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ŞTIINȚA ŞI INGINERIA MATERIALELOR

THE INFLUENCE OF MICROCLIMATE PARAMETERS IN WORKPLACES

BY

CONSTANTIN LUPU*, ANGELICA DRĂGHICI, GHEORGHE GHEȚIE, MARIUS KOVACS, LORAND TOTH and COSMIN ILIE

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Abstract: The microclimate of the workplace is determined by the temperature, air humidity, air currents and calorific radiations of the work environment. All microclimate factors act simultaneously and combined on the human body, influencing the health state of the workers. The microclimate conditions at the workplaces have to ensure the maintenance of the thermal balance of the human body according to the level of the carried out activity.

The knowledge of work conditions from a company, service section, workshop, workplace or profession is required for highlighting and estimating the occupational noxious and their influence upon the health of staff when exercising a profession.

This paper work presents the microclimate parameters, the manner for determining them in work spaces and their influences both in pollutant concentrations as well as upon the health of workers.

Keywords: work environment; noxious; occupational disease; microclimate parameters.

1. Introduction

In the paperwork there are presented the influence of microclimate parameters both on the results of noxious determinations carried out in workplaces from the steel industry, as well as on the health of workers.

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The microclimate of the workplace is characterised by the temperature and humidity of air, air currents and calorific radiations of the workplace. All microclimate factors act simultaneously and combined on the human body. The air temperature is decisive, the other parameters potentiating or diminshing the effects of the temperature. Microclimate conditions in workplaces have to ensure the maintenance of the thermal balance of the human body according to the level of the carried out activity.

Unfavourable microclimate is defined as all microclimate factors whose combined action exceeds the adaptive capacity of the body, overburdening the thermal-control system for maintaining the thermal balance. The burdening of the thermal-control system generates thermal stress.

The factors comprised by the occupational microclimate are the following:

a) air temperature, [°C];

b) air relative humidity, [%];

c) air currents velocity, [m/s];

d) calorific radiation, [cal/cm^2/min];

e) temperature of work surfaces, [°C].

Overall, these parameters influence the human body, the human mood and the work productivity.

The determination of microclimate factors has to be carried out as follows:

a) during the work day (start, middle, end);

b) during the peak periods of the technological process;

c) in the hot and cold seasons;

d) during the operation of the ventilation and when it is turned off.

Establishment of the determination points

When establishing the areas for determining the microclimate there have to be taken into account the following:

a. horizontally:

a_1) workplaces with maximum noxious emission (*e.g.* in front of the oven, near the steam boilers, etc.);

a_2) workplaces where the most workers are grouped;

a_3) at the entrance of the room (near doors, windows);

b. vertically:

b_1) at 0.5 m, 1.0 m and 1.5 m in order to estimate/notice eventual temeprature differences on the vertical of the work space;

b_2) at a height of 0.1m, respectively 1.1 m (which corresponds to the ankles and cervical area of a workers which sits down) in order to establish the values of the microclimate which are characteristic for the thermal comfort.

The representativeness of a series of measurements related to the exposure of workers to noxious has to be ensured by applying a well-defined measurement strategy, depending on the aimed objectives and on the available

manners, taking into account the microclimate parameters from the production section or bay.

2. Microclimate Parameters Effects Upon the Health State of Workers

According to Law 319/2006 on occupational health and safety, "occupational diseases are affections which occur following the exercise of a craft or profession, cause by physical chemical or biological harmful factors which are specific for the workplace, as well as by the overburdening of various organs or systems of the body during the work process".

The temperature is an important factor of the ambient, having effects upon the health state, effort and work results of the executants. We become aware of the environmental temperature when we have the sensation of cold or hot, which is triggered due to the imbalance between the thermal conditions of the environment and our body.

The achievement of a thermal ambiance which is proper for a physiological state of the body (subjective temperature) is based on the stable balance between the temperature and humidity of the environment. Therefore:

a) *if the temperature decreases*, the body reacts through peripheral vasoconstriction and through the intensification of the thermogenesis characterized by an increase of the metabolism several times over the normal value and by the muscular tonus increase – "shivering";

b) *if the temperature increases* over the upper limit of thermal neutrality (32^0C), it determines an adaptive reaction consisting in:

b_1) the increase of sweat flow up to 1.3 kg/h, if that liquid is not replaces there can be reached a hydro deficit state, and once with the sweat there are lost other constituents (sodium, vitamins, etc.);

b_2) activation of the circulation with an increase of the circulation flow;

b_3) increased respiratory rate.

The temperature of the work environment influences the health and performances of workers through the following:

i) the combined effect of temperature and humidity;

ii) the period of exposure to thermal conditions outside the comfort area, case in which the acclimatisation is required;

iii) temperature of objects and tools used for working, high differences (object temperature over 43^0C or under 0^0C) between the human body temperature and the one of the tools can produce pain or even destroy tissues.

Relative humidity: The human body is sensitive to relative humidity, values of it higher than 70% and lower than 30% being considered outside the thermal comfort zone for a work environment.

The lower limit of 30% characterises the situation in which a human starts to feel the dryness sensation, and under 25% occur negative repercussions

upon the structure and function of the respiratory mucosa which ensure the elimination of impurities (including germs) from breathed in air.

The upper limit is conditioned by the occurrence of the stuffiness sensation; humidity over 75% when working hard has negative impact upon the thermolysis process (until calorific shock).

Air movement velocity exercises a higher influence upon the heat exchange of the body, energy consumption and the neuropsychic state. The influence of air movement upon the thermal metabolism is manifested by the increase of heat loss through convection, because the air removes the heated layers of the body, and their place is taken by cold air

The maximum admitted air velocity in a room is established depending on the air temperature determined by the heat exchange through convection between the human and the environment. Depending on the air velocity, in the work place occurs the *sensation of air current*. The sensation of air current is subjective, for some persons it occurs at low air velocities, known the fact that some parts of the human body like the nep of the neck, are more sensitive than others; it is recommended in general to have air velocities in the room under 0.3 m/s.

3. Case Study Carried Out in Workplaces from the Steel Industry

The steel industry is one of the most developed industrial branches of the world, achieving more than 75% of the entire value of the metallurgical industry. The steel industry uses iron ore, scrap metal, coke, natural gases, fluxes. Obtaining cast iron is carried out in furnaces, which generate as sub-product the iron dross used in cement fabrics. Steel is obtained in ovens or converters with direct oxygen insufflation. Through lamination there are obtained products of a certain shape with a massif profile used for obtaining finite products.

The steel industry taken into study, depending on the activity profile, comprises the following sections: steelworks, laminators, logistics (transport, oxygen production, electrical energy and gas supply, maintenance and repairals).

Workers from the steelworks and from the laminators are exposed to a high level of occupational noxious.

The start point in the optimization of the activity of preventing work accidents and occupational disease in is system is represented by the risk assessment from that system.

Risk assessment involves the identification of all risks from the analysed system and the quantification of their dimension based on the combination of two parameters: severity and frequency of the maximal possible consequence upon the human body.

There are obtained partial risk levels for each risk factor, respectively global risk levels for the entire analysed system.

For fulfilling these desiderates there is required a quantification of the level of occupational exposure to noxious from the workplace, by carrying out determinations for noxious which are susceptible to exceed the maximum limits admitted by the legislation in force, including the microclimate changes from each workplace.

During 2013, INCD INSEMEX Petrosani has determined the microclimate parameters (temperature, humidity, air currents velocity and illumination level) at workplaces from economic operators in the steel industry.

The determination of microclimate parameters from the work environment has been carried out in compliance with the procedure of the Laboratory for Toxicology from within INCD INSEMEX authorized by the Ministry of Health, Direction for Public Health and Public Health Control.

For determining the microclimate parameters there has been used the AMI 300 device from the endowment of INCD INSEMEX Petrosani.

Pentru determinarea parametrilor de microclimat, s-a utilizat aparatul AMI 300 din dotarea INCD INSEMEX Petroşani.

AMI device 300 is a multifunctional tool for temperature measurements (range –20 to +80 ^{0}C), humidity (range 3%,…,98%), air velocity (range 0.2 to 30 m/s) and index WBGT thermal comfort – globtermometer temperature (Fig. 1).

Fig. 1 – AMI 300 Device.

Equipment has several Smart Pro probes that connects to the device.
AMI 300 functions:
a) Micro – manometer.
b) Thermo – hot-wire anemometer.
c) Thermo – Anemometer with hand mill probe.

d) Thermometer.
e) Thermometer – hygrometer.
f) Tachometer

To measure each parameter, connect the appropriate sensor (wired or wireles) to the device and positioned in the desired location determination, the measured value is shown on the display.

The results of microclimate measurements made at different workplaces in the steel industry are presented in Table 1.

Table 1

Item no.	Place of determinations	Temperature ºC	Relative humidity %	Airflow m/s	Lighting lux
0	1	2	3	4	5
1	Furnace platform	34.7	37.2	0.2	297.3
2	Laminating train	35	36.6	0.2	168
3	Cooling beds sector	29.5	38.7	0.2	180
4	KD Saw	24	37.2	0.2	350
5	Saw bridge	25.5	45.1	0.1	95
6	Reinforcements workshop	30.7	39.3	0.1	122
7	Fitting Sector	22.6	32,9	0,2	165
8	Overhead cranes laminating line	30.8	35.5	0.1	85
9	Machinery Hall	22.5	40.2	0.3	75
10	Hydraulic station	22.6	55.2	0.1	98
11	Electrical Station	20	38.2	0.1	130
12	Inside the rolling mill hall	29.3	41.6	0.2	120

The graphical representation of the temperature measurements, the profiles rolling mill section are shown in Fig. 2.

