR (National Company for Control of Boilers, Recipients under Pressure and Lifting Equipment).

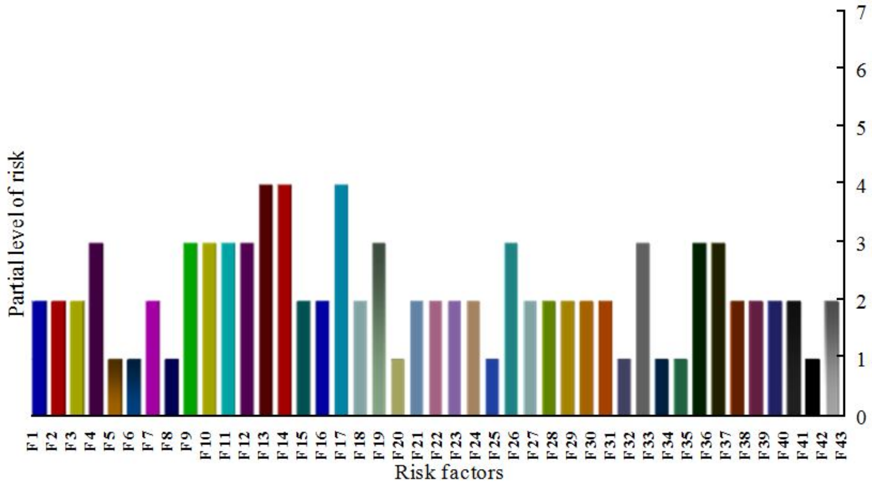

Fig. 3 – Levels of established risks.

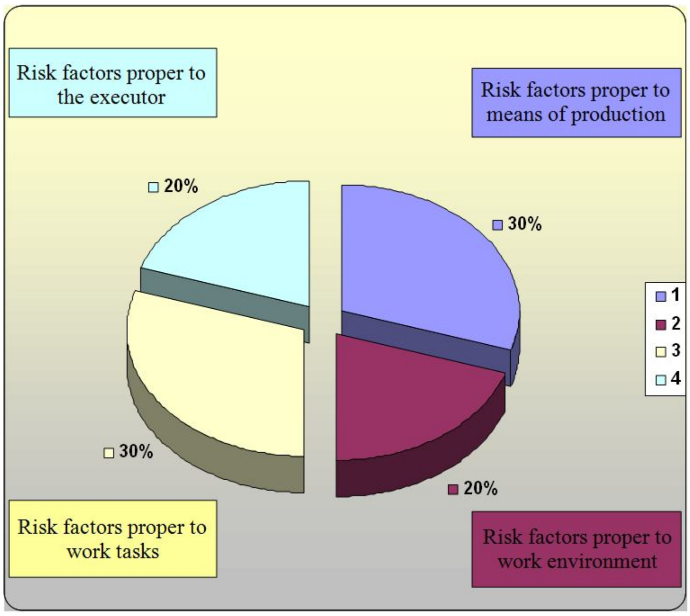

Fig. 4 – Share of risk factors in the analyzed work system.

In order to assure the safe operation system, the units which hold or use lifting equipment have the following duties and responsibilities:

a) To record the installations to ISCIR: to draw up and update their centralized record, according to technical regulations;

b) To have technical verification to the installations facilities executed by CNCIR staff or by their own authorized staff RSVTI (Technical supervisor of lifting equipment and vessels under pressure) according to the technical requirements;

c) *Prior* to putting into operation, to obtain from ISCIR, the operating authorization, delivered by ISCIR according to the technical regulations. It is prohibited the running operations of such facilities without the authorization issued by ISCIR;

d) To take the necessary measures for the installations to be used safely executing current revisions, repairs and maintenance, according to technical regulations;

e) To develop and equip every workplace with specific technical instructions in normal operation and the measures that should be taken in case of emergencies and accidents;

f) To use qualified staff in facilities operation. The authorization from the part of ISCIR Territorial Inspectorate is mandatory for the staff of handling auto propelled forklifts (electric or motor forklifts).

The technical requirements are mandatory for all those who design, manufacture, fit, fix, maintain, operate or verify those equipments and devices.

The lifting equipment maintenance covers the following main aspects:

- The maintenance and repairing works will be carried out by qualified staff authorized by ISCIR;

- For technical supervision of the installation is responsible the person designated by the management of the economic operator including as well the fulfillment of the condition of prior authorization issued by RSVTI;

- Any intervention consisting in: maintenance, inspections or repairing, will be written write in the equipment handbook;

- It is s strictly forbidden the removal of any safety item elements from the lifting equipments parts;

- Default systems that can have a negative impact in terms of employees' safety will be stopped and flagged as default. Their use will be made only after the intervention of the authorized service team.

3. Maintenance Program Drawn up Following the Risks Assessment

The use of lifting equipment shall be in accordance to the plan of daily and regular checks.

Daily checks are carried out before using the equipment which consists in: 1. Visual inspection; 2. Functional/running control.

1. Visual inspection is made before using the forklift and aims: 1 – steering system; 2 – warning signs; 3 – handbrake and footbrake; 4 – lifting forks; 5 – existence/non-existence of oil spills; 6 – checking the condition of the wheels.

2. Functional/running Control verification is made by maneuvers that run only from the driving seat of the forklift. Failure to comply to forklift

handling can lead to accidents, both to the person who operates and to other persons that are close to the forklift.

After finishing the risk assessment of lifting equipments, it was set up the lifting equipments maintenance program/plan and there were performed plan of revisions and periodic inspections.

The thorough and correct technical revision works represent the key prerequisite for security applications work with lifting equipment. The neglecting of regular servicing works can severely damage the lifting equipment and in addition this one may be a potential hazard to people and company. The framework conditions for the use of lifting equipment has a considerable influence on maintenance component wear.

The indicated revision/maintenance intervals are based on an operating system running during a working shift and in normal working conditions. In case of intensive applications such as massive deposits of dust, strong temperature fluctuations or multiple shifts, the intervals will be shortened accordingly.

Checklist for revision, shown below (Table 2) indicates the works that are to be made at runtime as well. Maintenance intervals are defined as:

– W = Every 50 operating hours, but at least once a week;
– A = Every 500 operating hours, but at least once per semester;
– B = Every 1,000 operating hours, but at least once a year;
– C = Every 2,000 operating hours, but at least once a year.

Servicing intervals W will be performed by the user through his own authorized staff. In the running-in phase - after about 100 operating hours - of the lifting equipment, the user is required to perform a check of wheel nuts or wheel bolts and their tightening if it is necessary.

Revisions A, B, C will be performed by his own stuff or by specialized companies authorized to carry out checks based on a maintenance contract.

Table 2
Samples of Checks at Regular Revisions of Lifting Equipment

		Revision intervals				
		Standard = ■	W	A	B	C
Braking system	1.2	Checking the brake garnishes wear off and checking brake drum diameter			■	
	1.3	Brake fluid level check, its correction			■	
	1.5	Control fittings and piping tightness			■	
Electric installation	2.1	Checking the tools, indicators and switches control functioning			■	
	2.5	Checking the lights functioning			■	
	2.7	Relays checking			■	
	2.10	Checking density and acid level of battery voltage			■	

Table 2
Continuation

			Revision intervals			
		Standard = ■	W	A	B	C
Lifting equipment structure	4.1	Checking the fixation frame elevator			■	
	4.3	Checking counterweight stability			■	
	4.5	Checking driver's seat and the restraint system			■	
Hydraulic installation	5.1	Checking elevator bearing frame			■	
	5.7	Checking the angle of the frame elevator			■	
	5.9	Checking the hydraulic system			■	
	5.13	Replacing the hydraulic oil				■
	5.14	Replacing the hydraulic oil filter			■	
Steering system	6.1	Checking the steering operation		■		
	6.2	Checking the mechanical parts of the steering column			■	
	6.3	Checking the weariness and damage of the front axle and knuckle		■		
End of action	7.1	Vehicle lubrication according to lubrication plan		■		
	7.2	Race of probation		■		
	7.3	Reception after finishing the works of revision		■		

4. Conclusions

Health and safety performance related to maintenance operations of lifting equipment should be assessed and continuously improved based on audits and inspections, risk assessment results, investigation of incidents, accidents and injuries avoided at the last moment, and based on feedback from employees , contractors and staff health and safety at workplace.

Carrying out maintenance in proper conditions is crucial for the management of hazards and risks at the workplace. However, proper maintenance activity shows a high level of risk.

It is essential to implement adequate risk assessment of maintenance operations and to take preventive measures to ensure workers' safety and health. Maintenance, repairing, settings, adjustments services rank on fourth place on the list of top ten work processes representing the largest number of fatalities. Accidents have an increasing tendency more likely to occur not during normal running, but during repairing work, maintenance, cleaning, adjusting, work, etc.

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RISCURI LA UTILIZAREA ECHIPAMENTELOR TEHNICE FOLOSITE LA MANIPULAREA MECANIZATĂ A MASELOR

(Rezumat)

Se prezintă un punct de vedere privind utilizarea echipamentelor de ridicat în domeniile care necesită manipularea maselor, astfel încât productivitatea muncii să se raporteze în mod direct la utilizarea acestora. Folosirea echipamentelor de ridicat este privită ca o soluție de combatere a afecțiunilor musculo-scheletice prin înlocuirea manipulărilor manuale cu cele mecanizate. În Europa, afecțiunile musculo-scheletice reprezintă cele mai frecvente probleme de sănătate legate de locul de muncă, afectând milioane de lucrători. De asemenea, sunt prezentate măsurile luate pentru utilizarea corectă a echipamentelor de ridicat, măsuri luate în urma evaluării riscurilor de accidentare şi îmbolnăvire profesională de la locul de muncă.

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STRESS MANAGEMENT
STRESS PREVENTION STRATEGIES IN COMPANY APAVITAL

BY

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Abstract: Scientifically, stress is defined as a model of specific or nonspecific reactions of an organism to stimuli, phenomenon that affects the organism's balance because the organism gets exhausted or its capacity to fight is exceeded. Stimuli include a range of external and internal conditions, generally defined as stressors.

Stressors are stimuli that are causing the installation of stress. A stress response is a reaction of the entire body to stressors and takes the form of various combinations of psychological, behavioral, emotional and cognitive reactions.

Response to stress varies from individual to individual: some are promptly reacting to low level stresses, and hence getting heavily altered, while others can easily tackle particularly stressful events. Only those persons being in good health can contribute to value creation and profitability for their own "inner company" and, respectively, for the company where they are employed.

Therefore, the costs of stress - for example, mobbing, layoff, illness, and their consequences (loss of motivation and productivity decreasing) - play an important role inside organizations. Stress is not an employee's issue, but the entire company's issue.

Stress at work is currently, in terms of importance, the second occupational health issue, affecting 28% of workers in the European Union.

Keywords: stress; stressor; balance; management; good practice; APA-VITAL.

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1. Introduction

Usually short-term measures are limited by change strategies or strategies of solving problems.

Additional reporting means in reference to stress are to be found and used properly:

a) in stressful situations, by suppressing and avoiding the hustle, and through scientific tools and methods, by keeping people away from the stress spiral;

b) by avoiding or mitigating stressful situations;

c) methods that are at hand , by using methods and strategies to address stress situations, by changing people's behavior, by pro-active actions , by undertaking the responsibility for our actions and practicing certain relaxation activities.

The balance between body, mind and spirit is essential.

Fig. 1 – STRESS http://psihoterapic.ro/wp-content/uploads/2013/02/stres.jpg (copied from website on 23.10.2014 , 9:35 hours).

Stress management cannot be carried out in a punctual manner, but it represents a lengthy process because:

– Stress management means managing everyday life - in agreement with our selves. No immediate solutions exist, given that our patterns of behavior are impregnated paths, but such paths can be abandoned. For a healthy mix of tension and relaxation, people can adopt their own personal management measures in order to switch to "correct" behavior.

– There is no "anti-stress pill" because it's basically about a changing of attitude. Changing our personal point of view is the basis of obtaining a state of relaxation. By such a proper changing negative energy (stress) can be switched into pure and creative vital energy.

– The motto is not "faster-more-further", but it is about undertaking actions depending on situation. In this context, we have learned that stress can be treated as a problem, and successfully go further towards the solving of these problems, by means of proper measures and techniques (stress has to be regarded as a project).

– Define your own agreement related to stress and use all project management tools for the reporting of stressful situations.

– In compliance to the rule of "several hits from one shoot" stress can be reduced by physical reliefs geared towards a specific purpose, thereby bringing great benefits to your body. "BEGINNING" is the magic word.

– Avoid alcohol consumption, sleeping pills or other stimulants and quit drugs.

1.1. Prevention

Stress and relaxation are like a magnet's opposite poles. For a proper relationship with stress we need a good physical condition and we need to try to reach a balance.

The successful relation with stress can be spelled as it follows:

S = Strategies (to fight stress).

T = Tolerance (as regards mistakes).

R = Respect for "here" and "now" - recognizing what it is.

E = emotional balance, physical and spiritual.

S = Super relaxation and balancing functions, such as sports, meditation and preventive measures; taking responsibility for various situations and our own life.

Find your own balance of body, emotions and/or soul, both at job (in the sphere of professional activity), and, as well, in your private climate. Adopt your optimal method that suits you best and is the most interesting for you from the rich offer of sports and relaxation area.

In order to successfully combat stress use the following 10 steps:

1. Define your own stress diagnosis: learn to understand your own body ("listen to your heart") and try to "decipher clues".

2. Deepen your knowledge about stress and integrate the consequences is an useful way.

3. Improve the awareness as regards your own personality and your own goals and visions.

4. Reflect on how to relate with stress.

5. Define priorities .

6. Be focused on the balance between body, mind and spirit. Accept the present in compliance to the rule “It is how it is”.

7. Actively take responsibility for everything you do and thus for your own life.

8. Organize your daily activities and life by means of plans, order and priority, according to their importance.

9. Prevention is a key component of relaxation, together with meditation, sports and balanced nutrition

10. Stay balanced, relaxed and tolerant. It is better to beat stress before stress beats you.

2. Example of Good Practices in Company SC APAVITAL SA Iași

The senior management in company Apavital was focused on the accessing of European funds for investments in machinery, equipment, modern technologies, by carrying out various measures for improving the work environment:

a) building measures (stations, water tanks etc.);

b) mechanical measures (reducing noises, vibrations, ergonomic job conditions);

c) organization measures (clear measures for work organization);

d) technical measures (new technologies) - personal protective gear;

e) promoting health and safety knowledge at workplace;

Promoting health and safety at workplace - a joint effort of employers, employees and the company to improve the people’s health and comfort at work place.

This can be obtained by improving work organization and work environment, by stimulating the involvement of employees into the whole process of improving health and safety systems, the possibility of making healthy choices and encouraging the personal development.

The campaign was always concerned about the employees’ working conditions, and tries to make employees feel respected by the company and therefore, besides the permanent professional trainings programs, there is a plan for social activities and social responsibility in order to prevent psycho-social risks:

– A training center has been created (for the employees’ continuing training).

– Along the endowment of workplaces with modern technologies the company has organized proper qualification trainings for employees (ensuring that employees attend free retraining courses, this for about 250 workers).