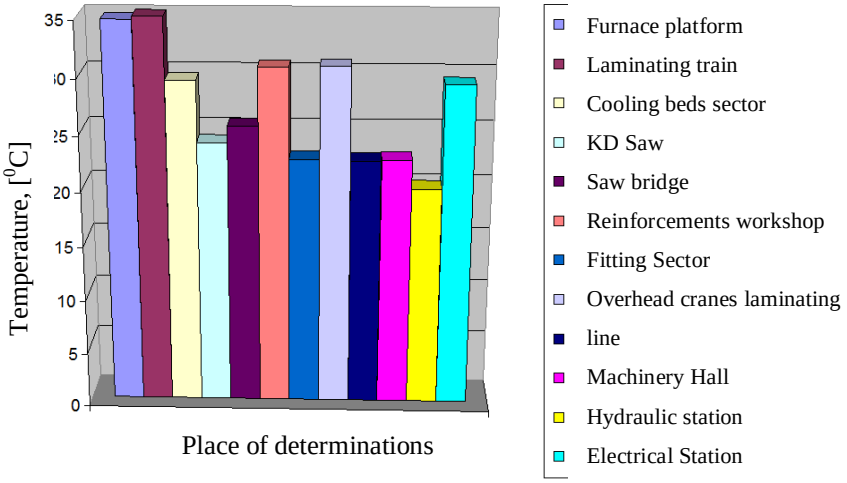

Fig. 2 – Measurement of temperature.

Graphic representation of the relative humidity measurements the profiles rolling mill section are shown in Fig. 3.

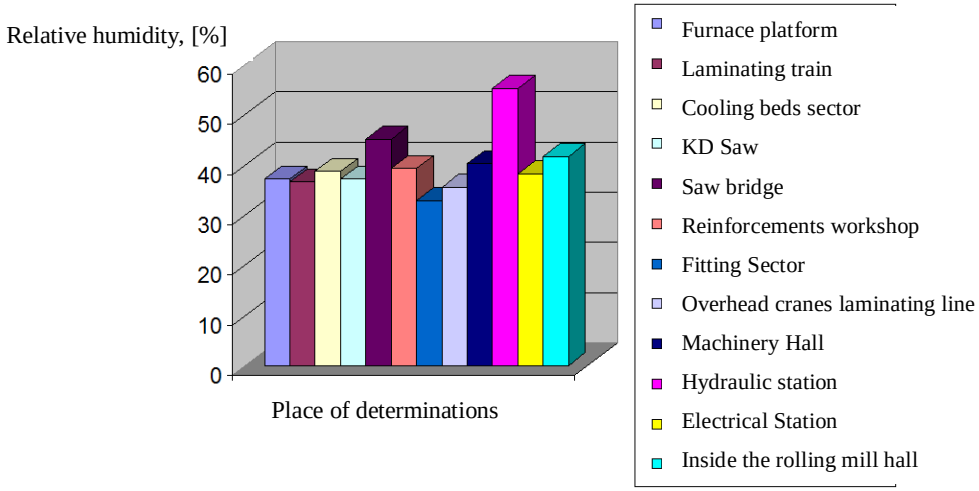

Fig. 3 – Determination of relative humidity.

The graphical representation of the airflow at the profiles rolling mill section are shown in Fig. 4.

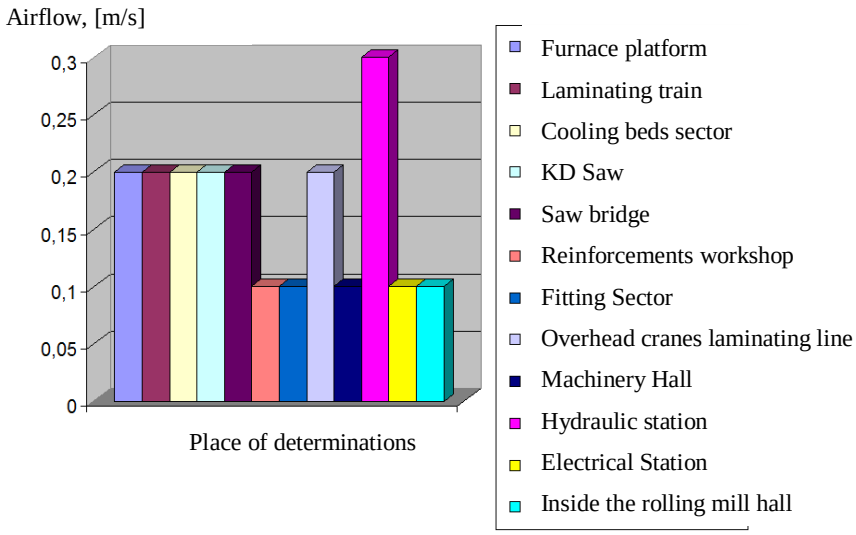

Fig. 4 – Determination of airflow.

Graphical representation of lighting measurements at the profiles rolling mill section are shown in Fig. 5.

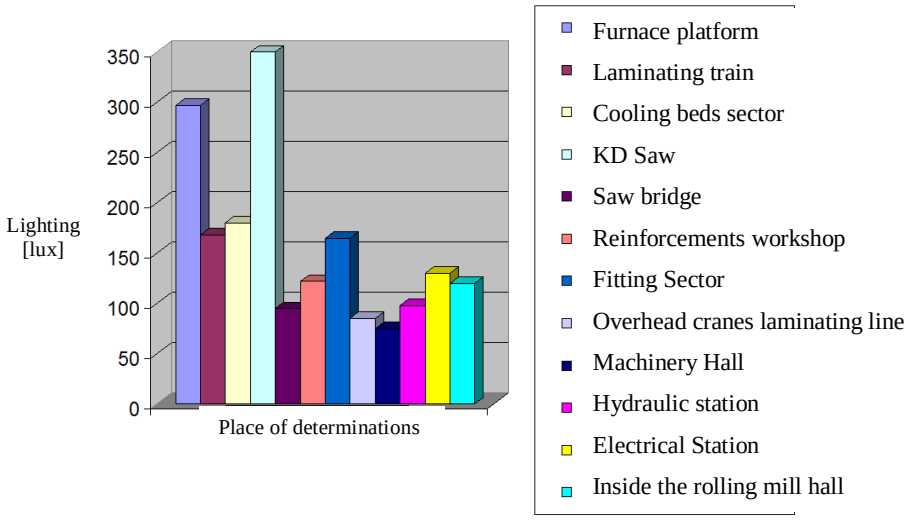

Fig. 5 – Determination of the lighting.

The results obtained from the measurements indicates that the temperature has been made higher values, ranging from 20 to 34.7 ^{0}C, which influence the relative humidity to which the values were 32.9%,…,50.7%.

Speed is relatively low air flow of 0.1,…,0.2 m/s and leads to higher values of the temperature record of the workplaces.

For light levels were measured value of between 29.9,…,297.3 lux.

If the General Norms of Labor Protection (NGPM) were set maximum limits for the parameters of microclimate in Law 319/2006 are not set such limits, even if they have great influence on the health of workers.

The values determined are considering reporting the General Norms of Labor Protection until a new legislative act.

4. Conclusions

Activity in the steel industry is characterized by intense physical exertion, held in generally poor environmental conditions.

According to the General Rules of Labor Protection, 2002 edition, the minimum permissible thermal limits in workplaces characterized by a very gut metabolism have values for temperature at 12ºC, respectively an air velocity $\leq$ 0.5 m/s.

The time values in excess of harm in terms of microclimate, which ensures that the heat balance of the human body, the risk of injury and / or occupational disease remains stubbornly high.

Effect of environmental conditions (temperature, humidity, pressure, thermal environment and heat stress) has significant influence on the

performance of workers. Knowledge microclimate at work by management allows decisions and appropriate measures to improve the working conditions of workers.

Microclimate in the workplace (temperature, humidity, air flow rate, surface and caloric radiation emitted in the work area) affect safety, health and working capacity of contractors, where its parameters do not fall within certain comfort limits, according to regulations.

Microclimate measurement results conducted in workplaces under section rolling mill temperature profiles show that there were elevated, ranging from 20 to 34.7 ^{0}C, which influence the relative humidity for which we obtained values of 32.9%,…,50.7%, airflow velocity is relatively smaller than 0.1,…,0.2 m/s and leads to higher values of the temperature record of the workplaces and the level of illumination were measured values between 29.9,…,297.3 lux.

REFERENCES

* * * Government Decision 355/2007 on workers' health surveillance
* * * Government Decision 601/2007 amending and supplementing certain acts of health and safety.
* * * Government Emergency Ordinance 195/2005 on environmental protection.
* * * Government Decision 1/2012 amending and supplementing Government Decision 1.218/2006 establishing minimum safety and health for the protection of workers from risks related to chemical agents and amending GD 1.093/2006 establishing minimum safety and health requirements to protect their workers from risks related to exposure to carcinogens or mutagens at work and GD 355/2007 on the supervision of health workers.
* * * *Workplace Atmosphere, Defining Factions Dimensional Measuring Air Particulates*. SR EN 481/2003.
* * * *Workplace Air Guide for Assessing Exposure Limit Values and Measurement Strategy*. SR EN 689/2003.
* * * General procedure for risk management INCD INSEMEX.
* * * User's manual of multifunction device AMI 300 and 300 STD.