– Employment contracts are concluded on indefinite periods, thus workers remain ensured about their job security, and therefore the stress caused by job insecurity feeling is eliminated.

– Workplaces in the company are standardized by a specialized staff, thus avoiding excessive workloads and over-charging, and therefore preventing the employees' mental fatigue.

– The re-training of employees is a risk prevention measure, related to the psycho-social stress related to job loss (already a number of employees are now already re-trained).

– As regards the work schedule this is implemented in compliance to work contracts. In reference to overtime situations these extra hours are compensated with off-work equivalent time.

– As regards the job descriptions these are drafted in compliance to law in force so that all employees know what activities are to be performed and what amount of work is required by the company.

In 2010 the company management set up a canteen at the main head-quarters, thus making possible to employees to have a hot meal during work time (in order to preserve their health and their work capacity).

Inclusion of employees into the APAVITAL community is carried out by means of internal communication:

a) the in-house APAVITAL journal, which describes aspects of the company's social life;

b) on the company's website, all press releases related to APAVITAL are daily published, in order to maintain the company's values.

In order to improve the awareness of belonging to the APAVITAL community the employees have received various promotion materials (T-shirts, caps, umbrellas, ball pens, mugs….).

In order to improve workplace conditions employees are annually consulted by means of employee consultation questionnaires (annually about 1,200 questionnaires are distributed). The questionnaires that are filled by employees are centralized at the Health-Safety where they are analyzed, and discussed during the meetings of the health and safety committee. Subsequently, all the necessary measures are carried out, in compliance to issues raised by employees.

Old age employees are valued by the company and are never forced to retire, because they have a sound professional expertise.

The company's medical office is monitoring the employees' health. Therefore in addition to the mandatory routine medical tests the senior management level has decided that employees, annually, must be subject of general tests in order to prevent any diseases and illnesses.

Following these medical tests it has been seen that some employees had illnesses that they were not aware of. Therefore, due to these test their diseases were early detected. The medical office is also surveying the employees' mental health by means of contracts concluded with psychological private medical practices.

Hence, the company manages to carry out all psychological tests that are mandatory in compliance to law (for certain employee categories and for certain trades sectors).

In order to create a comfortable internal communication system the following activities are organized":

a) various competitions: football, fishing, creativity and skill (pasta models making), cake-making contests;

b) recreational festivities for employees;

c) days celebrated inside the company: Apavital day; Mărțişor day – March 1st ; Women's Day - March 8th , New Year carols; festivities for employees' children - June 1st , St. Nicholas, Santa Claus;

d) documenting trips;

e) attending of professional exhibitions;

f) employees' children have visited the company's water plants and wastewater treatment plants.

This year the company shall also arrange chess and table tennis contests, an, also, a cross-country competition.

Fig. 2 – Pasta model making contest.

3. Conclusions

In order to prevent of psycho-social risks the company's senior management, in co-operation with the head of Human Resources Department has decided that all the staff must pass psychological tests this year.

Afterwards, at the end of the year, the results are to be assessed and new measures are to be implemented in order to prevent psycho-social risks.

All available documentation has been studied in order to deeper explore the main emerging risks that were identified in forecasts related to their spreading, their effects on health and safety, the possible prevention measures and the need for further research. Since this is a dynamic process the company shall permanently adapt to these new challenges, every year.

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MANAGAMENTUL STRESULUI
Strategiile de prevenire a stresului în APAVITAL

(Rezumat)

În plan ştiinţific, stresul este definit drept model de reacţii specifice sau nespecifice ale unui organism la stimuli, care afectează echilibru acestuia şi oboseşte sau depăşeşte capacităţile de combatere. Stimulii cuprind o paleta de condiţii externe şi interne, definite în general drept stresori. Stresorii sunt stimuli care reprezintă cauza instalării stresului. O reacţie la stres este un răspuns al întregului nostru corp la stresori şi se prezintă sub forma diferitelor combinaţii de reacţii la nivel psihologic, comportamental, emoţional şi cognitiv. Reacţia la stres diferă de la individ la individ – unii reacţionează prompt la un nivel scăzut de stres, alterându-se puternic, în timp ce alţii pot combate cu uşurinţă evenimentele deosebit de stresante. Doar sănătoşi putem contribui la crearea de valori şi la profitabilitatea propriei “firme interioare”, respectiv la firma la care suntem angajat. De aceea costurile stresului – de exemplu, mobbing-ul, disponibilizarea, îmbolnăvirea, cât şi consecinţele acestora (pierderea motivaţiei şi a productivităţii joacă un rol important în organizaţii. Stresul nu este problema unui angajat, ci a întregii firme. Stresul în muncă este în prezent, ca importanţă, a doua problemă de sănătate în muncă, ca răspândire, afectând 28% dintre lucrătorii din Uniunea Europeană.

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ERGONOMICS - A WAY TO ENSURE WORKER'S SAFETY

BY

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Abstract: Changes in the work environment in recent decades have both created new ergonomic related health problem and exacerbating existing ones in different working populations. This paper presents the basics of occupational safety and health, ergonomics, the aim and objectives of ergonomics. The authors also present the benefits of introducing health and safety intervention models, methods of ergonomic workplace evaluation or ergonomic training programs.

Keywords: occupational risks; occupational health and safety.

1. Introduction

Occupational safety and health (OSH) is an area concerned with protecting the safety, health and welfare of people engaged in work or employment. The objective of occupational safety and health programs include to facilitation a safe and healthy work environment (Health and Safety Executive, 2009). OSH may also protect co-workers, family members, employers, customers and many others who might be affected by the workplace environment. OSH can also reduce employee injury and illness related costs including medical care, sick leave and disability benefit costs.

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OSH may involve interactions among many subject areas including occupational medicine, industrial engineering, safety engineering, chemistry, occupational hygiene, ergonomics and occupational health psychology. Occupational safety is one of the most important factors contributing to productivity increases, which consequently leads to more benefits from business activities. The International Labor Organization estimates that each year around 2.3 million workers die as a result of occupational accidents and work-related diseases (Shengli Niu, 2010). So, the need to ensure a safe working environment is a prerequisite both to reduce the number of accidents and to provide high quality products and services.

In our country, the list of priorities for health and safety at work are: the development of specific measures of safety and occupational health as required by law, aimed at promoting health at work; organizing first aid and training employees for first aid; reduction of occupational risks; application of ergonomic and collective protective measures.

2. Ergonomics and Occupational Safety and Health

A common definition of occupational health was adopted by the Joint ILO/WHO Committee on Occupational Health at its First Session (1950) and revised at its 12th Session (1995) which states that occupational health should aim at (Shengli Niu, 2010):

i) the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;

ii) the prevention amongst workers of departures from health caused by their working conditions;

iii) the protection of workers in their employment workspace from risks resulting from factors adverse to health.

Ergonomics is the science of adapting work and working conditions to the physical needs of the workers rather than requiring the worker to adapt to the inadequately designed working environment (http:// www.iea.cc/ergonomics). Ergonomics is an essential and integral part of occupational health practice. According to the International Ergonomics Association (IEA): "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans 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" (http:// www.iea.cc/ergonomics; http://www.saptamanamedicala.ro).

Over the last 50 years, ergonomics, a term that is used here synonymously with human factors (denoted HFE), has been evolving as a unique and independent discipline that focuses on the nature of human–artifact interactions, viewed from the unified perspective of the science, engineering, design, technology and management of human-compatible systems, including a variety of natural and artificial products, processes, and living environments (Karwowski, 2000). Ergonomics is a field which integrates knowledge derived from medical science, technical science, economical, work psychology and sociology (Fig.1).

The aim of ergonomics is to optimize, first and foremost, the comfort of the worker, as well as his or her health, safety and efficiency.

Among the objectives of ergonomics is: adaptation of work to worker's performance; design of machines and tools, so that these can be easilly handled and used without injury; dimensioning of working place according to body size, allowing a natural position; adaptation of environmental influences, in particular to light and climate.

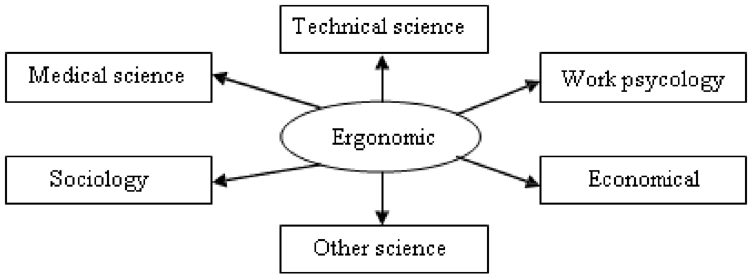

Fig. 1 – Science involved in the formation of ergonomics (http://www.saptamanamedicala.ro; http://ebooks.unibuc.ro/StiinteADM/enache/1.htm; http://www.ergonomie.ro).

International Ergonomics Association (IEA) classifies ergonomics in three broad domains (http://www.saptamanamedicala.ro; Van Cleave *et al.*, 2012):

1. *Physical ergonomics* – pertains to the physiological and biomechanical strain related to physical activity.

2. *Cognitive ergonomics* – relates to the mental processes of the employee in the work environment.

3. *Organizational ergonomics* – concerned with the policies and procedures at the workplace.

Although all three domains work collectively, physical ergonomics continues to be the primary focus of many ergonomic education models for employees. So, ergonomics is often viewed in a simplified way as it focuses mainly on the physical aspects of work and psychosocial factors are often misunderstood and ignored. Perceived changes in leadership, social climate, organizational commitment and job strain have significant effects on changes in workers health. Addressing these factors at workplace will improve workers health and affect organizational outcomes in the long run (Lohela *et al.*, 2009).

To identify risks that may potentially affect health an organization its necessary to develop and maintain hazard identification and occupational risk evaluation procedures for workplaces. Workers performing tasks that involve a potential hazard to them or other workers should be adequately competent (have proper education, training, and experience).

A company should identify those jobs and areas where serious hazards are most likely to occur and through proper planning and actions, they should ensure that such tasks are performed in proper conditions.

In order to eliminate or minimize the major work-related risk factors, various health and safety intervention models (Baumann *et al*., 2012), methods of ergonomic workplace evaluation (Grzybowski, 2001) or ergonomic training programs (Korunka *et al*., 2010; Grzybowski, 1997) are introduced.

A health and safety intervention model should take into account (1) training designs, (2) work environment (support on all levels, organizational climate, both in the learning and transfer phase) and (3) trainee characteristics (personality, motivation) predict learning transfer (Korunka *et al*., 2010).

The benefits of introducing methods of ergonomic workplace evaluation can help the following (Grzybowski, 2001): rationalize a company's spending on health protection; ensure availability of information on misguided purchases allowing for quick response; optimize spending on protective clothing and other personal protection items; support technical equipment decisions with studies on the cost of modernizing and repairing safety equipment and installations; increase employee awareness by means of keeping records of accidents, near-accidents, and their costs and reporting such events in departmental meetings (attended by health and safety specialists) held to reduce accident rates; demonstrate a company's care for its employees by presenting its health and safety spending to personnel, social organizations, and work inspectors.

Ergonomic training programs offered for all employees within an organization are a recommend method to implement ergonomic measures in a participatory ergonomics approach. Such programs may not only help to improve the quality of the working conditions, but also help to reduce injuries and accidents (Korunka *et al.*, 2010).

3. Conclusion

The need to ensure a safe working environment is a necessity to providing high quality products and services. Occupational safety is an important factor contributing to productivity increases, which consequently lead to more benefits from business activities.

The ergonomics intervention approach can reduce the human and economical burdens of workplace injuries, especially when workers gain the essential knowledge and attitudes needed about ergonomics.

In order to minimize the major work-related risk factors, various health and safety intervention models, methods of ergonomic workplace evaluation or ergonomic training programs are introduced and these presented many benefits.

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ERGONOMIA – O MODALITATE DE A ASIGURA SIGURANȚA LUCRĂTORULUI

(Rezumat)

Schimbările în mediul de lucru ce au apărut în ultimele decenii, au creat atât noi probleme ergonomice legate de sănătate cât și o accelerarea celor existente în rândul diferitelor domenii de de lucru. Acest articol prezintă noțiuni de bază legate de securitatea și sănătatea în muncă, ergonomie dar și scopul și obiectivele ergonomiei. De asemenea, autorii prezintă beneficiile introducerii unor modele de intervenție pentru sănătatea și securitatea în muncă, metode de evaluare ergonomică la locul de muncă sau programe de formare în ergonomie.

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VENTILATION IN THE DYEING HOUSE – AN ESSENTIAL FACTOR FOR WORKERS' HEALTH. NOXES VENTILATION SYSTEM MAINTENANCE

BY

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Abstract: In this work the authors make an analysis of the professional noxes from a dyeing house and the solution implemented to ensure a healthy work environment, consisting of installation of a modern ventilation system. The actions taken to ensure the system's maintenance, as a result of evaluation of the occupational illness and accident risks at the workplace, are also described.

Keywords: dyeing house; risk evaluation; ventilation system; maintenance.

1. Introduction

The issue of industrial ventilation appeared following serious pollution problems both of the environment in the industrial areas (as well as in the adjacent areas), and of the industrial enclosures. A ventilation system is commissioned anytime in a workplace where noxes are released that the limits approach or exceed the normally accepted limits by the work hygiene, health and safety norms.

The industry works with the most various raw materials, materials and basic chemical products, and their processing generally leads to spreading a part

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of the above listed items in the atmosphere of the workplace area. Such cases may lead either to occupational illnesses, or to poisoning of the exposed individuals, if the products are harmful, irritating or noxious, or might cause fires, explosions, etc. if the relevant products are flammable.

The development level of the society we are living in and the manifold opportunities offered by the technological processes that are continuously developing in the past few years, have deeply changed along the years the concept of health and, most of all, the concept of occupational health. In the past century, the health was simply defined as "the absence of illness", based on an existential, phenomenological, physiological or mechanical theory, the individual that was not ill being considered healthy, due to, at that time, the illness was the only condition that could be clinically observed, and most of the illnesses were leading to death.

The concept of health, formulated in 1948 by the World Health Organization, continues to be at the basis of the official definition of the term of "health", meaning that the definition of the concept of health is: "complete physical, mental and social welfare and not just the absence of illness or invalidity".

2. Occupational noxes and their impact

The occupational noxes represent certain factors within the occupational conditions that might negatively impact on the health condition of the body of the individuals exposed to the harmful environment and that trigger the illness or decrease the work capacity. For a component of the work condition, of the environment factors to be considered an occupational noxes, this must exceed a certain exposure limit for a long period of time. Occupational noxes are considered to be both the factors determining the work conditions and fostering the illness occurrence and the factors leading to the decrease of the work capacity, requiring the implementation of preventive measures to lower such noxes.