INFLUENȚA PARAMETRILOR DE MICROCLIMAT LA LOCURILE DE MUNCĂ

(Rezumat)

Microclimatul locului de muncă este determinat de temperatura, umiditatea aerului, curenții de aer şi radiațiile calorice ale ambianței de muncă. Toți factorii de microclimat acționează combinat şi concomitent asupra organismului uman, influențând starea de sănătate a lucrătorilor. Condițiile de microclimat la locurile de muncă trebuie să asigure menținerea echilibrului termic al organismului uman corespunzător cu nivelul activității desfăşurate.

Cunoaşterea condiţiilor de muncă dintr-o unitate economică, secţie, atelier, loc de muncă ori profesiune, este necesară pentru a putea evidenţia şi aprecia noxele profesionale şi influenţa pe care o pot avea asupra sănătăţii personalului în cadrul exercitării unei profesiuni.

Lucrarea prezintă descrierea parametrilor de microclimat, modul de determinare a acestora în spaţiile de lucru şi influenţa lor atât în concentraţiile de poluanţi cât şi asupra sănătăţii lucrătorilor.

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LE MEDECIN DU TRAVAIL DANS L'ENTREPRISE, EN FRANCE

PAR

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Résumé. Afin d'exercer ces missions, le médecin du travail en France conduit des actions en milieu de travail avec **l'équipe pluridisciplinaire** dont il est l'animateur et le coordonnateur. Le médecin du travail est habilité à signer les avis d'aptitude donnés au cours des différents types d'examens médicaux (embauche, reprise du travail, examens périodiques et examens à la demande du salarié ou de l'employeur). Il est membre de droit du Comité d'Hygiène, de Sécurité et des Conditions de Travail (CHSCT). **L'examen médical d'embauche** est obligatoire pour tous les salariés. Si le salarié est soumis à une surveillance médicale renforcée, il bénéficie obligatoirement de cet examen **avant** l'embauche. Si un salarié a été en arrêt de travail plus de trois mois, une **visite de pré-reprise** est organisée par le médecin du travail qui est habilité à proposer des mesures individuelles telles que mutations ou transformations de poste justifiées par des considérations relatives notamment à l'âge, à la résistance physique ou à l'état de santé physique et mentale des travailleurs. **L'examen médical de reprise du travail** réalisé par le médecin du travail est obligatoire après : un congé de maternité, une absence pour cause de maladie professionnelle, une absence d'au moins trente jours pour cause d'accident du travail, de maladie ou d'accident non professionnel. L'employeur doit prendre les mesures nécessaires pour assurer la prévention de **la pénibilité au travail**. Les risques professionnels entrant dans la définition de la pénibilité sont : **des contraintes physiques marquées** (les manutentions manuelles de charges; les postures pénibles définies comme positions forcées des articulations ; les vibrations mécaniques) ; **un environnement physique agressif** (les agents

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chimiques dangereux y compris les poussières et les fumés, les activités exercées en milieu hyperbare, les températures extrêmes, le bruit) ; **certains rythmes de travail** (le travail de nuit, le travail en équipe successives alternantes, le travail répétitif). L'employeur sollicite son médecin du travail pour la mise en place de cette règlementation sur la pénibilité. Le système de la médecine du travail en France est caractérisé par la vocation exclusivement préventive.

Mots clés : médecin du travail ; équipe pluridisciplinaire ; pénibilité ; aptitude.

Le système de la médecine du travail et des services de santé au travail constitue le premier réseau de prévention en France avec 6435 médecins en équivalent temps plein (chiffre du bilan annuel des conditions du travail 2010). Placé au cœur de ce système, le médecin du travail est souvent l'acteur de prévention le plus présent dans les entreprises et, en particulier, dans les plus petites d'entre elles. Les textes législatifs : la Loi n° 2011-867 du 20 juillet 2011 relative à l'organisation de la médecine du travail et les textes réglementaires publiés au journal officiel du 31 janvier 2012, le décret n°2012-135 relatif à l'organisation de la médecine du travail et le décret n° 2012-137 relatif à l'organisation et au fonctionnement des services de santé au travail entrés en vigueur le 1er juillet 2012.

Le médecin du travail est le conseiller de l'employeur, des travailleurs, des représentants du personnel et des services sociaux. Afin d'exercer ses missions, le médecin du travail conduit des actions sur le milieu de travail avec les autres membres de **l'équipe pluridisciplinaire** dont il est l'animateur et le coordonnateur. Ces actions comprennent : la visite des lieux de travail, l'étude de postes en vue de l'amélioration des conditions de travail, de leur adaptation dans certaines situations ou du maintien dans l'emploi, l'identification et l'analyse des risques professionnels, l'élaboration et la mise à jour de la fiche d'entreprise, la délivrance de conseils en matière d'organisation des secours et des services d'urgence, la participation aux réunions du Comité d'Hygiène, de Sécurité et des Conditions de Travail, la réalisation de mesures métrologiques, l'animation de campagnes d'information et de sensibilisation aux questions de santé publique en rapport avec l'activité professionnelle, les enquêtes épidémiologiques, la formation aux risques spécifiques, l'étude de toute nouvelle technique de production, l'élaboration des actions de formation à la sécurité et à celle de secouristes.

Le médecin du travail est habilité à signer les avis d'aptitude donnés au cours des différents types d'examens médicaux (embauche, reprise du travail, examens périodiques et examens à la demande du salarié ou de l'employeur). Il est membre de droit du Comité d'Hygiène, de Sécurité et des

Conditions de Travail (CHSCT). Il exerce son activité professionnelle en toute indépendance.

L'infirmier du travail exerce ses missions propres ainsi que celles confiées par le médecin du travail sous sa responsabilité, et dans le cadre de protocoles écrits. Il participe au suivi médical individuel des salariés en effectuant des entretiens infirmiers pouvant être mis en place en cas de modulation de certains examens périodiques. Il peut également effectuer des examens complémentaires et participer à des actions en milieu de travail et à des actions d'informations collectives conçues par le médecin du travail et validées par lui.

L'intervenant en prévention des risques professionnels (IPRP). Son domaine d'intervention se situe notamment dans la sécurité, l'ergonomie, la toxicologie, l'hygiène industrielle, l'organisation du travail. Il communique les résultats de ses études au médecin du travail qui les transmet à l'employeur. Il assure ses missions dans des conditions garantissant son indépendance.

L'assistant en santé au travail contribue à repérer les dangers et à identifier les besoins en santé au travail, notamment dans les entreprises ayant un effectif inférieur à 20 salariés, sous l'autorité du médecin du travail.

Le médecin du travail a libre accès aux lieux de travail. Le droit d'accès des autres membres de l'équipe pluridisciplinaire doit se faire en concertation avec le médecin du travail et l'employeur. Le médecin du travail et les autres membres de l'équipe pluridisciplinaire sont soumis au secret professionnel. Il leur est formellement interdit de révéler les secrets de fabrication et les procédés d'exploitation dont ils auraient connaissance dans l'exercice de leurs fonctions.

L'examen médical d'embauche est obligatoire pour tous les salariés. Le médecin du travail est habilité à effectuer cet examen, pour : s'assurer que le salarié est médicalement apte au poste de travail auquel l'employeur envisage de l'affecter ; proposer éventuellement les adaptations du poste ou l'affectation à d'autres postes ; rechercher si le salarié n'est pas atteint d'une affection dangereuse pour les autres travailleurs ; informer le salarié sur les risques des expositions au poste de travail et le suivi médical nécessaire ;sensibiliser les salariés sur les moyens de prévention à mettre en œuvre. Le salarié doit bénéficier d'un examen médical avant l'embauche ou au plus tard avant l'expiration de la période d'essai. Si le salarié est soumis à une surveillance médicale renforcée, il bénéficie obligatoirement de cet examen **avant** l'embauche. Les salariés bénéficiant d'une **surveillance médicale renforcée** sont les travailleurs âgés de moins de dix-huit ans ; les femmes enceintes ; les salariés exposés à l'amiante, aux rayonnements ionisants, au risque hyperbare, au bruit, aux vibrations, à certains agents biologiques, agents cancérogènes, mutagènes ou toxiques pour la reproduction ; les travailleurs handicapés. C'est à l'employeur de déclarer au service de santé au travail les salariés bénéficiant de la surveillance médicale renforcée.

Si un salarié a été en arrêt de travail plus de trois mois, une **visite de pré-reprise** est organisée par le médecin du travail, à la seule initiative du médecin traitant, du médecin conseil des organismes de sécurité sociale ou du salarié. Cet examen médical permet au médecin du travail de recommander éventuellement : des aménagements et adaptations du poste de travail ; des préconisations de reclassement ; des formations à organiser en vue de faciliter le reclassement du salarié ou sa réorientation professionnelle. Cet examen médical a lieu au cours de l'arrêt de travail. Le médecin du travail informe avec l'accord du salarié l'employeur et le médecin conseil de ses recommandations afin que toutes les mesures soient mises en œuvre pour favoriser le maintien dans l'emploi du salarié. Toutefois, le salarié peut s'opposer à l'information de l'employeur par le médecin du travail. Le médecin du travail est habilité à proposer des mesures individuelles telles que mutations ou transformations de postes, justifiées par des considérations relatives notamment à l'âge, à la résistance physique ou à l'état de santé physique et mentale des travailleurs. L'employeur est tenu de prendre en considération ces propositions et, en cas de refus, de faire connaitre les motifs qui s'opposent à ce qu'il y soit donné suite. En cas de désaccord ou de difficulté, l'employeur ou le salarié peuvent exercer un recours auprès de l'inspecteur du travail qui prendra sa décision après avis du médecin inspecteur du travail.