Main causal factors of the occupational noxes determinately act on the body and make causality between the occupational noxes and the cause-effect illness and may completely impact on the illness genesis. Occupational noxes may be fostered by various etiologic factors of some illnesses unrelated to the profession. An occupational noxes may act as a secondary etiologic factor in the etiology of non-occupational illnesses of wide occurrence or of occupational illnesses that the main etiologic agent is another type of noxe. The factors impairing various profession-related illnesses affect spreading of pre-existing non-occupational illnesses. Hence, it is important that the family doctor and the dentist cooperate to monitor the action of the occupational noxes, and the patient must be followed-up and aligned to the adjustment norms of the new work conditions and it is important as well that the patient is observed through regular medical control, in such manner that an effective, curative and preventive therapy is set up for the patient, for any illness.

The occupational environment where the human's activity takes place is characterized by the complex of microclimatic and specific physical chemical factors that might negatively affect the health of the employees. Such factors (air temperature, speed and humidity, noise, vibrations, harmful agents, unfavorable lighting, etc.) are also called harmful factors or dangerous factors. The factors that, in certain conditions, may cause acute health disturbances and body death are considered dangerous. The factors that have a negative impact on the work capacity or causes occupational illnesses and other unfavorable consequences are considered harmful. Parallel to dangerous and harmful factors, the work conditions are determined by the induction environment or labor nature.

The work capacity and health of the employees are affected by the work's nature, by its organization, interrelations between the work teams and workplaces organization. Related to such aspects, the term of occupational noxes is more frequently used in work hygiene – meaning all factors that may condition the decrease of the work capacity, the occurrence of poisonings and acute and chronic illnesses, the increase of the sickness rate with temporary work incapacity and other negative influences. The occupational noxes include the physical, chemical and biological factors, including the physical overstrain (static and dynamic), insufficiency of physical activity (hypodynamic) and psycho-emotional overstrains.

In the contemporaneous conditions of activity, the employees cope with a series of occupational risk factors that are called as a whole occupational noxes, which for the most part are determining their health condition. These manifold factors, specific to the work environment, need to be classified as it is important for the arrangement of the medical examinations and for taking preventive actions. The occupational harmful agents are classified based on toxicity, impact on health, origin (nature), etc. In particular, according to their nature, the occupational noxes are divided into:

a) Physical factors (agents) – mineral and organic powders, radiations, work environment temperature variations, air humidity variations, air currents, noise, vibrations and abnormal atmosphere pressures and so on;

b) Chemical factors (agents) – harmful chemical elements or agents contaminating the workplace atmosphere under scattered, solid, liquid or gaseous form;

c) Biological factors (agents) – with contaminating, infective or parasitic impact on the body;

d) Psychosocial factors (agents) – with prevailing psycho-neurological and stressful impact on the body, in particular on the central nervous system;

e) Ergonomic factors (agents) – insufficient machines adjustment to the work process and of the tools to the human possibilities.

3. Decisive factors for the installation of the noxes ventilation system

Risk evaluation is the first step to prevent most of work accidents and illnesses; it is the beginning of the risk management process, allowing the employers to understand the actions they must take to improve the health and security at the workplace. The evaluation of the risks due to exposure to dangerous chemical agents is a complex and difficult process due to their specific actions and to the complexity in appreciating the exposure degree.

The risk analysis of exposure to dangerous chemical agents must be performed by complex teams of specialists that include: the employer or its representative, appointed workers, individuals with duties in work security and health, risk evaluators, technological surveillance staff, workplace leaders, specialists in making determinations and analyses, work medicine physicians and other specialists, if the case. Such team runs the evaluation stages, by using various methods, starting by determining the posts or areas to evaluate, the steps to take to achieve the goals set and the responsibilities for every team member.

The next stage is a general examination that consists of a detailed verification of all the workplaces in terms of legal norms in force, of the best practices codes, of national and/or European standards. All documents and documentations that were the basis of the system are analyzed, such as: technical and technological documentations, technical manuals of the work equipment and technical security sheets of the dangerous chemical agents.

The verification considers the compliance with the essential requirements applicable in the work security and health field. All information that may supply elements to identify the specific dangers is submitted to analysis. The list of specific dangers is distributed to the site plan of the workplaces and areas under analysis, that were initially set-up by the team. The most efficient identification methods use verification lists with questions specific to the analyzed process, that are formulated as to observe the legal norms in force, and that the answers lead to dangers identification. In this identification stage of the specific dangers, it is important and mandatory to consult the exposed employees.

The next stage is actually the most difficult and laborious within the risk evaluation for dangerous chemical agents and it consists of the analysis of specific dangers. The team shall analyze the exposure values determined against the maximum allowed limits and, if these are exceeded, it shall ask for performance of additional measurements.

The essence of the methods stays in the identification of all risk factors of the system under analysis (workplace) based on pre-set control lists and in quantization of the risk size based on the combination between the seriousness and the frequency of the maximum predictable consequence.

Briefly, the method includes the following stages: definition of the analyze system (workplace); identification of the risk factors in the system; risk evaluation for accidents and occupational illness; risk ranking and set-up the prevention priorities; proposal of prevention actions.

The analyzed work system consisted of the liquid painting system in electrostatic field with drying tunnel with methane gas burner.

The main risk factor at the workplace was identified as the chemical factor, materialized in the presence in the workplace atmosphere of a mixture of vapors and gas of the preparation used for painting (Table 1), which, according to Directive 1999/45/EC, is classified as dangerous for human, as it results from the technical security sheet below (the text with the risks and composition), as it may be seen in Fig. 1.

Xn – Harmful
R10 – Flammable
R20/21/22 – Harmful by inhalation, in case of skin contact and by swallowing
R37/38 – Irritant for airways and skin
R41 – Risk of serious eye injuries
R67 – Vapours inhalation may induce lethargy and dizziness

Fig. 1 – Typification of the preparation used in the dyeing house.

The effects of such preparation used in the dyeing house are listed as it follows:

a) In case of inhalation: at low vapors concentration it may have an irritating effect on the mucosa, eyes, airways and skin, headaches and dizziness, restlessness, nausea, vomiting; at higher concentration or long term exposure, it may cause unbalance, lethargy, heavy breathing, asynergy, ventricular fibrillation;

b) In case of skin contact: it may cause skin drying, cracking and irritation;

c) In case of accidental ingestion: it may cause abdominal pain, nausea, vomiting with risk of absorption and pneumonia through absorption;

d) In case of eye contact: the vapors may cause the feeling of burn and tears appearance; accidental eye sprinkling may cause irritation.

Table 1
Information about the Composition of the Dyeing Preparation

Name or chemical nature of the dangerous ingredients	Concentration / concentration range (% weight)	*CAS number	**EC (EINECS) number	Index number of the "List of dangerous agents"	Letter for danger indication	Risk phrases
Xylene	< 70	1330-20-7	215-535-7	601-022-00-9	Xn	R10 R20/21 R38
n-Butanol	< 30	71-36-3	200-751-6	603-004-00-6	Xn	R10 R22 R37/38 R41 R67
Ethylbenzene	< 2.5	100-41-4	202-849-4	601-023-00-4	F Xn	R11 R20
Triethylenetetramine	< 2	112-24-3	203-950-6	612-059-00-5	C Xn	R21 R34 R43 R52/53

Note: *CAS - Chemical Abstracts Service; **EC (EINECS) - European Community (European Inventory of Existing Commercial Chemical Substances).

Maximum allowed concentrations of harmful agents in the workplace atmosphere, according to the classification of Government Decision no. *1218*/2006, are shown in the Table 2.

Table 2
Information About the Composition of the Dyeing Preparation

Agent name	Allowed concentration, [mg/m^3]			
	Average	Peak	After 8 hours	Short-term (15 min)
Xylene	200	300	221	442
n-Butanol	50	75	100	200
Ethylbenzene	440	920	442	884
Triethylenetetramine	8	18	10	20

The evaluation of the harmful chemical agents (dyes, thinners) used in the company, in the dyeing department, has revealed the following risks related to such agents: fire and/or explosion risk; risks caused by dangerous chemical reactions or that may affect the workers' health and security; inhalation risk; skin absorption risk; risk in case of skin or eye contact; ingestion risk.

The methodology used to evaluate the chemical accident risk is a simplified methodology, based on forecasting the probability of occurrence of the dangerous analyzed situation, on the exposure frequency and on the usual consequences in case of occurrence of the dangerous situation. The methodology allows quantifying the risk size and, therefore, the rationally rank the priorities of the prevention and protection actions. The first thing to do is to identify the deficiencies found with the systems, equipment, processes, tasks, by filling-in a questionnaire. There were used verification lists with questions specific to the analyzed process, the exposed employees being also consulted.

In the next risk evaluation stage, that consists of the analysis of the specific dangers, the exposure values determined against the maximum allowable limits were submitted to analysis, such limits being exceeded, as it results from the status of determinations shown in the Table 3.

Table 3
Noxes Concentrations at Various Hours During a Work Shift (before installation of the noxes ventilation system)

Agent denomination	Allowable concentration [mg/m^3]			
	6^{00} AM	10^{00} AM	2^{30} PM	Average
Xylene	220	840	910	656
n-Butanol	140	580	510	410
Ethylbenzene	210	1,240	1,408	952
Triethylenetetramine	11	44	62	39

The occupational exposure to such agents was evaluated by measuring the concentration of the harmful agent in the work areas air and by measuring various biological parameters on the occupationally exposed personnel. The concentrations determined by the noxes toxicological test laboratory – the determinations (air sampling) were performed at first light at the morning shift start, in the middle period of such shift and at the end of the work shift (Fig. 2).

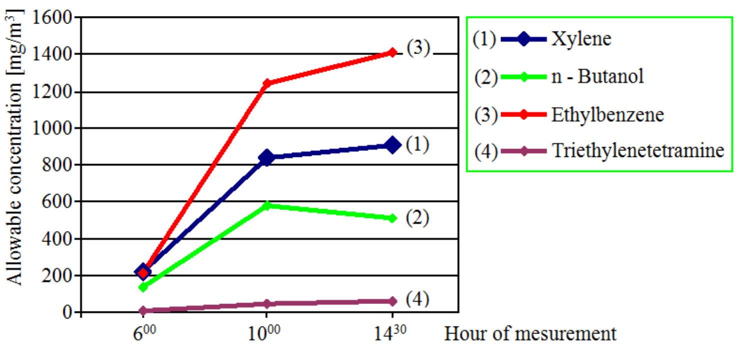

Fig. 2 – Noxes concentration variation during an exchange of work.

4. Results of the Medical Tests

Regarding the health condition control of the workers exposed to occupational noxes, measurements of the biological parameters of the occupationally exposed personnel were performed, obtaining the results shown in the Table 4.

Table 4
Measurements of the Biological Parameters of the Occupationally Exposed Personnel

Age	No. of subjects	Years of service at the workplace	Exposure agent	Biological index	Biological material	Determined values	Max. biological limits
20-29	4	1-5 years	Xylene	Methyl-hippuric acid	Urine	280-360 mg/l	300 mg/l
30-39	6	More than 5 years				310-520 mg/l	
40-49	12	1-5 years				320-440 mg/l	
>50	8	More than 5 years				380-610 mg/l	
20-29	4	1-5 years	Ethylbenzene	Mandelic acid	Urine	210-340 mg/g C	150 mg/g C (C is Creatinine)
30-39	6	More than 5 years				280-470 mg/g C	
40-49	12	1-5 years				180-220 mg/g C	
>50	8	More than 5 years				220-340 mg/g C	

Concerning the medical aspects as symptoms within the body's reaction to the agents it was submitted to, the cardiac disorders, disturbances of view, hepatic injuries and diabetes mellitus were observed. The results are shown in the Table 5.

Table 5
Types of Workers' Health Condition Impairments

Age	No. of subjects	Years of service at the workplace	Hepatic injuries	Cardiac disorders	Disturbances of view	Diabetes mellitus
20-29	4	1-5 years	0	1	2	0
30-39	6	More than 5 years	2	1	5	1
40-49	12	1-5 years	4	5	6	3
>50	8	More than 5 years	6	7	6	8

The pathology of the subjects (workers in the dyeing house) is more significant at the superior age decades and in majority related to the work conditions: the noxes presence over the maximum allowable limits. The pathology study of the workers in the dyeing house shows that it detachedly prevail the injuries related to the noxes presence in the work environment against those resulting from the other components of the work system. The cardiac disorders and diabetes mellitus are well represented.

In the period immediately following to the installation in the dyeing house of the noxes ventilation system (Fig. 3), the noxes concentrations were determined by the toxicological test laboratory (air sampling), in the same periods of the day as the previous determinations.

Fig. 3 – The installation of noxes ventilation system.

The results are shown in the Table 6 and Fig. 4.

Table 6

Noxes concentrations at various hours during a work shift
(after installation of the noxes ventilation system)

Agent name	Determined concentration [mg/m³]			
	6^{00} AM	10^{00} AM	2^{30} PM	Average
Xylene	120	140	155	138.33
n-Butanol	10	20	28	19.33
Ethylbenzene	20	120	180	106.66
Triethylenetetramine	1	4	5	3.33

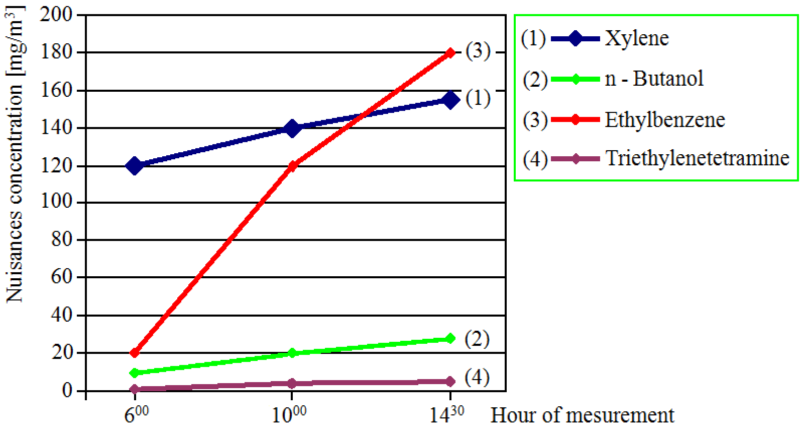

Fig. 4 – Changes in the concentration has calculated nuisances after fitting ventilation.

By comparing the results of the two noxes determinations – before and after installation of the ventilation system – one may very clearly observe that the concentration of the dyeing house has decreased a lot, with positive impact on the workers' health condition evolution, fact that will prove after not more than one year, when the workers will be submitted to another set of specialized medical tests.