L'examen médical de reprise du travail réalisé par le médecin du travail est obligatoire après : un congé de maternité ; une absence pour cause de maladie professionnelle ; une absence d'au moins trente jours pour cause d'accident du travail, de maladie ou d'accident non professionnel. Le but est de délivrer l'avis d'aptitude médicale du salarié à reprendre son poste ; préconiser l'aménagement, l'adaptation du poste ou le reclassement du salarié ; examiner les propositions d'aménagement, d'adaptation du poste ou de reclassement faites par l'employeur à la suite des préconisations émises par le médecin du travail lors de la visite de pré-reprise lorsqu'elle a eu lieu. Dès que l'employeur a connaissance de la date de la fin de l'arrêt de travail, il doit saisir le service de santé au travail qui organise l'examen médical de reprise du travail dans un délai de huit jours à compter de la date effective de la reprise du travail par le salarié. Le contrat de travail du salarié est suspendu jusqu'à l'examen de reprise effectué par le médecin du travail. L'employeur doit informer le médecin du travail de tout arrêt de travail pour cause d'accident du travail d'une durée inférieure à trente jours. Le médecin du travail pourra ainsi apprécier l'opportunité d'un nouvel examen médical.

La pénibilité au travail. La loi du 9 novembre 2010 portant sur la réforme des retraites a introduit dans le Code du travail et dans le Code de la Sécurité sociale de nouvelles obligations pour l'employeur. L'employeur doit prendre les mesures nécessaires pour assurer la prévention de la pénibilité au travail. Les risques professionnels entrant dans la définition de la pénibilité sont : **des contraintes physiques marquées (**les manutentions manuelles de

charges ; les postures pénibles définies comme positions forcées des articulations ; les vibrations mécaniques) ; **un environnement physique agressif (**les agents chimiques dangereux y compris les poussières et les fumés ; les activités exercées en milieu hyperbare ; les températures extrêmes ; le bruit) ; **certains rythmes de travail (**le travail de nuit ; le travail en équipe successives alternantes ; le travail répétitif caractérisé par : la répétition d'un même geste à une cadence contrainte, imposée ou non par le déplacement automatique d'une pièce ;la rémunération à la pièce, avec un temps de cycle défini). L'employeur sollicite son médecin du travail pour être conseillé sur la mise en place de cette règlementation sur la pénibilité.

Le système de la médecine du travail en France repose sur des principes qui restent au cœur de son organisation : l'universalité d'abord puisque la médecine du travail s'adresse à tous les salariés, quels que soient leur secteur d'activité, la taille de leur entreprise et la vocation exclusivement préventive de ce système.

BIBLIOGRAPHIE

* * * Loi n° 2011-867 du 20 juillet 2011 relative à l'organisation de la médecine du travail
* * * Décret n° 2012-134 du 30 janvier 2012 tirant les conséquences de la création de la fiche prévue à l'article L. 4121-3-1 du code du travail
* * * Décret n° 2012-135 du 30 janvier 2012 relatif à l'organisation de la médecine du travail
* * * Décret n° 2012-136 du 30 janvier 2012 relatif à la fiche prévue à l'article L. 4121-3-1 du code du travail
* * * Décret n° 2012-137 du 30 janvier 2012 relatif à l'organisation et au fonctionnement des services de santé au travail
* * * Circulaire DGT n°13 du 9 novembre 2012 relative à la mise en œuvre de la réforme de la médecine du travail
* * * Circulaire DGT n°1 du 5 février 2007
* * * Décret n° 2004-760 du 28 juillet 2004 et sa Circulaire DRT n°3 du 7 avril 2005
* * * Circulaire DRT 2004-01 du 13 janvier 2004.
* * * Décret 2003-546 du 24 juin 2003.
* * * Décret 2001-1016 du 5 novembre 2001
* * * Loi n° 2002-73 du 17 janvier 2002,
* * * Loi du 11 octobre 1946 (articles L.4621-1 et suivants du Code du Travail).

MEDICUL DE MEDICINA MUNCII DE ÎNTREPRINDERE, ÎN FRANȚA

(Rezumat)

În Franța, pentru a-şi îndeplinirii atribuțiile, medicul de medicina muncii desfăşoară acțiuni la locul de muncă animând şi coordonând o echipă pluridisciplinară.

Medicul de medicina muncii este abilitat să semneze avizul de aptitudine la finalul diverselor tipuri de examene medicale (la angajare, la reluarea activității, după examinări periodice ori după examene efectuate la cererea salariatului ori a angajatorului). Medicul de medicina muncii este membru de drept al Comitetului de Igienă, de Securitate şi a Condițiilor de muncă din întreprindere. **Examenul medical la angajare** este obligatoriu pentru toți salariații. Dacă salariatul este supus unei supravegheri medicale speciale, acesta beneficiază de acest examen înaintea angajării. După un concediu medical cu o durată de peste trei luni medicul de medicina muncii efectuează o vizită medicală înainte reluării activității, ocazie cu care poate propune măsuri individuale de protecție cum ar fi mutarea la un alt loc de muncă ori transformarea postului, propuneri justificate mai ales de vărstă, rezistența fizică ori de starea fizică ori mentală a muncitorului. **Examenul medical efectuat la reluarea activității** de către medicul de medicina muncii este obligatoriu după concediul de maternitate, dupa o absență datorată unei boli profesionale, după o absență de cel puțin treizeci de zile din cauza unui accident de muncă ori după boli sau accidente ne profesionale. Angajatorul trebuie să ia măsurile necesare pentru a asigura **prevenirea penibilității** legate de muncă. Riscurile profesionale cuprinse în definiția penibilității sunt : dificultățile fizice accentuate (manipularea manuală de greutăți ; pozițiile de muncă dificile definite ca poziții forțate ale articulațiilor ; vibrațiile mecanice) ; o ambianță fizică agresivă (agenți chimici periculoşi incluzând pulberi şi vapori, activitățile în mediu hiperbar, temperaturile extreme, zgomotul) ; anumite ritmuri de muncă (munca de noapte, munca în schimburi succesive alternante, munca repetitivă). Angajatorul solicită medicul de medicina muncii în vederea aplicării reglementărilor cu privire la penibilitate. **Sistemul de medicina muncii din Franța este caracterizat prin aspectul său exclusiv preventiv**.

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DIAGNOSIS AND PROGNOSIS OF THE HEARING IMPAIRMENT RISK

BY

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Abstract: This paperwork presents a methodological approach on the analysis and on the statistical and probabilistic assessment of the hearing impairment risk, based on the hazards quantified as risk predictors, in order to establish the modalities for assessing the caution limits related to the acceptability ranges.

The statistical approach is based on the rational quantification of what exists and can be observed, the probabilistic part of this fact representing the extrapolation to what it can be reasonably deduced from these statistics of hearing impairment occurrence probability.

Keywords: noise; auditory handicap; diagnosis; prognosis; distribution; algorithm.

1. Generalities Regarding the Hearing Impairment Due to Noise

Individuals regularly exposed to noise may suffer from hearing loss with variable severity. Due to hearing loss, there may be damaged both the speech understanding as well as the perception of acoustic signals generated during the work process or daily life. Excluding the exposure to explosions, to high impulse noise and extremely high levels of stationary noise, the permanent damage of the organ of hearing may be achieved progressively in time, depending on the exposure time (NUCLEU Research Program).

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The term regarding the *"permanent displacement of the threshold caused by noise"* is discussed in the paper as a component independent of other elements of the audibility threshold levels, which is usually equal to zero, and for a given noise exposure has a range of positive values representing the variation of individual susceptibility of hearing impairment to noise. The permanent displacement of the threshold caused by noise is generally preceded by a temporary reversible effect on the hearing named *temporary modification of the threshold cause by noise*, whose severity and recovery mode depend on the exposure level and time.

Since the precise determination related to the clearly differentiation of the changes of the hearing threshold levels caused by noise or other factors is difficult in case of punctual approach for each individual, there has been choses to determine the statistical distribution changes of the hearing threshold levels for a population exposed to a specific kind of noise. In this regard, in order to highlight the differences between the hearing threshold levels of two groups of persons which are similar in all important aspects, excepting the fact that one grouo is exposed to occupational noise, there may be successfully used the average or median parameters related to the permanent displacement of the hearing threshold caused by noised (SR ISO 1999).

In some countries, the haring handicap caused by noise exposure may have legal consequences regarding the responsibility and compensation. Levels of the hearing threshold at different frequencies at which it is considered that there is a hearing handicap (limit level) depends not only on the damage itself, but also on the legal aspects based on social and economic considerations. In addition, defining the hearing handicap depends on the required speech understanding quality, on the average background noise level and, in relation to the relative importance of different frequencies, perhaps even on the spoken language (Vasilescu, 2008). Because the hearing impairment caused by noise isn't only the results of exposure to occupational noise, but also the result of the entire exposure to noise of the population, there is necessary to take in to account the non-occupational exposure of individuals (during their travelling to or from their jobs, home and during recreational activities, etc.).

The prognosis of hearing impairment due to occupational noise exposure is possible when the non-occupational exposure is negligible compared to the occupational one, case in which it is required to calculate the hearing impairment due to total daily and combined exposures (occupational and non-occupational) to noise, and, if required, there may be also estimated the contribution to the total hearing impairment due to occupational noise exposure.

2. Generalized Mathematical Model for Assessing the Risk of Hearing Impairment Caused by Noise

2.1.Theoretical and Practical Considerations on the Prognosis of the Effects of Noise on the Hearing Threshold

The hearing quality depending on the age of a population which is to exposed to noise depends on the extent to which there are accidentally included other factors besides natural ageing. Also, some diseases, ototoxic drugs problems and unknown exposure to occupational noise may influence the *hearing threshold level related to age.*

In order to substantiate the hearing threshold level related to age, there are used two databases, *A* and *B*, where one is fully specified (*A*), and the other one being at the latitude of the user (*B*) (SR ISO 1999).

So, the *A* database is provided from otologic normal people, with normal health condition, who do not present signs or symptoms or ear diseases and wax plugs in the auditory channels and which have not been excessively exposed to noise. The statistical distribution of the thresholds of a population of this kind "very protected" have been standardized for male populations, as well as for female populations.

For the *B* database there is recommended a dataset collected from a control population which has not been exposed to occupational noise.

Also, choosing the proper database depends on the problem supposed to be solved.

The determination of the permanent displacement of the hearing threshold caused by noise:

a) *The calculation of* $N_{0.50}$

Values of the permanent displacement of the threshold caused by noise depend on the audiometric frequency, on the exposure time, on the θ/θ_0 ratio and on the exposure level for a 8 h working day, $L_{EX,8h}$ mediated on the θ exposure time. So, for exposure times between 10 and 40 years, values of permanent displacements of the threshold caused by noise (potential medians), are given for both sexes by the following relation (Desroches, 1995; SR ISO 1999):

$$N_{0.50}=\left\{\begin{bmatrix}-0.033^{(500\,\mathrm{Hz})}\\-0.020^{(1{,}000\,\mathrm{Hz})}\\-0.045^{(2{,}000\,\mathrm{Hz})}\\0.012^{(3{,}000\,\mathrm{Hz})}\\0.025^{(4{,}000\,\mathrm{Hz})}\\0.019^{(6{,}000\,\mathrm{Hz})}\end{bmatrix}+\begin{bmatrix}0.110^{(500\mathrm{Hz})}\\0.070^{(1{,}000\,\mathrm{Hz})}\\0.066^{(2{,}000\,\mathrm{Hz})}\\0.037^{(3{,}000\,\mathrm{Hz})}\\0.025^{(4{,}000\,\mathrm{Hz})}\\0.024^{(6{,}000\,\mathrm{Hz})}\end{bmatrix}\lg\left(\frac{\theta}{\theta_0}\right)\right\}\times\left\{L_{\mathrm{EX,\,8\,h}}-\begin{bmatrix}93^{(500\,\mathrm{Hz})}\\89^{(1{,}000\,\mathrm{Hz})}\\80^{(2{,}000\,\mathrm{Hz})}\\77^{(3{,}000\,\mathrm{Hz})}\\75^{(4{,}000\,\mathrm{Hz})}\\77^{(6{,}000\,\mathrm{Hz})}\end{bmatrix}\right\}^2, \tag{1}$$

where: [$93^{(500\ Hz)}$, $89^{(1{,}000\ Hz)}$, $80^{(2{,}000\ Hz)}$, $77^{(3{,}000\ Hz)}$, $75^{(4{,}000\ Hz)}$, $77^{(6{,}000\ Hz)}$] is the range of values of the limit acoustical pressure level defined depending on the frequency, L_0, [dB]; θ – exposure time, θ_0 = 1 year; $L_{EX,8h}$ – represents the level of exposure to noise for an 8 h working day; [500, 1,000, 2,000, 3,000, 4,000, 6,000] – audiometric frequency values, [Hz].

Equation (1) is applied in case in which $L_{EX,8h}$ is higher than L_0, otherwise the level of exposure to noise for an 8h working day ($L_{EX,8h}$) being equal to L_0, so that $N_{0.50}$ is equal to 0.

Also, for periods of time smaller than 10 years, N will be extrapolated from the value of $N_{0.50}$ corresponding to a 10 year period, according to the following relation (Desroches, 1995; SR ISO 1999):

$$N_{0.50,\ \theta<10\ \text{years}} = \frac{\lg(\theta-1)}{\lg 11} N_{0.50,\ \theta=10\ \text{years}}, \tag{2}$$

b) *Statistical distribution of N*

The distribution of N is approximated by two different halves of normal distributions (Gaussian), respectively: upper half for the quantile with the hearing weaker than the median found over the $N_{0.50}$ median value and the lower half which is found below the $N_{0.50}$ median value (Desroches, 1995; SR ISO 1999).

So, there are two situations:

1. If $0.05 \le Q \le 0.50$ then the permanent displacement of the threshold caused by noise, N_Q, is given by

$$\begin{bmatrix} N_{0.05;0.95} \\ N_{0.10;0.90} \\ N_{0.15;0.85} \\ N_{0.20;0.80} \\ N_{0.25;0.75} \\ N_{0.30;0.70} \\ N_{0.35;0.65} \\ N_{0.40;0.60} \\ N_{0.45;0.55} \\ N_{0.50} \end{bmatrix} = N_{0.50} + \begin{bmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{bmatrix} \times \left\{ \left[\begin{pmatrix} 0.044^{(500\ Hz)} \\ 0.022^{(1{,}000\ Hz)} \\ 0.031^{(2{,}000\ Hz)} \\ 0.007^{(3{,}000\ Hz)} \\ 0.005^{(4{,}000\ Hz)} \\ 0.013^{(6{,}000\ Hz)} \end{pmatrix} + \begin{pmatrix} 0.016^{(500Hz)} \\ 0.016^{(1{,}000\ Hz)} \\ -0.002^{(2{,}000\ Hz)} \\ 0.016^{(3{,}000\ Hz)} \\ 0.009^{(4{,}000\ Hz)} \\ 0.008^{(6{,}000\ Hz)} \end{pmatrix} \lg\frac{\theta}{\theta_0} \right] \times \left[L_{EX,\ 8\ h} - \begin{pmatrix} 93^{(500\ Hz)} \\ 89^{(1{,}000\ Hz)} \\ 80^{(2{,}000\ Hz)} \\ 77^{(3{,}000\ Hz)} \\ 75^{(4{,}000\ Hz)} \\ 77^{(6{,}000\ HZ)} \end{pmatrix} \right] \right\}. \tag{3}$$

2. If $0.50 < Q \le 0.95$ then the permanent displacement of the threshold caused by noise is given by

$$\begin{bmatrix} N_{0.05;0.95} \\ N_{0.10;0.90} \\ N_{0.15;0.85} \\ N_{0.20;0.80} \\ N_{0.25;0.75} \\ N_{0.30;0.70} \\ N_{0.35;0.65} \\ N_{0.40;0.60} \\ N_{0.45;0.55} \\ N_{0.50} \end{bmatrix} = N_{0.50} - \begin{bmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{bmatrix} \times \left\{ \left[\begin{pmatrix} 0.033^{(500\text{Hz})} \\ 0.020^{(1{,}000\text{Hz})} \\ 0.016^{(2{,}000\text{Hz})} \\ 0.029^{(3{,}000\text{Hz})} \\ 0.016^{(4{,}000\text{Hz})} \\ 0.028^{(6{,}000\text{Hz})} \end{pmatrix} + \begin{pmatrix} 0.002^{(500\text{Hz})} \\ 0.000^{(1{,}000\text{Hz})} \\ 0.000^{(2{,}000\text{Hz})} \\ -0.010^{(3{,}000\text{Hz})} \\ -0.002^{(4{,}000\text{Hz})} \\ -0.007^{(6{,}000\text{Hz})} \end{pmatrix} \lg\frac{\theta}{\theta_0} \right] \times \left[L_{\text{EX,8h}} - \begin{pmatrix} 93^{(500\text{Hz})} \\ 89^{(1{,}000\text{Hz})} \\ 80^{(2{,}000\text{Hz})} \\ 77^{(3{,}000\text{Hz})} \\ 75^{(4{,}000\text{Hz})} \\ 77^{(6{,}000\text{Hz})} \end{pmatrix} \right] \right\} \quad (4)$$

where: [1.645;1.282;1.036;0.842;0.675;0.524;0.385;0.253;0.126;0] is represents the values of the k multiplication factor in 0.05 intervals for the Q quantile; [$93^{(500\text{ Hz})}$, $89^{(1{,}000\text{ Hz})}$, $80^{(2{,}000\text{ Hz})}$, $77^{(3{,}000\text{ Hz})}$, $75^{(4{,}000\text{ Hz})}$, $77^{(6{,}000\text{ Hz})}$] – the range of values of the limit acoustical pressure level defined depending on the frequency, L_0, [dB]; θ – the exposure time, $\theta_0 = 1$ year; $L_{\text{EX,8h}}$ – the level of exposure to noise for an 8 h working day; [500, 1,000, 2,000, 3,000, 4,000, 6,000] – audiometric frequency values, [Hz].

The values which correspond to the statistical distribution queues for situations in which $0 < Q < 0.05$ and $0.95 < Q < 1$, aren't sure and therefore they aren't estimated following the difficulties to validate these domains.

2.2. The Determination if the Hearing Impairment and of the Hearing Handicap Caused by Noise

Potentially hearing impairment due to occupational exposure to noise is directly assessed through the permanent displacement of the threshold caused by noise, which may be (NUCLEU Research Program):

a) separately considered for each frequency of interest;

b) gathered for a certain number of frequencies having as result a total threshold displacement;

c) averaged over a number of selected frequencies which usually represent the main frequency domain for speech understanding.