5. Technical and Organizational Actions Taken

Starting with such actual data, that are available on site, the evaluation commission considered that in this case it is required, for the work system – dyeing system, to take a series of technical and organizational actions, meant to lower the occupational accident and illness risks, in compliance with the stipulations (Law no. *319*/2006).

a) *To design and organize the work systems at the workplace.* The employer must ensure, through design, work and control processes that avoid the release of dangerous chemical agents in the workplaces, according to the stipulations (Government Decision no. *1425*/2006).

b) *To provide appropriate equipment for working with chemical agents, to issue and implement maintenance procedures, that ensure workers' health and security in the work process.* It is very important that the employer ensures the needed environment not only for purchasing the proper work equipment but also to maintain them operational and at the designed parameters. For this purpose, the employer shall issue and implement check/maintenance/revision/ repair procedures of the work equipment, based on the technical manual. These shall be kept for an appropriate period of time, depending on the manufacturer's recommendations or specifications.

c) *To minimize the number of workers exposed or that may be exposed.* This may be achieved by organizing the work tasks/separating the work areas where dangerous chemical agents are found from the rest of the activities by limiting the access to the risk areas. While organizing the work systems, the employer shall seek to minimize the number of workers exposed or that might be exposed, in particular, in case of the maintenance, repair, revision works, where the workers' exposure to noxes may be significantly high. In order to perform repair, intervention, revision works that carry a work accident risk or occupational illness risk, the employer shall issue work permits to certify taking the needed safety actions to execute works in security conditions, and it shall appoint the qualified personnel, per types of works, indicated in the permit and trained and/or authorized for such purpose.

d) *To minimize the exposure duration and intensity.* It is well known that the exposure through inhalation to a chemical agent = concentration × × exposure time. The reduction of any of the two variables leads to the exposure decrease. It is recommended that the work is organized as to have the lowest possible exposure time, by reducing it to the absolutely indispensable time. The concentration value of the work environment depends on manifold factors, among which: the generation level of the chemical agent and the ventilation in the workplace. The generation level of a chemical agent depends on various parameters, such as temperature, pressure etc. Keeping such parameters within normal process values could maintain the noxes level in the work environment at low level. For example, checking the air pressure used to spray the dies or covering the baths, tanks, recipients of chemical agents based on volatile organic compounds, may significantly lower the quantity of solvents in the work environment. The concentration in the environment of a chemical agent generated during work continuously increases in a non-ventilated room, and, for this reason, all workplaces must fulfill the minimum ventilation requirements.

e) *Appropriate hygiene actions.* It is well known that the chemical agents may also penetrate the body through by dermal route and by ingestion. This is why it is important to avoid direct contact of the chemical agent with the skin or, in case of accidental contact, to immediately wash the affected area. The contaminated cloths must be immediately replaced, due to it offers a contact area and, therefore, of dermal absorption. On the other hand, contaminated cloths are an additional focus of contamination. The habits against the elementary hygiene, such as smoking, drinking or eating in the workplace, must be root out, especially when the work is with dangerous chemical agents, due to such habits foster their involuntary and systematic ingestion. For these reasons, it is recommended to implement the best personal hygiene practices through: restraint to eat, drink or smoke in the areas where dangerous chemical agents may be present/cleaning individual work equipment before use and at the end of the work shift/making available to the workers the personal hygiene systems and using such systems before having lunch and at the end of the work day/using skin cleaning and care products that are not aggressive, etc. The workers must be informed, encouraged and controlled to keep the workplace cleanliness and to avoid accumulating materials that contain dangerous chemical agents. In case of carcinogen agents, it is mandatory to regularly clean the floors, the walls and other surfaces, to confine the risk areas and to use proper security indicators, including the indicator “Smoking is forbidden”. The spills removal or cleaning shall be done, as the case may be, with absorbing or neutralizing agents who, after use, shall be collected in the waste recipients and then taken out of the work rooms and, potentially, treated. Appropriate signaling and warnings boards that are clear and legible shall be used in the workplaces. The signaling shall be visible as possible.

g) *Proper work procedures including in particular technical rules concerning the safe handling, storage and transportation to the workplace of the dangerous chemical agents and waste containing such chemical agents.* Also as general risk prevention actions, the employer shall ensure drafting and implementation of appropriate work procedures for safe handling, storage and transportation to the workplace of the chemical agents (Directive 1999/92/EC).

h) *To minimize the risk when it is not possible to remove the risk by replacing the dangerous agents, through protection and prevention actions taken in the priority order:* to design appropriate technical control and work processes; to use proper equipment and materials, in such manner as to avoid or minimize the release of dangerous chemical agents; implementation of collective protection actions at the risk source, such as proper ventilation and proper organization actions; implementation of individual protection actions, including by providing the individual protection equipment, if the exposure cannot be avoided through other means. The priority shall be given to the collective protection actions at the risk source that are meant to safeguard a high number of workers at the workplace. In this regard, it is recommended to process in a closed system, by shutting-down the encased equipment where negative pressure is being generated, processes automating, general ventilation, to equip the machines with shields and safety screens against splashing, to provide local systems to trap, retain and neutralize the noxes release in the technological process, to provide measurement and control devices for the technological parameters and danger conditions warning devices. The individual protection equipment shall be selected based on the dangerous properties of the agents used and on the type of work task. Procedures shall be drafted and conditions to check and clean the equipment before and after every use shall be ensured to disinfect, store, control, repair or replace before new utilization if it shows failures, for regular maintenance of the individual protection equipment, in particular of the breath safety masks. The individual protection equipment, as the name shows, must be use by every single worker, being forbidden to be used by other individuals. Hygienic – sanitary materials shall also be granted, based on the recommendation of the work medicine physician, including skin protection creams, considering the type of chemical products that may be oily, fat or sticky, as the case of resins, adhesives or coats, by using safety gloves.

i) *Continuous monitoring of the health condition.* The workers' health condition is monitored by specialist work medicine physicians, by medical services of work medicine, before exposure to chemical agents and afterwards, on a regular basis, according to the stipulations (Government Decision no. *355*/2007). For each and every worker under medical monitoring, the employer shall draft the Identification sheet of the occupational risk factors that shall be submitted to the work medicine physician who, depending on the mentioned risks, on described work conditions and specified dangerous agents; it shall establish the type and frequency of the medical controls.

The work medicine physician shall compile for every employee under medical monitoring a medical file to be kept, with the Identification sheet of the occupational risk factors, in the work medicine office, and it shall accompany the worker throughout its occupational activity, in all the workplaces. The medical records file shall be sent to another work medicine office when changing the workplace, to the public health directorates in case the employer become bankrupt or to the family physician in case of employee's retirement or unemployment. The medical records shall be kept for a period of time at list equal to the exposure period. In case of exposure to carcinogen and mutagenic agents, the medical file shall be kept for a min. period of 40 years after the end of the exposure. The employer does not have access to the employee's medical file. The employer shall prepare, keep and make available to the control authorities the list of workplaces with occupational risks, the skill sheets of the employees exposed to noxes in the work environment, filled-in and stamped by the work medicine physician. Depending on the results of the medical control, the work medicine physician shall recommend individual safety actions appropriate for the exposure or it shall recommend changing the workplace.

6. Maintenance of the Ventilation System

The casting factor in proposing the action to install the ventilation system was the high noxes value existing in this workplace, value determined by the "Noxes test laboratory" within the Environment protection directorate.

To ensure the efficiency of the selected ventilation system, a work procedure was established regarding the maintenance of this system, according to Solomon (2011). The needed documents meant to ensure compliance with the work procedures in terms of maintenance of the ventilation system are the following:

1. For identification, the ventilation system shall be marked by an order number, written with white dye on a few important components (fan, filter, heating battery, main pipes). Counting will be from 1 to *n*, this range including all systems in the company; at the same time, it shall be indicated with Roman number the department where the system is installed (*e.g.*: system 3 from the department IV shall be written as 3/IV);

2. For each and every ventilation system delivered for operation a technical documentation shall be prepared, that includes: the technical sheet of the system; the operation and repair record of the department (for every ventilation system in the department); specific operation instructions.

The *technical sheet* shall be prepared for every ventilation system commissioned. It includes: general details about the system; technical description of the system; technical operation characteristics, as well as the results of the technical tests and of the hygienic sanitary effectiveness of the system, determined on receipt; ventilation system scheme.

The technical sheet shall be filled-in in two steps:

a) in the first step, the beneficiary fills-in the sheet according to the design and system details; such filled-in sheet is one of the basic documents of the receipt deed;

b) in the second step (at the system's reception), the actual data obtained following the technical test and performed measurements are filled-in.

The technical sheet of the ventilation system shall be filled-in in two copies, out of which:

a) one copy is kept with the workplace of the chief mechanic;

b) the second copy is kept by the responsible for the sector's ventilation.

The department operation and repair registry shall be prepared for every ventilation system in the department. It allows recording:

a) the failures occurred during operation;

b) the stoppages and repairs of the system.

The minimum duration of the system stoppages, that must be mandatorily recorded, shall be set-up by the State Sanitary Inspection or (if not ruled by this authority), by the relevant entities of the company. In case of companies where stopping the operation of the ventilation system, for one hour or less, may cause workers' poisoning, such stoppage shall be interlocked with the operation of the technological systems that produce noxes and it shall be recorded. Where stopping the ventilation leads to disturbances in the production process, on such systems it shall also be mandatorily installed, interlocks with the technological systems, as well as acoustic and optical warnings.

In case the system operates continuously, or according to the prepared operation schedule, no record shall be made in the registry.

The department's operation and repair registry shall be kept and filled-in by the responsible for the sector's ventilation.

7. Conclusions

As already shown, the work health and security in a workplace where, due to the technological process, to raw materials and materials used, chemical noxes are produced, could be ensured through a risk evaluation and execution of a ventilation (exhaust) system, as well as by submitting such system to maintenance.

The maintenance works may endanger the workers, although not performing the maintenance works may represent a serious risk for more workers. The employers who fail to maintain the work equipment in appropriate conditions or who ignore the security of the ventilation system, risk to suffer disastrous accidents. The damages caused by maintenance may contribute to broad-scale disasters, with negative consequences for the people and the environment.

The management's commitment, which is the most important casting factor of the security culture of an organization, is essential for the work health and security in general, and much more during the maintenance operations. This determines the resources (of time, manpower and financial) allocated to security and health and generates higher levels of motivation for the work safety and health intercessions at the level of the entire organization.

The maintenance tasks and the health and security aspects related to the maintenance tasks must be part of the general management system of a company's health and security that must be permanently developed and improved.

Acknowledgement. Any company that acknowledges the "man as value and supreme purpose" will admit that protecting the man's life is justified and entitles the biggest possible effort.

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VENTILAȚIA ÎN VOPSITORIE – FACTOR VITAL PENTRU SĂNĂTATEA LUCRĂTORILOR. MENTENANȚA INSTALAȚIEI DE VENTILAȚIE A NOXELOR

(Rezumat)

Se prezintă o analiză a noxelor profesionale dintr-o secție de vopsitorie şi soluția adoptată, în vederea asigurării unui mediu de muncă sănătos, respectiv montarea unei instalații de ventilație modernă. De asemenea, sunt prezentate măsurile luate pentru asigurarea mentenanței instalației, măsuri luate în urma evaluării riscurilor de accidentare şi îmbolnăvire profesională de la locul de muncă.

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MECHATRONIC MODULAR SPATIAL DRIVE SYSTEMS OF TRIANGULAR TYPE FOR OBJECT MANIPULATION IN EXTREME CONDITIONS

BY

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Abstract: Modular spatial drive systems composed of triangular elements, forming tetrahedral and octahedral modules, have been developed. Synthesis of circuit solutions and computer simulation of basic drive system variants have been performed. Regularities in the operation of the drives of triangular type, installed on a curvilinear surface, have been determined. The paper proposes element base of spatial drive systems, particularly, spherical joints with ferrofluid and bellows drives. The control system algorithms, which provide displacement of the drives, are presented. Prototypes of the modular spatial drive systems have been developed and manufactured, their approbation have been performed. Efficiency and reliability of the proposed engineering solutions have been verified.

Keywords: algorithm; drive; geometry; joint; module; octahedron; structure.

1. Introduction

Development of principally new mechatronic drive systems enables object manipulation in extreme conditions. Therefore, research in this direction is of current importance.

Problem, in the general form, consists in creation of manipulation devices capable to operate in extreme conditions, particularly, in closed

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volumes, pipelines, slots. The problem is connected with important scientific and practical tasks of manipulator development for solving problems in industry, civil engineering, public utilities, etc.

Recent research and publications present circuit solutions of manipulators, based on application of the mechanisms with parallel kinematic connections. Static characteristics of manipulators and their engineering parameters have been determined (Рыбак *et al.*, 2011). Manipulators, which provide spatial displacement of an object by means of changing the length of kinematic links or by displacement of the supports, are used (Ketao & Jian, 2015). In some publication Yongjie *et al*. (2015), it is noted that manipulators with parallel kinematic connections have special properties and can be used in extreme conditions.

In literary sources, however, no results of research and development, which deal with spatial drive systems for object manipulation in extreme conditions, have been found.

Development of spatial drive systems for object manipulation is related to the unsolved aspects of the general problem.

The presented research aims at scientific substantiation of the development of mechatronic modular spatial drive systems of triangular type for object manipulation in extreme conditions. The research tasks include synthesis of circuit and design solutions of drive systems, establishing regularities in operation of the drives and their element base realization, development of the algorithms of mechatronic control systems for the drives and creation of prototypes for verification of the theoretical research statements.

2. Presentation of the Main Research Material

2.1. Synthesis of the Circuit and Design Solutions of Drive Systems

Mechatronic modular spatial drive systems include devices, which can change their length or shape and are connected at points, located randomly in space, and moved by means of control systems with powerful intellectual units (Подураев & Кулешов, 2000).

Mechatronic spatial drive systems are most efficient for solving extreme problems (Воробьев *et al.*, 1988). Such problems include operation in limited volumes such as pipelines, vessels, reservoirs, manifolds etc. Application of manipulation devices, based on spatial drive systems, is also efficient for mechanization of complicated dangerous works for operation in challenging environmental conditions. The devices are intended for painting and cleaning surfaces, particularly, hydrocleaning or sand-cleaning. Manipulation devices are effective for collecting garbage at dumping grounds, for sorting garbage and scrap. They are also useful for packing substances, in particular, toxic materials.

Certain applications of spatial drive systems are oriented towards operation in extreme external conditions (Fig 1).

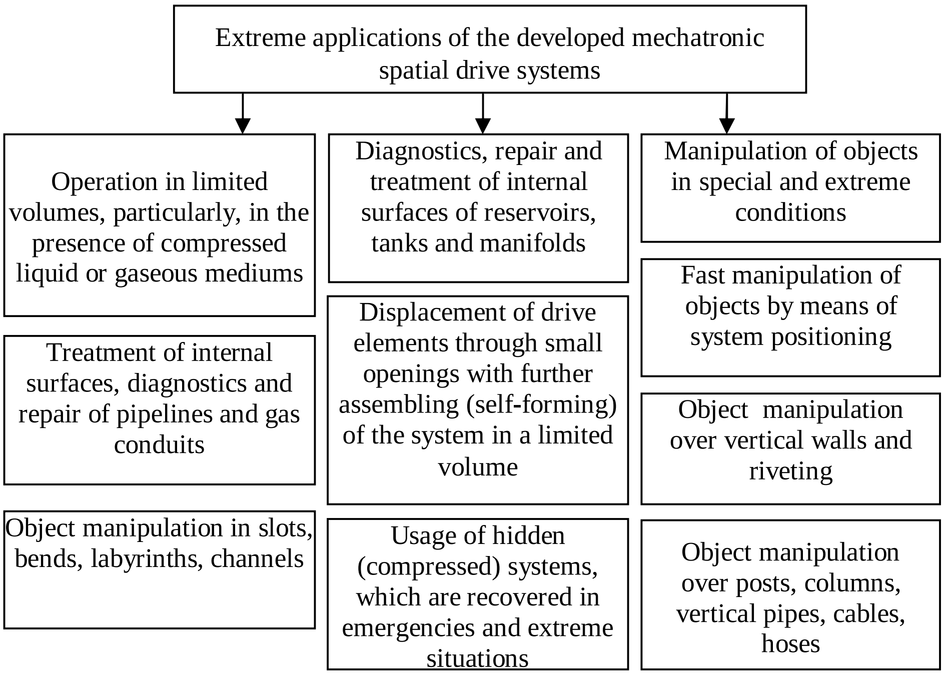


Fig. 1 – Some applications of mechatronic modular drive systems of triangular type in extreme conditions.

Three principally different conceptual approaches to realization of innovative spatial drive systems are proposed (Fig. 2).

The first approach corresponds to the application of traditional drives in the form of pneumatic cylinders coupled by means of joints. The drives are realized in the form of complete set of multiposition pneumatic cylinders with respective discrete control systems. To ensure the required accuracy, discrete drive sets are equipped with linear microdisplacement drives.

Another approach to realization of circuit solutions of discrete drive systems involves application of elastically-deformed bellows drives or drives based on hose pneumatic engines (pneumatic muscles). A special type of spatial drive systems, based on bellows pneumatic engines, is represented by the proposed non-articulated spatial drive systems.

The third approach involves application of innovative plastically-deformed articulated and non-articulated systems, which combine thermomechanical mechatronic drives on the basis of shape-memory alloys.

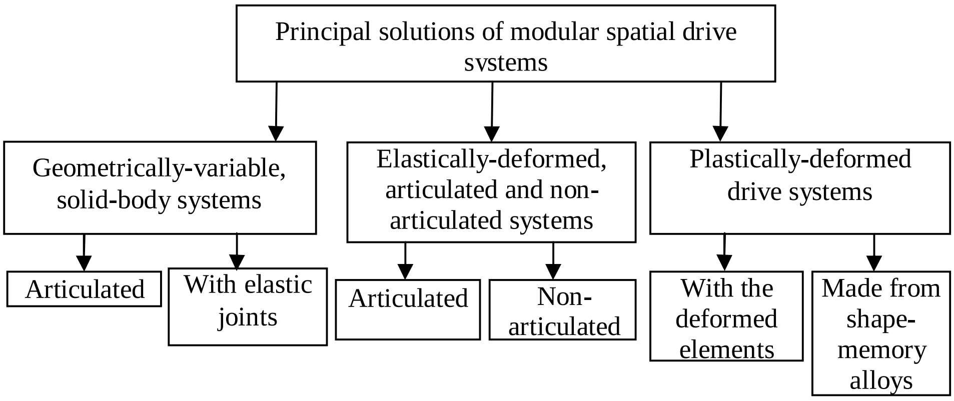


Fig. 2 – Conceptual circuit solutions of mechatronic modular spatial drive systems of triangular type.

The developed drive systems are composed from flat or 3-D modules, where individual linear drives are coupled as a triangular circuit. Different types of modules are proposed (Fig. 3).

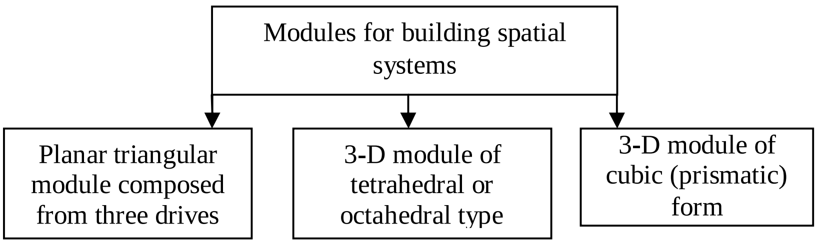


Fig. 3 – Types of modules, from which circuit solutions of mechatronic spatial drive systems for object manipulation are composed.

Modules are used as independent drive systems or are included into more complex drive systems as their components.

Combination of several modules creates innovative mechatronic spatial drive systems in the form of structures (Fig.4).

Circuit and design solutions of modular spatial drive systems of different types have been developed. They are realized with the application of both pneumatic cylinders, coupled by joints, and elastic bellows drives, rigidly connected at the ends. In this way planar and 3-D structures are obtained. Among them characteristic are 3D structures composed from the modules of octahedral type (Fig. 5)

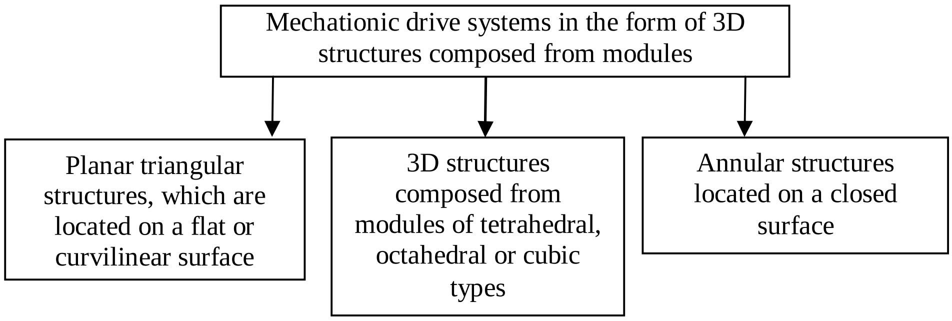
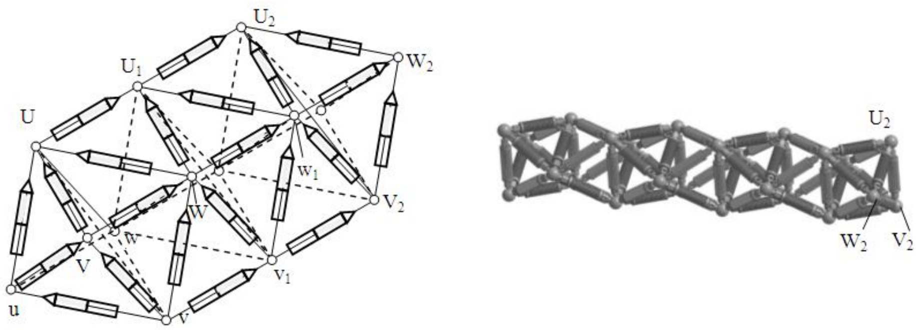


Fig. 4 – Innovative mechatronic spatial drive systems in the form of planar and 3-D structures.



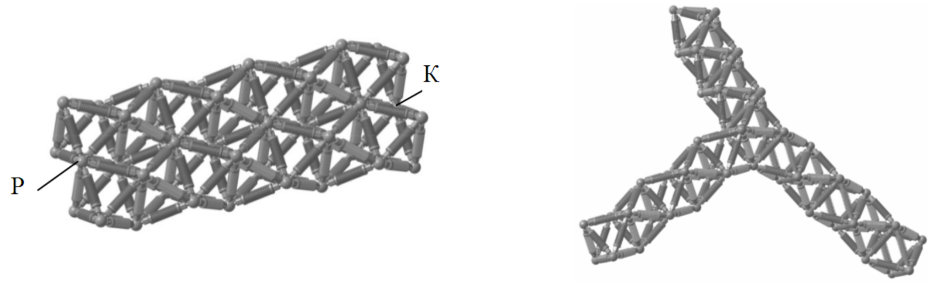
a *b*

Fig. 5 – Principal circuit solutions of mechatronic modular spatial drive systems of triangular type composed from the modules of octahedral form: *a* – system, composed from two modules on the basis of pneumatic cylinders, coupled by joints; *b* – system of non-articulated bellows drives that includes seven modules.

Working member of the drive system is installed at certain nodal points of the structure, *e.g.* at points U_2, W_2, V_2.

When length of the drives is changed, the shape of the structure is altered. It can change its length and also its width in longitudinal direction. Torsion of the structure sections and their shifting relative to the system edges is permissible.

The presented drive systems are equipped with vacuum-aerostatic supports at nodal points *u*, *v*, *w*…. In certain cases drive systems have mechanical or electromagnetic locators at the nodal points with the possibility of displacement over curvilinear surfaces of different types. Movements of the structure, similar to those of real snail or caterpillar, are also possible. The structure option, that combines two rows of modules (Fig. 6), enables significant variations of the system shape and configurations.



a *b*

Fig. 6 – Spatial system that combines 14 modules of octahedral form (*a*) and linear structure, branching into three parts (*b*).

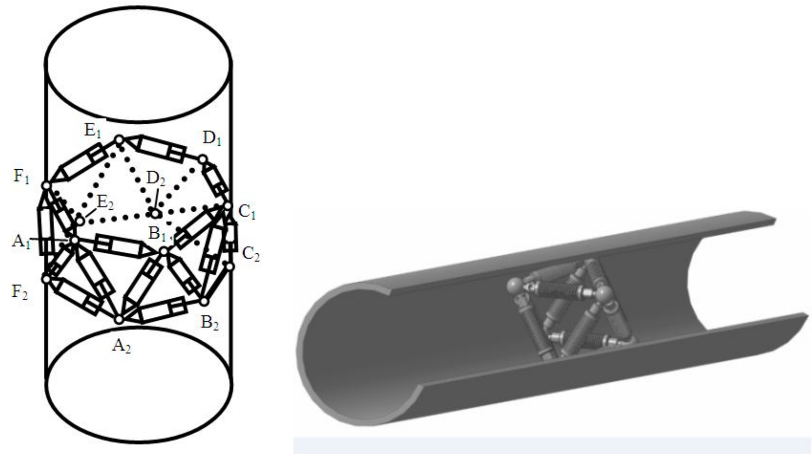
The presented drive systems can move over curvilinear surfaces, changing their shape and size. Bending of the structure in various directions and its torsion are possible. In this case the drive system acquires a helical shape.

Drive systems in the form of planar structures of different types have practical importance. Planar structures can be located on a closed surface such as inner cylindrical surface of a pipeline (Fig. 7).

At nodal points A_1, A_2… supports are installed, which fix the node on the pipeline surface. Due to changes of the length of separate drives, the system can move along the pipeline axis or rotate about this axis. The movements occur stepwise with periodical fixation of the system nodal points.

An annular structure, that in its minimal configuration includes 12 bellows drives, forms a module of octahedral type (Fig. 7 *b*).

This structure can move in a pipeline or in a slot with curvilinear walls.



a *b*

Fig. 7 – Annular triangular chain structure, that includes 24 drives located on cylindrical surface (*a*), and spatial structure of octahedral type, intended for displacement in a pipeline (*b*).

2.2. Regularities in the Operation of the Drives of Triangular Type

Drives, composed from triangular elements, are generally placed on a curvilinear surface (Берже, 1984).

Triangulation operation provides division of the curvilinear surface into triangles, which are generally curvilinear. If at the triangle vertexes supports of the drives are installed and the triangle sides are formed by respective drives, the obtained drive system will be a planar triangular structure. The structure will interact with the surface at the vertexes of triangles.

Regularities in operation of the modular spatial drive system are determined for the types of curvilinear surfaces which are of practical importance, *i.e.* spherical and cylindrical surfaces. We will consider a planar module, composed from three drives located on a curvilinear surface. The module forms a triangular structure in the form of a triangle (Fig. 8).

This structure has three pneumatic drives (pneumatic cylinders or bellows), coupled by joints *A*, *B*, *C*. The lengths of the drives L_1, L_2, L_3 is changed as the structure moves over the surface. Joints *A*, *B*, *C* are fixed periodically on the surface by means of special facilities, *e.g.* by vacuum-aerostatic supports or magnetic lock.

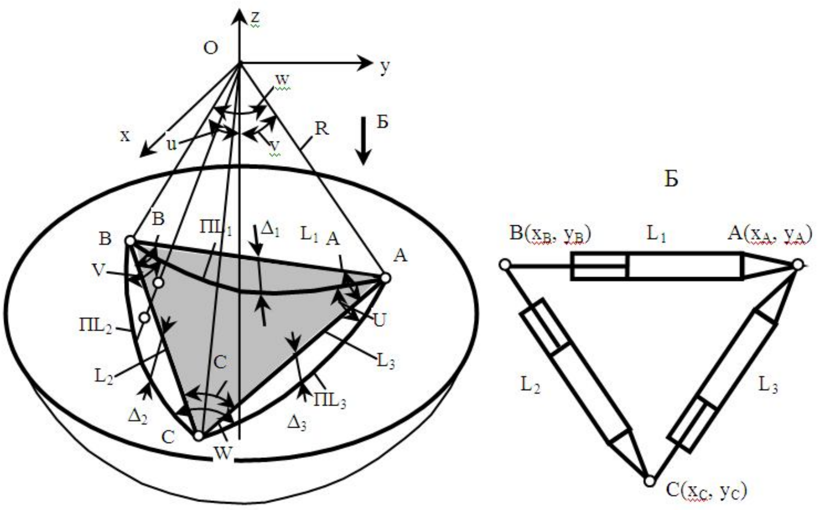


Fig. 8 – The scheme of spatial location of an elementary triangular structure on a curvilinear surface and cross-section of the structure in the plane of the drives.

In order to simplify the analysis, the structure in assumed to be located on the surface with constant curvature, which corresponds to a sphere with radius *R*. For determining basic geometric relationships the formulas of spherical trigonometry are used (Берже, 1984). Let us introduce a coordinate system x, y, z with the center coinciding with the center of the sphere. In this coordinate system the surface equation is given by:

$$x^2 + y^2 + z^2 = R^2. \tag{1}$$

It is assumed that joints A, B and C of the drive system are located directly on the sphere and have small size. To determine the structure position on the surface, it is sufficient to define its characteristic dimensions and three parameters. Distances between the joints (lengths of the drives) L_1, L_2, L_3 are taken as characteristic dimensions of the structure. Two Cartesian coordinates of joint $A(X_a, Y_a)$ and one coordinate of joint $B(X_b)$ are taken as the parameters.

Coordinates of the joints are found by means of computations. Coordinate Z_a is found from the sphere eq.:

$$z_A = \sqrt{R^2 - x_A^2 - y_A^2}. \tag{2}$$

For finding unknown coordinates of joint $B(Y_b, Z_b)$ we use the following equation system:

$$\begin{cases} x_B^2 + y_B^2 + z_B^2 = R^2, \\ (x_A - x_B)^2 + (y_A - y_B)^2 + (z_A - z_B)^2 = L_1^2. \end{cases} \tag{3}$$

In order to determine the unknown coordinates of joint $C(X_c, Y_c, Z_c)$, we use the system of three equations:

$$\begin{cases} x_C^2 + y_C^2 + z_C^2 = R^2, \\ (x_A - x_C)^2 + (y_A - y_C)^2 + (z_A - z_C)^2 = L_3^2 \\ (x_B - x_C)^2 + (y_B - y_C)^2 + (z_B - z_C)^2 = L_2^2 \end{cases} \tag{4}$$

Equation systems (3) and (4) are solved by the iteration method using mathematical packages.