In order to calculate the hearing handicap there may be used (for each ear; for the average of both ears; for weighted average of both ears) a combination of hearing threshold levels at mentioned frequencies, respectively: average hearing threshold level at 500 Hz, 1,000 Hz, 2,000 Hz; average hearing threshold level at 500 Hz, 1,000 Hz, 2,000 Hz and 3,000 Hz; average hearing threshold level at 1000Hz, 2000Hz and 4000Hz; average hearing threshold level at 1,000 Hz, 2,000 Hz and 3,000 Hz; average hearing threshold level at 1,000 Hz, 2,000 Hz, 3,000 Hz and 4,000 Hz; average hearing threshold level at

2,000 Hz and 4,000 Hz; average hearing threshold level at 2,000 Hz, 3,000 Hz and 4,000 Hz, etc.

The risk of hearing handicap due to noise exposure and age or only due to noise exposure frequently represents measures of the negative effects of noise exposure over the population (Vasilescu, 2008).

2.3. Calculating the *A* Database

Equations applied for the *H* hearing threshold level depending on the *Y* age (years) for different intervals of the Q quantile which has the value of the threshold higher than the H_Q are the following (Desroches, 1995; SR ISO 1999):

1. If $0.05 \le Q \le 0.50$ then le hearing threshold level related to the H_Q age is given by the eq. (5) for a male population and by eq. (6) for a female population.

$$\begin{pmatrix} H_{0.05;0.95} \\ H_{0.10;0.90} \\ H_{0.15;0.85} \\ H_{0.20;0.80} \\ H_{0.25;0.75} \\ H_{0.30;0.70} \\ H_{0.35;0.65} \\ H_{0.40;0.60} \\ H_{0.45;0.55} \\ H_{0.50} \end{pmatrix} = H_{0.50} + \begin{pmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{pmatrix} \times \left[\begin{pmatrix} 7.23^{(125Hz)} \\ 6.67^{(250Hz)} \\ 6.12^{(500Hz)} \\ 6.12^{(1,000Hz)} \\ 6.67^{(1,500Hz)} \\ 7.23^{(2,000Hz)} \\ 7.78^{(3,000Hz)} \\ 8.34^{(4,000Hz)} \\ 9.45^{(6,000Hz)} \\ 10.56^{(8,000Hz)} \end{pmatrix} + 0.445 H_{0.50} \right] \quad (5)$$

$$\begin{pmatrix} H_{0.05;0.95} \\ H_{0.10;0.90} \\ H_{0.15;0.85} \\ H_{0.20;0.80} \\ H_{0.25;0.75} \\ H_{0.30;0.70} \\ H_{0.35;0.65} \\ H_{0.40;0.60} \\ H_{0.45;0.55} \\ H_{0.50} \end{pmatrix} = H_{0.50} + \begin{pmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{pmatrix} \times \left[\begin{pmatrix} 7.23^{(125Hz)} \\ 6.67^{(250Hz)} \\ 6.12^{(500Hz)} \\ 6.12^{(1000Hz)} \\ 6.67^{(1500Hz)} \\ 7.23^{(2000Hz)} \\ 7.78^{(3000Hz)} \\ 8.34^{(4000Hz)} \\ 9.45^{(6000Hz)} \\ 10.56^{(8000Hz)} \end{pmatrix} + 0.445 H_{0.50} \right] \quad (6)$$

2. If $Q = 0.50$ then le hearing threshold level related to the H_Q age is given by the equation (7) for a male population and by equation (8) for a female population.

$$H_{0.50} = \begin{pmatrix} 0.0030^{(125Hz)} \\ 0.0030^{(250Hz)} \\ 0.0035^{(500Hz)} \\ 0.0040^{(1,000Hz)} \\ 0.0055^{(1,500Hz)} \\ 0.0070^{(2,000Hz)} \\ 0.0115^{(3,000Hz)} \\ 0.0160^{(4,000Hz)} \\ 0.0180^{(6,000Hz)} \\ 0.0220^{(8,000Hz)} \end{pmatrix} \times (Y-18)^2 + H_{0.50;18} \tag{7}$$

$$H_{0.50} = \begin{pmatrix} 0.0030^{(125Hz)} \\ 0.0030^{(250Hz)} \\ 0.0035^{(500Hz)} \\ 0.0040^{(1,000Hz)} \\ 0.0050^{(1,500Hz)} \\ 0.0060^{(2,000Hz)} \\ 0.0075^{(3,000Hz)} \\ 0.0090^{(4,000Hz)} \\ 0.0120^{(6,000Hz)} \\ 0.0150^{(8,000Hz)} \end{pmatrix} \times (Y-18)^2 + H_{0.50;18} \tag{8}$$

3. If $0.50 \le Q \le 0.95$ then le hearing threshold level related to the H_Q age is given by the equation (9) for a male population and by equation (10) for a female population.

$$\begin{pmatrix} H_{0.05;0.95} \\ H_{0.10;0.90} \\ H_{0.15;0.85} \\ H_{0.20;0.80} \\ H_{0.25;0.75} \\ H_{0.30;0.70} \\ H_{0.35;0.65} \\ H_{0.40;0.60} \\ H_{0.45;0.55} \\ H_{0.50} \end{pmatrix} = H_{0.50} + \begin{pmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{pmatrix} \times \left[\begin{pmatrix} 5.78^{(125Hz)} \\ 5.34^{(250Hz)} \\ 4.89^{(500Hz)} \\ 4.89^{(1,000Hz)} \\ 5.34^{(1,500Hz)} \\ 5.78^{(2,000Hz)} \\ 6.23^{(3,000Hz)} \\ 6.67^{(4,000Hz)} \\ 7.56^{(6,000Hz)} \\ 8.45^{(8,000Hz)} \end{pmatrix} + 0.356 H_{0.50} \right] \tag{9}$$

$$\begin{pmatrix} H_{0.05;0.95} \\ H_{0.10;0.90} \\ H_{0.15;0.85} \\ H_{0.20;0.80} \\ H_{0.25;0.75} \\ H_{0.30;0.70} \\ H_{0.35;0.65} \\ H_{0.40;0.60} \\ H_{0.45;0.55} \\ H_{0.50} \end{pmatrix} = H_{0.50} + \begin{pmatrix} 1.645 \\ 1.282 \\ 1.036 \\ 0.842 \\ 0.675 \\ 0.524 \\ 0.385 \\ 0.253 \\ 0.126 \\ 0 \end{pmatrix} \times \left[\begin{pmatrix} 5.34^{(125Hz)} \\ 4.89^{(250Hz)} \\ 4.89^{(500Hz)} \\ 4.89^{(1,000Hz)} \\ 5.34^{(1,500Hz)} \\ 5.34^{(2,000Hz)} \\ 5.78^{(3,000Hz)} \\ 6.23^{(4,000Hz)} \\ 7.12^{(6,000Hz)} \\ 8.45^{(8,000Hz)} \end{pmatrix} + 0.356 H_{0.50} \right] \quad (10)$$

2.4. Algorithm of the Generalised Mathematical Model for Assessing the Hearing Impairment Risk

In order to substantiate a hearing impairment risk assessment system, there has been designed a graphical-analytical mathematical mode which confers the possibility to estimate and appreciate the risk of hearing handicap due to noise exposure, based on the difference between the hearing handicap risk due to age and noise and on the hearing handicap risk of the population (NUCLEU Research Program; SR ISO 1999).

The application of the mathematical prognosis model of the hearing impairment risk, involves the following steps (Vasilescu, 2008):

(S1): Defining the problem to solve (establishing the type of population: male or female; age of the subjects from the analysed population; daily noise exposure for n years (8h/day, 5 days/week, 50 weeks/year);

(S2): Establishing the combination of frequencies for the mediation of the hearing threshold levels;

(S3): Calculating the hearing threshold level related to the H_Q age for a certain type population (male or female) unexposed to noise according to the A database; Also, verification of the equation related to the sum of values between permanent threshold displacement caused by noise and the level of the hearing threshold related to age, which if it is higher than 40dB, then it significantly modifies the result and therefore the value of the permanent displacement of the threshold caused by noise shall be corrected according to the equation:

$$N - (H \times N)/120;$$

(S4): Calculating the permanent displacement of the threshold caused by noise:

$$H' = H + N = \frac{H \times N}{120}, \quad (11)$$

(S5): Determining the hearing threshold level related to age and noise for the population exposed to noise;

(S6): Graphical representation in Gaussian coordinates (within a rectangular axis system in which, on the abscissa there are highlighted as percentage, at the lower part the values of people with weaker hearing (from right to left)/at the upper part the values of people with better hearing, and on the ordinate the values of the hearing threshold level in dB);

(S7): Determining the hearing impairment risk corresponding to a daily exposure to noise level in each day, over a period of time (expressed in years). With data specific for the hearing threshold level related to the age from the *A* database.

2.5. Case Study on the Hearing Impairment Risk Assessment

In order to apply the mathematical model for assessing the hearing impairment risk, there is taken into account a 50 years old male population, which has been exposed to a medium level of daily noise of $L_{EX,8h}$ = 90 dB, each day, during 30 years (NUCLEU Research Program). Application of the mathematical prognosis model of the hearing impairment risk, involves the following steps:

(P1): Defining the problem to solve: population: male; age 50 years; daily exposure level each day during 30 years (8h/day, 5 days/weeks, 50 weeks/year): $L_{EX,8h}$ = 90 dB.

(P2): Establishing the combination of frequencies for the mediation of the hearing thresholds level: in order to determine the hearing handicap there is used the combination of frequencies 1,000 Hz, 2,000 Hz and 4,000 Hz.