Angles A, B, C between the axes of the drives are found from trigonometric relations for triangle ABC. On the basis of the cosine law we obtain:

$$A = \arccos\frac{L_1^2 + L_3^2 - L_2^2}{2L_1L_3},\ B = \arccos\frac{L_1^2 + L_2^2 - L_3^2}{2L_1L_2},\ C = \arccos\frac{L_2^2 + L_3^2 - L_1^2}{2L_2L_3}. \tag{5}$$

The plane of location of the structure with drives and joints is determined in an analytical form by three points (A, B and C) and described by the equation:

$$P_x x + P_y y + P_z z = Q\ , \tag{6}$$

where coefficients of eq. (6) are determined in the form of

$$P_x = \begin{vmatrix} y_A & z_A & 1 \\ y_B & z_B & 1 \\ y_C & z_C & 1 \end{vmatrix},\ P_y = \begin{vmatrix} z_A & x_A & 1 \\ z_B & x_B & 1 \\ z_C & x_C & 1 \end{vmatrix},\ \ P_z = \begin{vmatrix} x_A & y_A & 1 \\ x_B & y_B & 1 \\ x_C & y_C & 1 \end{vmatrix},\ Q = \begin{vmatrix} x_A & y_A & z_A \\ x_B & y_B & z_B \\ x_C & y_C & z_C \end{vmatrix}.$$

Determinants, included in formula (6), are computed using coordinates of the joints found by formulas (2,…,4).

Equations of the normal to the plane, where the drives are located and which passes through the center of the sphere, are determined by the equation system:

$$\frac{x}{q_x} = \frac{y}{q_y} = \frac{z}{q_z},\ \text{where}\ \frac{q_x}{P_x} = \frac{q_y}{P_y} = \frac{q_z}{P_z}. \tag{7}$$

This normal intersects the structure plane at the point, where solutions of equation (6) and (7) coincide.

Distance from the center of sphere to the plane of the structure is determined by the formula:

$$h = \frac{Q}{\sqrt{P_x^2 + P_y^2 + P_z^2}}\ . \tag{8}$$

Respectively, the biggest deviation of the structure plane from curvilinear surface will be as follows:

$$\Delta = R - h\ . \tag{9}$$

Some drives of the structure L_1, L_2, L_3 are projected on a curvilinear surface. Arcs ΠL_1, ΠL_2, ΠL_3 are their projections. They form a spherical triangle with vertexes *A*, *B*, *C*, sides *u*, *v*, *w* and angles *U*, *V*, *W*. The triangle is defined on the sphere with radius *R*. Sides of the spherical triangle are determined in the angular measurement and found from trigonometric relations for triangles ΔOAB, ΔOBC and ΔOCA. The sides of the spherical triangle are found in the form of respective dependencies:

$$u = 2\arcsin\frac{L_2}{2R},\ v = 2\arcsin\frac{L_3}{2R},\ w = 2\arcsin\frac{L_1}{2R}. \tag{10}$$

Angles *U*, *V*, *W* of the spherical triangle are determined on the basis of the cosine theorem for spherical triangles:

$$U = \arccos\frac{\cos u - \cos v \cdot \cos w}{\sin v \cdot \sin w},\ V = \arccos\frac{\cos v - \cos u \cdot \cos w}{\sin u \cdot \sin w},$$
$$W = \arccos\frac{\cos w - \cos u \cdot \cos w}{\sin u \cdot \sin w}. \quad (11)$$

Arcs of the projections on the sphere of the drives and corresponding drives form segments, the height of which is the biggest distance from the drive axis to the surface. Height of the segments is calculated by the formulas:

$$\Delta_1 = R(1 - \cos w / 2),\ \Delta_2 = R(1 - \cos u / 2),\quad \Delta_3 = R(1 - \cos v / 2). \quad (12)$$

Formulas 5,…,12, presented above, serve as the basis for determining the structure position on the spherical surface. Formulas for surfaces of other types become more complicated.

2.3. Element Base of Mechatronic Modular Spatial Systems

For the spatial drive system realization in the form of movable triangular structures a special element base has been developed. It includes magnetic spherical joints, supporting elements and drives (Струтинський & Гуржий, 2013).

Magnetic spherical joints have wide ranges of transverse angular displacements. The basis of the spherical joint is a magnetic sphere, which rotates freely during operation process of the joint. Magnetic sphere 1 interacts with spherical surfaces of shanks 2, which are fixed at the bodies or rods of pneumatic engines (Fig. 9).

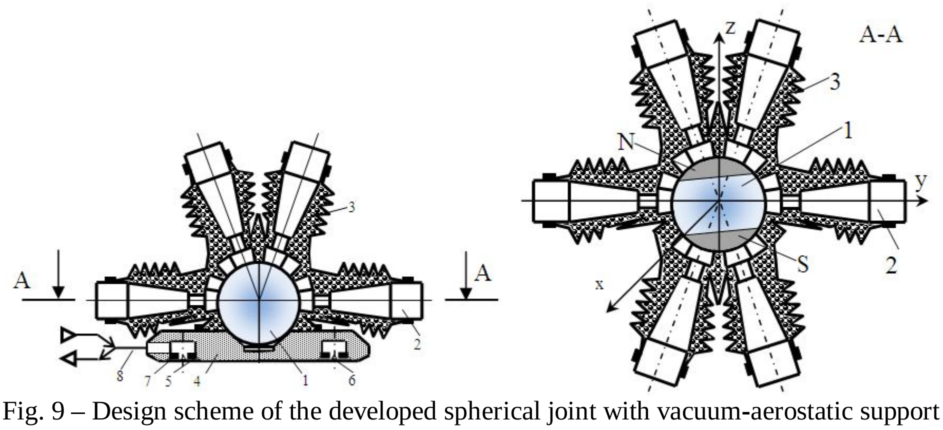


Fig. 9 – Design scheme of the developed spherical joint with vacuum-aerostatic support

The joint is equipped with a vacuum-aerostatic support. Body of support 4 has a conic opening in its central part, where a magnetic sphere is located. On the support surface of the body pockets 5, 6 are formed, to which compressed air is supplied via throttles 7 from pipeline 8. When air is supplied to pipeline 8, the support body opens from the base surface and between the surface of the body and the surface of the base an air-passing slot is created. Friction forces are reduced to practically zero value and the support allows for free displacement, parallel to the base surface.

Aerostatic support is a device of dynamic action. Due to the presence of compressed air in the cavities of the pockets, vertical vibrations of the support occur. This essentially reduces friction forces and increases the gap between the support and the base. Correspondingly, irregularities of the base surface are compensated.

During vacuuming of line 8 pressure in pockets 5 and 6 drops and support 4 is pressed to the base by the forces of atmospheric pressure.

In the operation process of the joint the sphere, which interacts with the shank in fluid medium, rotates and occupies such position, that magnetic pole of the sphere is located on the side of the shanks (Fig. 10).

a *b*

Fig. 10 – Magnetic sphere interaction with the support surface of the shanks in the presence of ferrofluid: *a* – shank at the pole of the magnetic sphere; *b* – location of two shanks at the sphere pole.

As it is evident from the figure, ferrofluid is localized in certain areas of the sphere. These areas are its magnetic poles. If two shanks are positioned on the sphere (Fig. 10 *b*), it rotates so that its magnetic pole is located between the shanks.

Four and more shanks could be located on the sphere (Fig. 11). Contact of the sphere with the shanks is quite reliable.

To provide reliable contact of the shank with the sphere, it must take up momentum loads acting in the radial plane of the shank. Therefore, shanks have three shaped projections each on their spherical surface (Fig. 12).

Fig. 11 – Positioning of six shanks of the joints on the magnetic sphere fixed on the vacuum-aerostatic support.

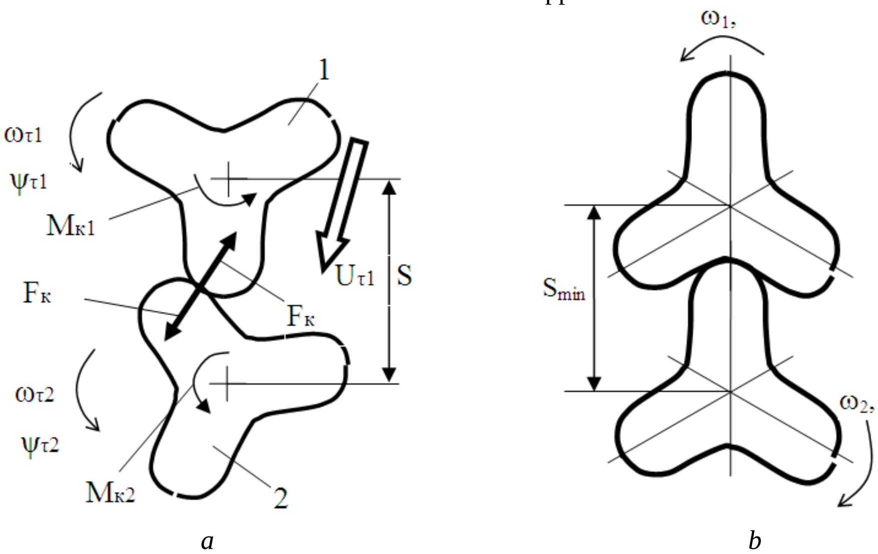


Fig. 12. Mutual displacement of two adjacent shanks on the sphere:
a – current position; *b* – minimum permissible distance between the shanks.

Presence of the projections makes it possible to increase the diameter of location of the shank extreme supporting points and, respectively, to increase the force of the shank magnetic interaction with the sphere. When a shank moves over the sphere surface, shank projections interact with one another.

In a certain current position angle between the shank axes is α and, correspondingly, distance along the arc of the big circle of the sphere will be $S = \alpha R$, where R is the sphere radius (Fig. 12 *a*). Displacement of shank 1, when it is in contact with shank 2, will occur in a certain direction at speed $U_{\tau 1}$. This will cause emergence of force F_k of contact interaction and torques M_{k1} and M_{k2}, which act on the shanks. The torques are caused by displacement of the shanks in direction $U_{\tau i}$, but their value will depend on the drive resistance moment, when the shank turns, and on the force of friction between the contact surfaces of the shanks and the sphere. Under the action of torques both shanks will turn to angles $\Psi_{\tau i}$ and $\Psi_{\tau 2}$ with angular velocities $\omega_{\tau i}$ and $\omega_{\tau 2}$. Opposing motion and turning of the shanks will take place until the minimum possible distance between the shanks is reached (Fig. 12 *b*):

$$S_{\min}=R\alpha_{\min},$$

where: $\alpha_{\min}$ is minimum possible transverse angular distance between the axes of the shanks.

When $S = S_{\min}$, only rotational motion of the shanks will be possible. In this case the shanks rotate one relative to another and projections interact, forming an interrelated rotational system. Angular rotation velocities ω_1, ω_2 are determined, in particular, by rotation angles ψ_1, ψ_2 and resistance moments, when the shank interacts with the magnetic sphere. The necessity of the shank axial rotation requires special drives in the form of pneumatic cylinders, the rods of which are able to turn relative to the bodies of the cylinders.

In certain cases magnetic spherical joints cannot be used. Therefore, alternative variants of implementation of movable triangular structures have been developed. They are based on the application of elastically-deformed drives of bellows type. In this case articulated joints cannot be used in triangular structures (Fig. 13 *a*)

2.4. Algorithms of Displacement of a Mechatronic System in the Form of Triangular Structure

A triangular structure moves by changing the position and configuration of each of the elementary triangular structures. Elementary triangular structure includes three drives in the form of pneumatic cylinders or bellows, coupled at points *A*, *B* and *C* (Fig. 13)

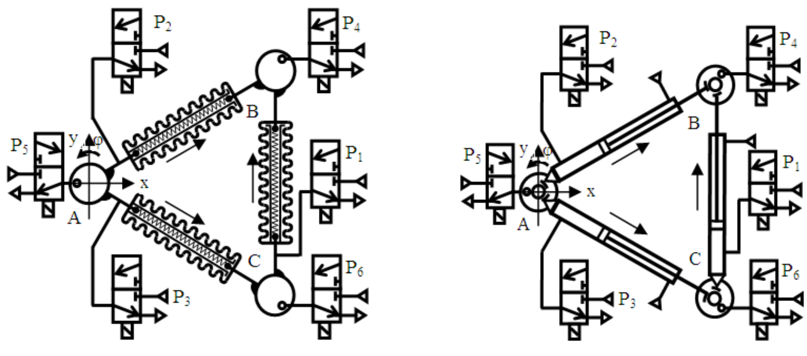


Fig. 13 – Non-articulated triangular structure with flexible bellows drives (*a*) and triangular structure with three pneumatic cylinders coupled by spherical joints installed on vacuum – aerostatic supports (*b*).

The mechanical drive system includes electric pneumatic directional control valves $P_1 – P_3$ for switching pneumatic cylinders and directional control valves $P_4 – P_6$ for switching vacuum-aerostatic supports.

In particular, directional control valve P_1 provides displacement of the rod of *CB* drive. After switching directional control valve P_1, air is supplied under pressure to the piston chamber of *CB* cylinder (Fig. 13 *b*). Simultaneously, the compressed air, via directional control valve $P_{4,}$ is supplied to aerostatic support *B*. As a result, support *B* moves to the distance, equal to the cylinder rod stroke. At the end of the piston stroke directional control valve P_4 is switched off and support *B* is fixed on the base by means of the support chamber degassing.

Reverse stroke of *CB* cylinder rod is provided by switching off the directional control valve P_1. The cylinder rod is retracted by the compressed air in the rod chamber. Directional control valve P_6 is switched on and the compressed air is supplied to the vacuum-aerostatic support C, which acquires the property of free displacement. The rod of *CB* pneumatic cylinder is retracted, shifting support *C*. In this way the structure transverse angular position is changed by angle α due to its rotation relative to support *A*. Similarly, the structure is turned by means of two other pneumatic cylinders *AC* and *AB*.

For translational displacement of the structure two directional control valves are switched simultaneously. *E.g.*, by switching directional control valves P_2 and P_3 the compressed air is supplied simultaneously to piston chambers of pneumatic cylinders *AB* and *AC*. By means of switching directional control valves P_4, P_6 the air is supplied to vacuum-aerostatic supports *B* and *C*. Respectively, the rods of pneumatic cylinders are extended, shifting supports *B* and *C*. At the end of the strokes of the pneumatic cylinders rods the structure stops. Directional control valves P_4, P_6 are switched off, and vacuum-aerostatic supports *B* and *C* are fixed on the base. Later, directional control valves P_2 and P_3 are switched off and directional control valve P_5 is switched on. The compressed air in rod chambers of cylinders *AB* and *AC* causes retraction of their rods. Aerostatic support *A* moves freely. Therefore, when bodies of pneumatic cylinders *AB* and *AC* move simultaneously, the structure is shifted in the direction of axis *x*.

Translational motion of the structure in other directions is realized in a similar way. A disadvantage of the above devices is the presence of complex spherical joints. The construction could be simplified by the application of non-articulated flexible bellows drives (Fig. 13 *a*). The non-articulated structure moves similarly to the structure with joints. Translational motion in various directions or rotational movements of the structure is provided. Deformation of bellows drives is a characteristic feature of such movements. Therefore, bellows drives *AB*, *AC* and *BC* will have a curvilinear shape during their displacement.

The developed triangular structures are designed for performing special functions. They can move both over a plane and over a curvilinear surface.

The surfaces are located at different angles to the horizontal plane. For reliable fixation of the structure vacuum-aerostatic supports are equipped with additional electromagnets and the structure acquires the capability to move over a randomly located curvilinear surface. The structure could also move over a vertical wall or riveting.

3. The Developed Prototypes of Modular Spatial Drive Systems in the Form of Triangular Structures

During the research process prototypes of triangular structures with pneumatic drives and vacuum-aerostatic supports have been developed and manufactured.

The developed planar triangular structure has one planar module that includes three pneumatic cylinders, at the bodies and rods of which shanks, interacting with magnetic spheres, are fixed (Fig. 14 *a*).

a *b*

Fig. 14 – Drive systems in the form of planar triangular modules:
a – module of an articulated type with drives in the form of pneumatic cylinders;
b – module of a non-articulated type with bellows drives.

The modules have mechatronic control systems, which provide displacement of the modules and their rotation.

At the nodal points of the drive systems the required equipment is installed, in particular, module of a non-articulated type (Fig. 14 *b*) is equipped with a pneumatic spindle.

A number of mobile innovational mechatronic drive systems have been developed, manufactured and tested. They move over curvilinear surfaces on regulated vacuum-aerostatic supports. Drives in the form of a single module of the tetrahedral type are made according to the schemes with articulated joints and without them (Fig. 15).

a b

Fig. 15 – Prototypes of spatial drive systems of a triangular type in the form of tetrahedral modules: *a* – system of six pneumatic cylinders with spherical joints; *b* – non-articulated system with bellows drives.

In these drive systems the actuator is installed on a joint located at the tetrahedral vertex. It moves in space along three coordinates.

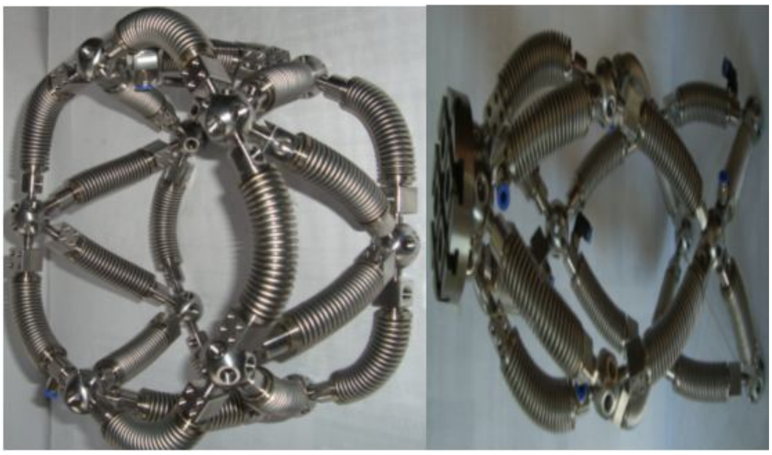
Drive systems in the form of modules of tetrahedral type have been also developed (Fig. 16 *a*).

a *b*

Fig.16 – Spatial drive systems in the form of octahedral modules: *a* – of the articulated type with magnetic joints; *b* – of the non-articulated type with bellow drives.

The developed systems are capable to move over a curvilinear surface, in a pipe or in a slot. The non-articulated system (Fig. 16 *b*) is equipped with a pneumatic spindle, installed on a movable platform, and designed for performing cleaning of the surface and its dimensionless machining.

Drive systems in the form of annular planar structures have been developed (Fig. 17).



a *b*

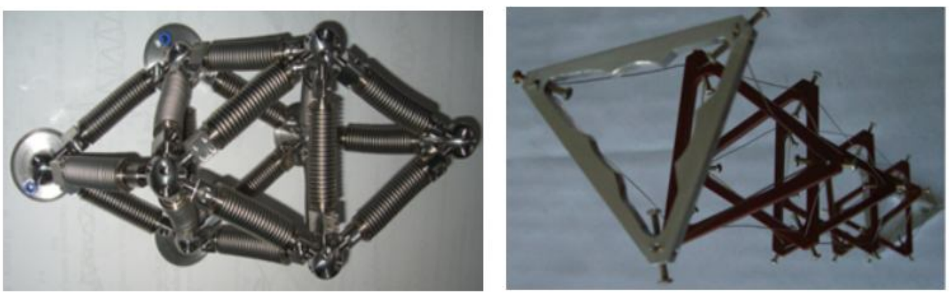
Fig. 17 – Annular non-articulated planar structures on the basis of bellows drives: *a* – annular chain structure, which includes 20 bellows drives; *b* – structure, composed of 18 drives.

Annular structures are located on a closed surface such as inner surface of a pipeline. They are designed for actuator movement inside a pipeline and performing various operations. Annular structures are efficient drive systems intended for operation in closed volumes. They include different quantities of triangular modules. Annular structure, in its minimum configuration, corresponds to a hexapod mechanism.

More complex spatial structures, composed from modules of different types, have been developed (Fig. 18).

The spatial drive system of octahedral type (Fig. 18 *b*) has drives made from a shape-memory alloy. These drive systems are used for object manipulation in extreme conditions.

Testing of the developed drive system has confirmed its operability and efficiency as well as reliability of operation.



a *b*

Fig. 18 – The developed drive systems in the form of spatial structures of tetrahedral (*a*) and octahedral (*b*) types.

4. Conclusions

1. It has been determined that circuit solutions of spatial drive systems for object manipulation in extreme conditions are expedient to be built according to the modular principle from elements composed of three drives, connected according to a triangular scheme and forming flat or spatial modules, in particular, modules of tetrahedral or octahedral type.

2. Spatial drives, located on a curvilinear surface, realize its triangulation. In the first approximation, for a constant surface curvature radius, geometric relationships of the triangulation process are determined by the formulas of spherical trigonometry that establish regularities of the drive system operation.

3. In order to realize the developed modular spatial drive systems of triangular type, a special element base including magnetic spherical joints with ferrofluid must be used. Shanks of the joints with a spherical surface have three projections each, which ensures reliable contact of the shank with the magnetic surface.

4. The developed algorithms of mechatronic control systems provide motion of the drive in the required direction or rotation of the drive system installed on the base. Modification of the algorithm enables displacement of the spatial drive system over curvilinear surfaces, walls or riveting.

Approbation of the developed prototypes of spatial drive systems has confirmed reliability of their operation and their wide functional capabilities. As further research direction, it is recommended to develop industrial prototypes of spatial modular drive systems of triangular type.

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SISTEME SPAŢIALE DE DISPOZITIVE MECATRONICE MODULARE DE TIP TRIUNGHIULAR PENTRU MANIPULAREA OBIECTELOR ÎN CONDIŢII EXTREME

(Rezumat)

Au fost dezvoltate sisteme spaţiale de dispozitive mecatronice modulare compuse din module tetraedrice şi octaedrice. Au fost realizate sinteze ale solutiilor de circuit şi simulari pe computer ale variantelor sistemului de dispozitive de bază. Au fost determinate regularităţile în funcţionare ale dispozitivelor de tip triunghilar, instalate pe o suprafaţă curbilinie. Lucrarea propune elemente de bază ale sistemelor spaţiale de dispozitive, şi anume, cuple sferice cu ferofluide şi dispozitive tip burduf. Sunt prezentaţi algoritmii de control ai sistemului ce asigură deplasarea dispozitivelor. Au fost dezvoltate şi realizate prototipuri de sisteme de dispozitive spaţiale modulare şi s-a realizat aprobarea lor. A fost verificată eficienţa şi siguranţa în funcţionare a soluţiilor inginereşti propuse.

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MECHATRONIC HYDRAULIC SYSTEM WITH ADAPTIVE CONTROLER ON THE BASIS OF NEURAL NETWORKS

BY

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Abstract: The paper considers structural variants of hydraulic systems, based on constant and variable pumps, for mobile working machines. A circuit of mechatronic hydraulic system on the basis of two variable pumps and neural network-based controller is presented. The mechatronic hydraulic system is shown to provide better controllability of the machine, higher economic efficiency and the possibility to reduce the load on hydraulic units in transient operating modes.

Keywords: controller; controllability; economic efficiency; hydraulic systems of mobile machines; mechatronic hydraulic system; neural network; proportional control.

1. Introduction

Mobile machines with manipulators on the basis of wheel tractors are widely used in construction engineering and other industries. The manufacturers of such machines produce wide nomenclature of various attachments, different types of gripping devices, excavation equipment, lifters, hydraulic shears, etc. In order to ensure optimal performing of operations, manipulators of mobile working machines require proportional control and stabilization of flow rate of the working fluid, supplied to hydraulic engines. It is also important to provide efficiency of the machine hydraulic system operation when two hydraulic engines are working simultaneously.

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Operating cycle of the working machine manipulator is characterized by frequent changes of the load values and directions as well as of the motion speed, which determines presence of significant dynamic loads in hydraulic systems of mobile working machines. Therefore, development of advanced hydraulic systems for mobile working machines with proportional electrohydraulic control, which provide stabilization of the manipulator motion speed, reliable and efficient simultaneous operation of two hydraulic engines and reduction of the dynamic loads on the working equipment of the machine during its operating cycle, is an important current task (Burennikov & Kozlov, 2000; Козлов, 2015).

2. Review of Hydraulic Systems for Working Machines

Hydraulic system circuit on the basis of two constant pumps is the most common in mobile working machines (Козлов, 2000).

The circuit (Fig. 1) includes pumps 1 and 32, directional control valves 2, 3, 4, hydraulic cylinders 5 – 17, pressure relief valves 18, 19, 20, 21, bypass valves 22, 23, throttles with check valves 24, 30, 31, hydraulic locks 25 – 27, hydraulic tank 28 and filter 29.

The hydraulic system operates in the following way. Pump 1, through directional control valve 2, supplies working fluid to the hydraulic cylinders of the bucket 5, 7, of the arm 6, 7 and of the boom 8 in order to activate them for performing working operations. Pressure relief valves 18 and 19 provide overload protection of bucket 5 and boom 8. Throttle with check valve 30 provides reduction of the boom motion speed, when it is lowered under load. Pump 32, through directional control valve 3, supplies working fluid to hydraulic cylinders 9, 10 of the loader boom, cylinders 13, 14 of the loader bucket and cylinders 11, 12 of the swing mechanism, activating them in a certain sequence for performing working operations. Pressure relief valves 20 and 21 ensure overload protection of the pipelines and hydraulic cylinders 11, 12 during the swing mechanism operation. Throttles with check valves 24 and 31 provide reduction of motion speed of the loader boom and bucket, when they are lowered under load. Pump 32, through directional control valves 3 and 4, activates hydraulic cylinder 15 of the blade and hydraulic cylinders 16, 17 of the outriggers. Hydraulic locks 25, 26 and 27 ensure sealing of the work chambers of hydraulic cylinders 15, 16, 17 under load.

Hydraulic system, based on two constant pumps, provides reliable simultaneous operation of the hydraulic cylinders of boom 8, arm 6, bucket 5 and hydraulic cylinders 11, 12 of the swing mechanism if regulation of their motion speed values is not required. If it is necessary to control motion speed of the hydraulic cylinders of the bucket 5, of the arm 6, 7, of boom 8 as well as of the hydraulic cylinders 9, 10 of the loader boom or hydraulic cylinders 13, 14 of the loader bucket, there will be significant power losses in the hydraulic system, caused by bypassing of the part of high-pressure working fluid through the bypass valves of the directional control valves 2 and 3. A disadvantage of such

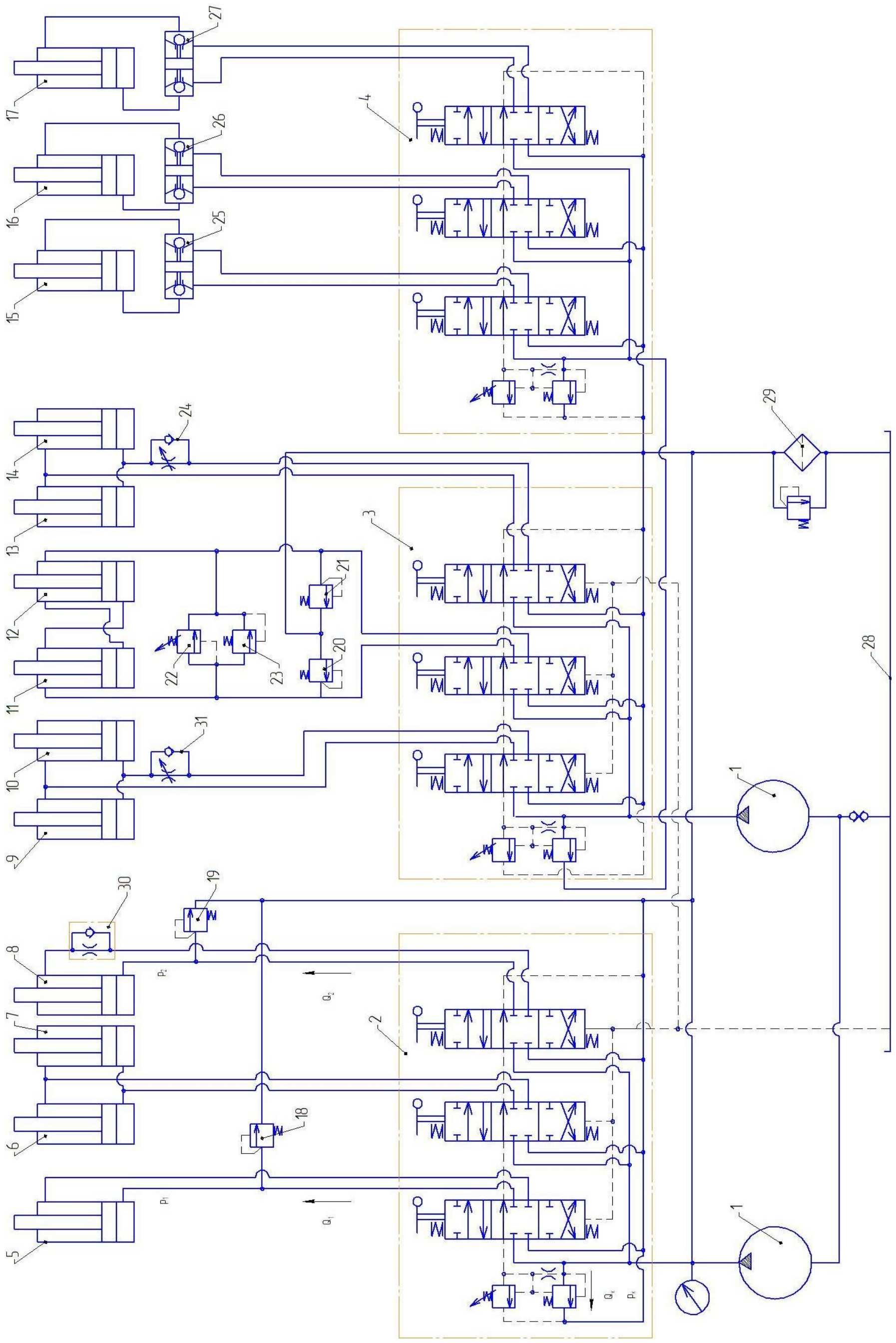

Fig. 1 – Circuit of the hydraulic system, based on two constant pumps

hydraulic system is the fact that speeds of lowering the hydraulic cylinder 8 of the boom, hydraulic cylinders 9, 10 of the loader boom and hydraulic cylinders 13, 14 of the loader bucket will depend significantly on the value of the load, acting on the working members of the mobile machine. Another disadvantage of hydraulic system, based on constant pumps, is connected with wide-range proportional control of the motion speed of hydraulic cylinders, which involves considerable power losses caused by throttling the excessive working fluid in the pressure relief valves. As a result of such control by means of throttling the excessive flow, stabilization of the motion speed of hydraulic cylinders is not provided. The above-mentioned disadvantages reduce the efficiency of the machine operation and complicate the working equipment control process.