Table 1

Hearing threshold level, [dB]									
Frequency Hz	Age: 50 years								
	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Men									
500	–4	–2	0	2	4	6	8	10	13
1,000	–4	–1	1	2	4	6	8	11	14
2,000	–4	0	3	5	7	10	13	16	21
3,000	–2	3	6	9	12	15	19	23	28
4,000	0	6	10	13	16	20	25	30	36
6,000	0	7	11	15	18	23	28	33	41

Selected values of the hearing threshold level, in dB, from the *A* database.

(P3): Calculating the hearing threshold level related to H_Q age for a certain type population (male or female), unexposed to noise according to database *A*: The level of the hearing threshold level related to H_Q noise for the unexposed to noise population is calculated according to the *A* database (Table 1) and it is mediated for 1,000 Hz, 2,000 Hz and 4,000 Hz frequencies, respectively:

$$\begin{pmatrix} H_{0.9;50} \\ H_{0.8;50} \\ H_{0.7;50} \\ H_{0.6;50} \\ H_{0.5;50} \\ H_{0.4;50} \\ H_{0.3;50} \\ H_{0.2;50} \\ H_{0.1;50} \end{pmatrix} = \begin{bmatrix} (-4-4+0)/3 \\ (-1+0+6)/3 \\ (1+3+10)/3 \\ (2+5+13)/3 \\ (4+7+16)/3 \\ (6+10+20)/3 \\ (8+13+25)/3 \\ (11+16+30)/3 \\ 14+21+36)/3 \end{bmatrix} = \begin{pmatrix} -2.7 \\ 1.7 \\ 4.7 \\ 6.7 \\ 9.0 \\ 12.0 \\ 15.3 \\ 19.0 \\ 23.7 \end{pmatrix}$$

Values of the hearing threshold level related to H_Q age for the unexposed to noise population

(P4): Calculating the permanent displacement of the threshold caused by noise and the verification of the equation related to the sum of values between the permanent displacement of the threshold caused by noise and the threshold hearing level related to age: at a 4,000 Hz frequency, the sum of the values related to the permanent displacement of the threshold caused by noise and the hearing threshold level related to age for the quantile 01. Is higher than 40 dB (Table 2). Therefore, the 19 dB value from Table 2 is reduced as following:

$$19-\frac{36\times 19}{120}=13.3\ \text{dB}$$

Table.2

NIPTS, [dB] Noise exposure level $L_{EX,8h}$ = 90 dB									
Frequency Hz	Exposure time: 30 years								
	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500	0	0	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0
2,000	3	4	4	5	5	6	7	8	9
3,000	8	9	9	11	11	13	14	16	18
4,000	10	11	12	13	14	15	16	17	19
6,000	5	7	8	8	9	10	11	13	15

Permanent displacement of the hearing threshold level caused by noise, in dB

$$\begin{pmatrix} N_{0.9;30} \\ N_{0.8;30} \\ N_{0.7;30} \\ N_{0.6;30} \\ N_{0.5;30} \\ N_{0.4;30} \\ N_{0.3;30} \\ N_{0.2;30} \\ N_{0.1;30} \end{pmatrix} = \begin{bmatrix} (0+3+0)/3 \\ (0+4+11)/3 \\ (0+4+12)/3 \\ (0+5+13)/3 \\ (0+5+14)/3 \\ (0+6+15)/3 \\ (0+7+16)/3 \\ (0+8+17)/3 \\ 0+9+13.3)/3 \end{bmatrix} = \begin{pmatrix} 4.3 \\ 5.0 \\ 5.3 \\ 6.0 \\ 6.3 \\ 7.0 \\ 7.7 \\ 8.3 \\ 7.4 \end{pmatrix}$$

Values related to the permanent displacement of the threshold caused by noise.

(P5): Determining the hearing threshold level related to age and noise for the population exposed to noise: Through the application of equation (11) referring to the hearing threshold level related to the *H* age and to the permanent displacement of the threshold caused by noise, real or potential N, there is obtained an approximation of the biological events, considered to be precise enough according to the specialized literature:

$$\begin{bmatrix} H'_{0.9} \\ H'_{0.8} \\ H'_{0.7} \\ H'_{0.6} \\ H'_{0.5} \\ H'_{0.4} \\ H'_{0.3} \\ H'_{0.2} \\ H'_{0.1} \end{bmatrix} = \begin{bmatrix} -2.7 \\ 1.7 \\ 4.7 \\ 6.7 \\ 9.0 \\ 12.0 \\ 15.3 \\ 19.0 \\ 23.7 \end{bmatrix} + \begin{bmatrix} 4.3 \\ 5.0 \\ 5.3 \\ 6.0 \\ 6.3 \\ 7.0 \\ 7.7 \\ 8.3 \\ 7.4 \end{bmatrix} - \frac{1}{120} \left\{ \begin{bmatrix} -2.7 \\ 1.7 \\ 4.7 \\ 6.7 \\ 9.0 \\ 12.0 \\ 15.3 \\ 19.0 \\ 23.7 \end{bmatrix} \times \begin{bmatrix} 4.3 \\ 5.0 \\ 5.3 \\ 6,0 \\ 6.3 \\ 7.0 \\ 7.7 \\ 8.3 \\ 7.4 \end{bmatrix} \right\} = \begin{bmatrix} 1.7 \\ 6.6 \\ 9.8 \\ 12.4 \\ 14.8 \\ 18.3 \\ 22.0 \\ 26.0 \\ 30.0 \end{bmatrix}$$

(P6):Graphical representation in Gaussian coordinates: The results obtained in (S5) are graphically represented in Gaussian coordinates with different handicap risks represented for an arbitrary limit of 27 dB, in order to study the dependency of the risks values with limits values (Fig. 1).

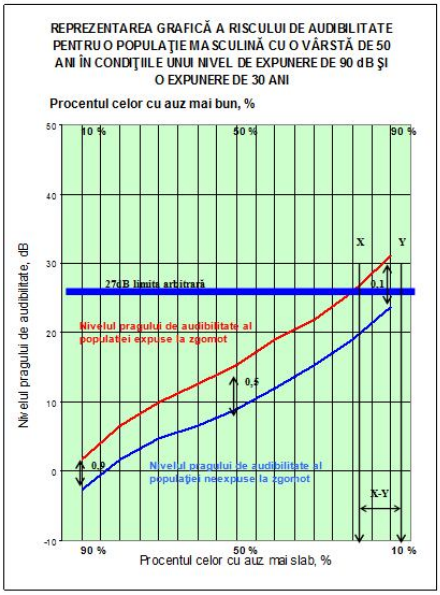

Fig.1 – Graphical representation in Gaussian coordinates for the hearing impairment risk.

P7): Determining the hearing impairment risk corresponding to the daily noise exposure, for each day during a time period (in years), with specific data for the hearing threshold level related to age from database A: The graphical-analytical determination of the hearing impairment risk for a 50 year old male population exposed to average daily exposure to noise level of $L_{EX,8h}$=90 dB / day, during 30 years (8h/day, 5days/week, 50 weeks/year), has led to the following results:

a) the auditory handicap risk due to age and noise is 18% (*X* point);

b) the handicap risk of the population is 6.5% (*Y* point);

c) the auditory handicap risk due to noise exposure is 11.5% (the horizontal difference between *X* and *Y*).

3. Conclusions

1. Starting from theory to practice, the paperwork highlights objectively through modern mathematical tools from the field of risk generated by noise in the occupational process, structural and process components which allow the proper determine a relative percentage of hazards identified as risk predictors, as well as the implications of these results on health and safety of the exposed population. Also, there is presented a method for estimating the hearing impairment due to noise exposure, in terms of conceptual and methodological defining for the auditory handicap assessment, taking into account both the legal

consequences related to liability and compensation, as well as the legal definitions and interpretations based on economic and social considerations.

2. The graphical-analytical method determining the hearing impairment risk presented in the paperwork, provides the possibility to estimate this type of risk based on the auditory handicap risk of the population (determined in relation with the auditory threshold level of population un-exposed to noise) and on the auditory handicap due to age and noise (determined in accordance with the auditory threshold level of population exposed to noise). At the same time, the generalized mathematical model for assessing the hearing impairment risk, ensures, based on an algorithm, the method for estimating the auditory risk for a certain type population (male or female) which is exposed to daily noise over a certain period of time (years), representing calculation tool which is very useful for making decisions regarding the caution level required to be established for clarifying the acceptable/tolerable risk domain.

3. Results gained from the application of this mathematical model may contribute to the development of specialised databases for various fields of activities carried out at the level of the national economy, in order to develop the knowledge from the occupational risk prognosis and diagnosis field, having a preventive role for an occupational safety problem.

REFERENCES

Desroches A., *Concepts et methodes probabilistes de base de la securite*. Lavoisier, TEC&DOC, 1995, Paris.

Vasilescu G.D., *Probabilistic Calculation Methods Used for Industrial Risk Prognosis And Diagnosis*. INSEMEX Publishing House, Petroşani, 2008.

Vasilescu G.D., *Unconventional Methods for Occupational Risk Analysis and Assessment*. INSEMEX Publishing Hiuse, Petroşani, 2008.

*** *Advanced System for Assessing the Environmental Conditions for Economic Agents that Carry Out Activities of Useful Mineral Resources Extraction from the Underground and from the Surface, in Terms of Risks Generated by Noise and Vibrations.* NUCLEU Research Program, Project45 07 01 15, INSEMEX, 2009-2010.

*** *Acoustics. Determination of Occupational Noise Exposure and Estimation of Noise – Induced Hearing Impairment*. SR ISO 1999.