The possibility to regulate motion speed of the mobile machine hydraulic cylinders with inconsiderable power losses is provided by the hydraulic system presented in Fig. 2 (Козлов, 2000).

The system comprises variable pump 1 and constant pump 2, directional control valves 3 and 4, hydraulic cylinders 5 – 17. Each section of the directional control valve 3 includes flow regulator 18, pressure relief valve 20, variable throttle 19. Directional control valve 4 includes bypass valve 22 and pressure relief valve 21.

The system operates in the following way. Pump 1, through directional control valve 3, supplies working fluid to hydraulic cylinders 5, 6 of the loader boom, hydraulic cylinders 7, 8 of the loader bucket, hydraulic cylinder 9 of the arm, hydraulic cylinder 10 of the excavator bucket, hydraulic cylinder 11 of the excavator boom. Presence of the variable throttle 19 and flow regulator 18 in each section of the directional control valve enables adjustment and maintaining the required level of motion speed of hydraulic cylinders 5 – 11 independent of the loads acting on their rods. Presence of pressure relief valve 20 in each section ensures protection of hydraulic cylinders 5 – 10 and the pipelines, communicating them with the directional control valve, from damage caused by excessive pressure growth. Presence of the logic valves, connected to the directional control valve 3, provides supplying signal, proportional to the value of pressure at the input of the most loaded hydraulic cylinder, to the variable pump. This signal makes it possible to control the variable pump so that pressure at the pump output will be proportional to the highest pressure at the connected cylinders and total flow rate of pump 1 will slightly exceed the total consumption of the working fluid by hydraulic cylinders, which operate at the given moment. This will provide the possibility to control motion of hydraulic cylinders 5 – 11, which will significantly improve controllability of the working machine, when it performs operations, and minimize unproductive power losses determined by regulation of the speed modes of hydraulic cylinders motion as compared with the hydraulic system presented in Fig. 1.

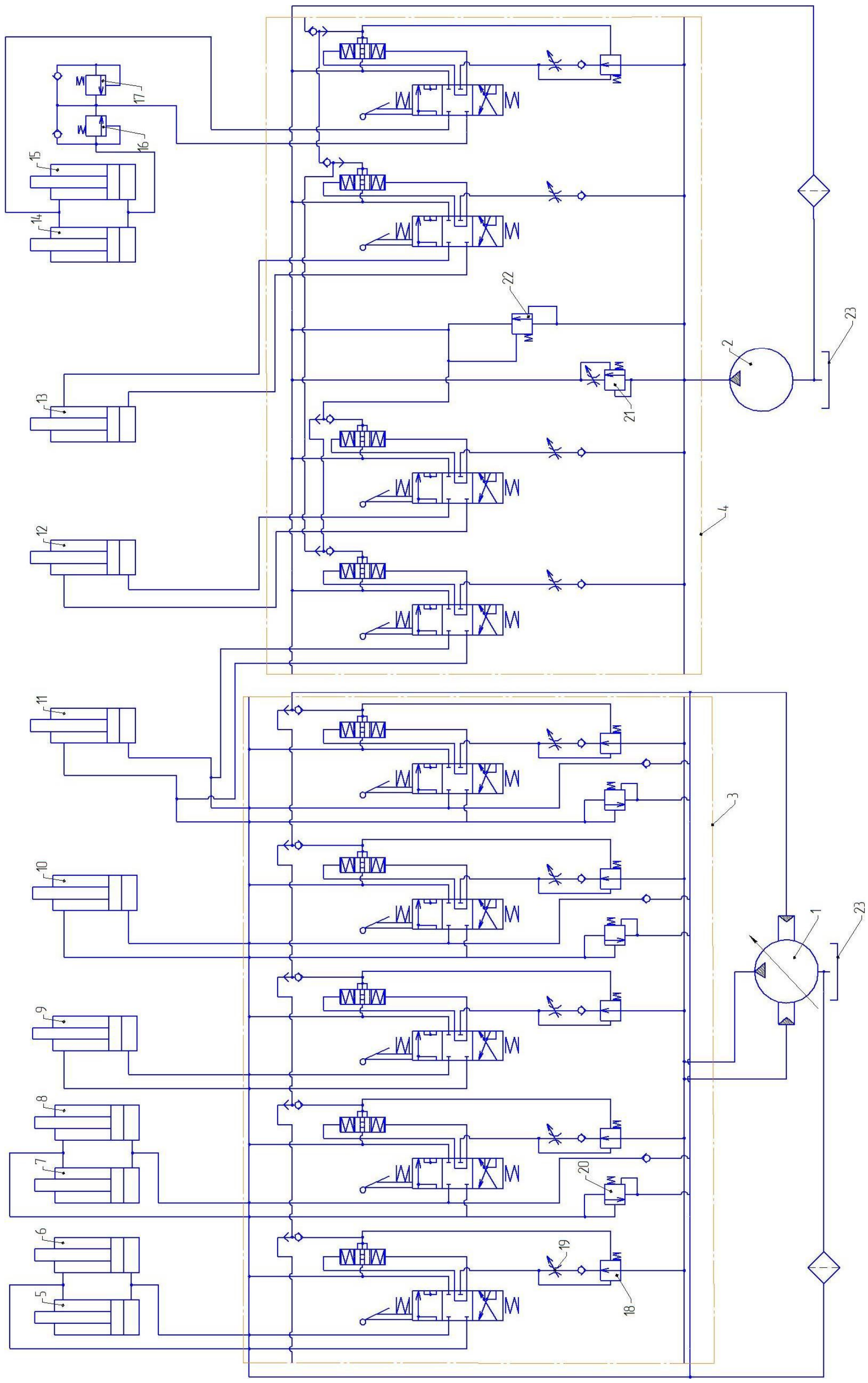

Fig. 2 – Circuit of the hydraulic system, based on constant and variable pumps

From pump 2, *via* directional control valve 4, working fluid is supplied to hydraulic cylinders 12, 13 of outriggers of the machine and hydraulic cylinders 14, 15 of the swing mechanism. The presence of bypass valves 16, 17 allows protecting hydraulic cylinders 14, 15 and pipelines, connecting them, from damage caused by excessive pressure growth. Bypass valve 22 provides dumping of the working fluid to hydraulic tank 23 during regulation of the motion speed of hydraulic cylinders 14, 15 of the swing mechanism.

The hydraulic system on the basis of constant and variable pumps ensures reliable simultaneous operation of several working members in the working cycle of the machine and provides proportional control and stabilization of the motion speed for hydraulic cylinders of the loader and excavator buckets, arms and booms, which improves controllability of the machine and its productivity. It should be noted, however, that stabilization accuracy is not sufficiently high and depends on the value, direction and variation range of the load, acting the working members. Besides, considerable pressure growth is observed in the hydraulic system during transient processes, which is determined by frequent switching of the directional control valves, sharp changes of the load values and directions as well as by the delay occurring in the response of the pressure relief valves.

In order to improve the control accuracy and ensure stabilization of the speed of hydraulic cylinders as well as to reduce overloading of the units due to sharp changes of the loads acting on the working members of the machine, in Vinnytsia National Technical University a mechatronic hydraulic system has been developed (Козлов, 2015).

The mechatronic hydraulic system includes constant pump 1 and variable pump 2, sectional directional control valve 3 with pressure relief valve 4 and programmable controller 5. Working sections of directional control valve 3 include proportional spools 6, 7, brake valves 8, 9, relay directional control valves 10, 11, pressure sensors 12, 13, position sensors 14, 15. In programmable controller 5 neural networks are realized. To terminals A_1 B_1, A_2, B_2 hydraulic cylinders of the working members of the machine are connected.

The mechatronic system operates in the following way. On switching of spool 6 the hydraulic cylinder, connected to terminals A_1, B_1, is communicated with variable pump 2 and on switching of the spool 7 the hydraulic cylinder, connected to terminals A_2, B_2, is communicated with constant pump 1. Opening of the working port of spool 7 determines the value of flow rate, supplied to the hydraulic cylinder connected to terminals A_2, B_2, and determines its speed value, which is maintained constant during wide-range load variations. Availability of the brake valve 9 makes it possible to keep the hydraulic cylinder motion speed at a constant level under concurrent load. Pressure sensor 13 generates signal, used by the programmable controller 5 for improving the accuracy of the hydraulic cylinder speed stabilization. In addition, neural network 16 enables reduction of the peak loads at the output of pump 2 under sharp changes of the

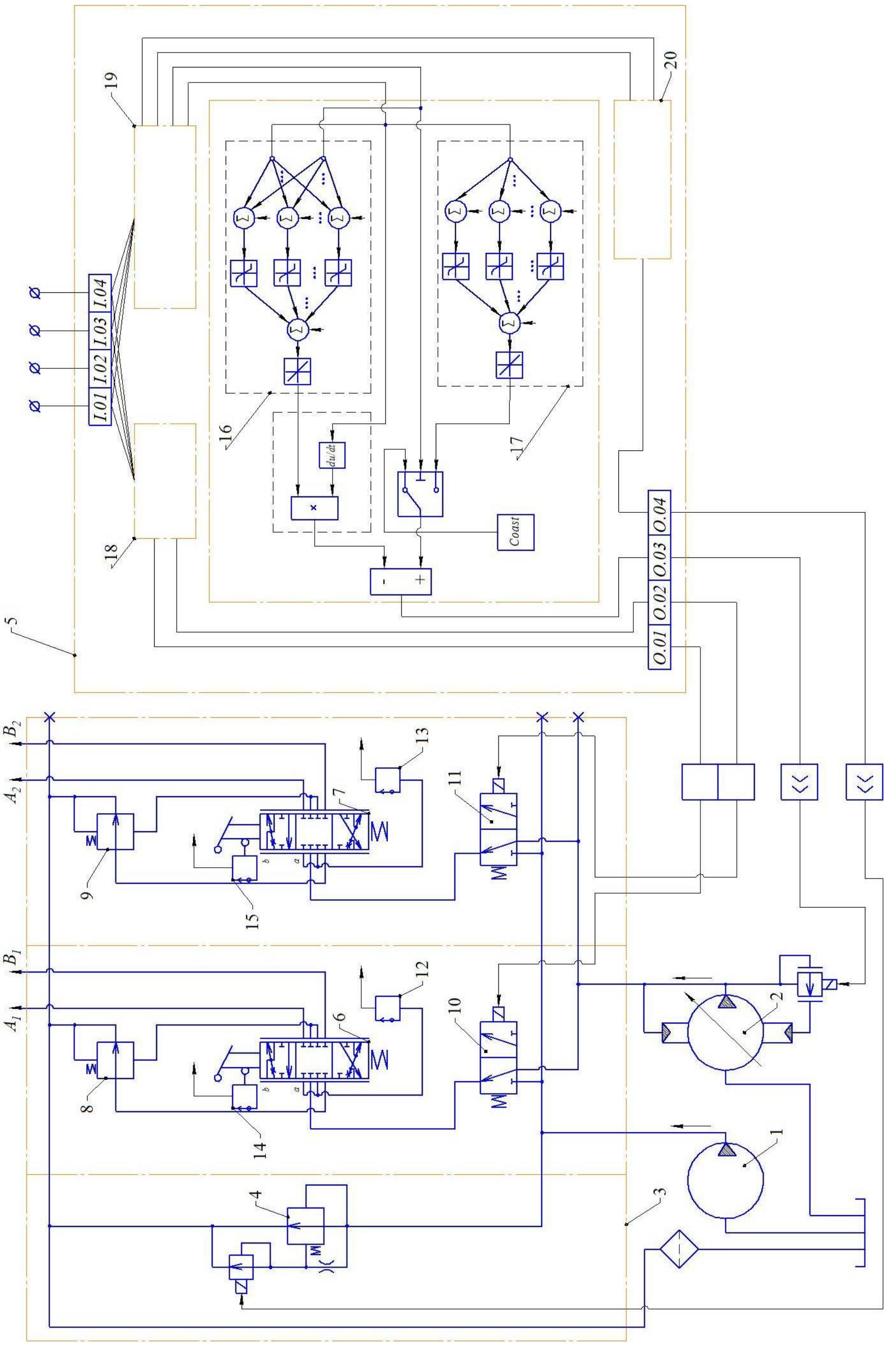

Fig. 3 – Circuit of the mechatronic hydraulic system.

working fluid flow direction in the working section and variations of the load acting on the working member of the machine.

On opening of the working port of spool 6 working fluid will be supplied from pump1 to the hydraulic cylinder, connected to terminals A_1, B_1. Its motion speed will be kept stable by means of pressure relief valve 4 and brake valve 8 both under counter load and concurrent load. Pressure valve 12 generates signal, which is used by the programmable controller 5 for improving the accuracy of the hydraulic cylinder speed stabilization. Neural network 17 makes it possible to reduce the values of peak pressure, acting on pump 1, when the direction of flow in directional control valve 3 is changed as well as the load, acting on the working member of the machine. Presence of the relay directional control valves 10, 11 in the mechatronic hydraulic system provides commutation of pumps 1, 2 with hydraulic cylinders, which could be connected to the pumps through other sections of the directional control valve 3.

4. Conclusions

The proposed circuit of the mechatronic hydraulic system provides the possibility of efficient simultaneous operation of any two hydraulic cylinders of the mobile machine. Proportional control of the motion speed of hydraulic cylinders under both counter and concurrent loads is also provided, which improves controllability of the machine. Presence of the controller, based on neural networks, enables regulation of transient processes in the hydraulic system and reduction of the load, acting on the hydraulic units.

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SISTEM HIDRAULIC MECATRONIC CU CONTROLER ADAPTIV PE BAZĂ DE REȚELE NEORONALE

(Rezumat)

Lucrarea consideră variante structurale ale sistemelor hidraulice bazate pe pompe constante şi variabile pentru maşini de lucru mobile. Este prezentat un circuit al unui sistem hidraulic mecatronic pe baza a două pompe variabile şi a unui controler bazat pe rețea neuronală. Sistemul hidraulic mecatronic demonstrează un control mai bun al maşinii, eficiență economică mai mare şi posobilitatea de a reduce încărcarea unităților hidraulice în momentele de funcționare în regim tranzitoriu