DIAGNOZA ŞI PROGNOZA RISCULUI DE PIERDERE A AUZULUI

(Rezumat)

Se prezintă o abordare metodologică de analiză şi evaluare probabilistică şi statistică a riscului de pierdere a auzului pe baza pericolelor cuantificate ca predictori de risc, în vederea stabilirii modalităților de evaluare a limitelor de prudență asociate intervalelor de acceptabilitate.

Abordarea statistică se bazează pe cuantificarea raţională a ceea ce există şi poate fi observat, partea probabilistă a acestui fapt constituind extrapolarea către ceea ce se poate deduce în mod rezonabil din aceste statistici pentru evaluarea probabilităţii de apariţie a handicapului auditiv.

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PROFESSIONAL COMPETENCE IN OCCUPATIONAL HEALTH AND SAFETY

BY

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Abstract: This presents the skill requirements for workers who operate in the field of occupational health and safety (OH&S). The organizations are constrained by various situations applicants or existing labor market requirements.

The requirements for qualification and compentence in the safety and health are heavily regulated by relevant legislation and labor relations. Lack of fulfillment of these requirements leads to violations of the law and bring sanctions for employers. But most important is that over these ceerinte Recruiters and employers should understand that an employer competent adds value to their organization pays for long-term costs.

Keywords: OH&S competence; OH&S management.

1. Introduction

Competence is the ability to rule on something, on the basis of a deep knowledge of issues discussed, the capacity of an authority of a clerk and so on, to exercise certain powers. A person who is well informed in a particular field and is capable of, which is able to judge something, is concerned with the fall, the legal authority to do something. Also, the competence is defined by personal skills demonstrated and proven ability to apply knowledge and skills.

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Education and qualifications, professional experience and personal skills leads to demonstrate competency for a particular job. Improving skills through continuous professional and personal development lead to getting added value for the organization in which they work.

The competence and occupation are terms that supplement each other for defining and holding a job to work in a particular field and to have the occupation or profession.

The specification for the job or a job description define workers' competency in specific skills required, knowledge, skills and other physical and personal characteristics necessary for successful performance.

2. Legal and Other Requirements Qualification and Competence

In the field of labor relations developed between employers and employees, the labor market in the process of globalization there are many legal requirements, occupational standards, regulations issued by authorities in the field internationally and nationally.

The multinational companies in the areas of high develops and labor market demands require advanced jobs that competent supose variety of experience, multidisciplinary qualification.

International Labour Organization ILO has defined a structure it ISCO occupations 08 - International Standard Classification of Occupations accepted at the European level by Resolution of 6 December 2007.

In our country was approved by Government decision and order of the Minister of Labour of the structure COR-Classification of Occupations in Romania according to the international classification to the basic groups.

Defining the job title on the market employee labor in the international classification groups was made by Occupational classification of qualifications Table 1.

Table 1

Occupational Classification of Qualifications

Group 1 Members of the legislature, the executive, senior government leaders, managers and senior officials	Group 2 Specialists in various fields	Group 3 Technicians and other technical professionals
Group 4 Funcționari administrativi Functionary administrative officials	Group 5 Service employees	Group 6 Skilled workers in agriculture, forestry and fishing
Group 7 Skilled workers and related	Group 8 Plant and machinery operators, assemblers machinery and equipment	Group 9 Unskilled workers

Labor Code governing employment relationships, how to carry out enforcement of regulations in the field of employment and labor jurisdiction. This applies to employment relationships governed by special laws only as they do not contain specific provisions derogating.

The fundamental principles of labor law are guaranteed by the Constitution, any person is free to choose the job and profession, trade or business which is to provide, no one can be forced to work or not to work in a particular place or work in a particular profession, whatever they may be.

It can be declared a job was taken when as made in a labor individual contract between the employee and the employer thus establishing a working relationship that is assigned position / occupation according to the Classification of Occupations in Romania or other regulations, such as specifying the duties and job description, art. 17 d), and professional activity evaluation criteria applicable to the employee's employer pct. d 1). This is basically ends after preliminary verification of professional and personal skills of the person seeking employment, article 29, para 1.

Verification of professional and personal skills can be done by may establish a probationary period not exceeding 90 calendar days for executive and a maximum of 120 calendar days for management positions, within 30 calendar days from the employment of people with disabilities, art. 31. During or at the end of the probationary period, the individual employment contract may be terminated only by a written notice, without notice, at the initiative of either party, without requiring its motivation.

The employer has rights mainly on the organization and functioning of the organization, responsibilities of employees, establishing obligation to fulfill control tasks, to establish individual performance goals and evaluation criteria are implemented article 40.

The suspension of the labor contract law may be possible in the various situations covered but the date of expiry of the period for which they were issued permits, authorizations or approvals required by the profession.

The individual labor contract law can be dissolved, following the agreement of the parties, on the date agreed by them as a result of the unilateral will of one of the parties in the cases and boundary conditions provided by law, art. 55, that due to prohibition of the exercise of a profession or function as a safety measure or complementary punishment, the date when the court decision ordering, art. 56.

Dismissal for reasons related to the employee if, by decision of the competent medical expertise, physical unfitness is found and/or mental employee, which does not allow him to fulfill his duties corresponding to the position held, respectively If the employee does not meet professional job that is framed art. 61. This method can be ordered only after prior assessment of the employee, according to the evaluation procedure established by the applicable collective labor contract or, failing that, the rules of art. 63, para. (2).

Labor standards define the amount of labor required to perform the operations or works by a suitably qualified person who works with normal intensity, in terms of processes and determined work.

The norm of work time includes time for interruptions imposed by the technological process during breaks in the program of work laws, art. 126 . This is expressed, depending on the characteristics of the production process or other activities that are standardized in the form of rules as rules of production, personnel rules, the scope of duties or other forms appropriate to the nature of each activity, art. 127.

Employers authorized by the Ministry of Labour and Social Solidarity and the Ministry of Education, art. 200 can organize training of workers by signing contracts that special training and professional qualification contract agreement retraining, art. 198 . Also another form of training in a profession may be by discipleship agreement, art. 205.

Legal regulations of labor relations establish responsibilities by law on patrimonial liability, administrative liability, criminal liability to parties in various breaches of labor legislation but no reference to that failure Standard of occupational competence of qualification/trade.

Labour Code by Law no. *53* of 01/24/2003 with subsequent amendments as per law no. *40*/31.03.2011 – date of entry into force: 30.04.2011, art. 298 repeal Law 30/1990 regarding hiring employees based on competence, published in the Official Monitor no. *125* of 16 November 1990. This latter refers not detailed on skills and ways of filling jobs in the context of the globalization of the market economy and workforce.

Health an safety legislation defines categories of workers and specialized such as: a) the worker b) employer d) representative of workers with specific responsibility, prevention, event, industrial accidents, illness, work ed equipment, individual equipment protection, serious and imminent n) health and safety at work; incident p) external services ability to provide protective and preventive services in health and safety at work, the law, art. 5.

The references on view to competence are established by Chapter 4. Obligations of employers S4, art. 13 other obligations for ensuring the safety and health at work and to prevent work accidents and occupational diseases, such as:

i) take action to authorize the exercise of trades and professions provided by specific legislation;

j) to employ individuals that medical examination and, where appropriate, psychological testing skills correspond to the task you are going to execute and ensure regular medical examination and, where appropriate, psychological control periodically thereafter employment.

The article 22, refer to Obligation workers is that each worker must operate in accordance with training and instruction to and instructions of the employer, so as not to expose to danger of injury or occupational disease as

themselves, and others who may be affected by actions or omissions during the work.

Legislation and reglementation of labor standards and other special areas that covered as well I.S.C.I.R., A.N.R.E. establish various categories of competent qualified staff working in these areas.

The organizations that have more than 250 workers must organize one or more internal service for prevention and protection art. 19, workers staffed by designated qualified and specialized in safety and health, art. 21.

The minimum requirements for training in health and safety, art. 49 or art. 51 ^ 1 lit. are: a) secondary school theoretical profile real or technological branch in technical profile.

The minimum requirements for safety training and health for higher level, to be fulfilled cumulatively, art. 50, are:

a) completion of the fundamental areas: engineering sciences, agricultural sciences and forestry, with bachelor's degree or equivalent cycle of university studies, undergraduate studies or university studies of longer term or graduation diploma short term university;

b) course in health and safety, with minimal content as that provided in Annex 6.B, with a minimum of 80 h;

c) completion of a diploma or certificate of completion, where appropriate, a program of postgraduate education in health and safety, with a minimum of 180 h.

Proof of qualification requirements is attested by diploma, graduate certificate, master's degree or doctorate in occupational safety and health.

The specific occupations of health and safety, necessary for the prevention and protection activities currently art. 51 ^ 1, are technician health and safety, safety expert and health Article 51 ^ 1, the minimum qualification requirements Table 2.

Table 2

Minimum Qualification Requirements

Technician H&S	Expert H&S
a) secondary study highschool theoretical profile real or technological branch in technical profile;	a) graduate studies of university attested by a diploma that higher education long or short graduated with a bachelor's degree or equivalent in key areas: engineering sciences, agricultural sciences and forestry;
b) training program for occupation health and safety technician at least 80 hours.	b) training program for occupation health and safety expert working at least 80 hours;
	c) postgraduate course in health and safety, with a minimum of 180 hours, or master / doctorate in this field.
Bachelor Degree Certificate of Graduation	Bachelor Degree Certificate of Graduation

The leader/manager internal service for prevention and protection must meet minimum training level (art. 123, H.G.1425) workers must carry only the service of prevention and protection activities and more than complementary activities such as fire fighting and protection environment.

The representatives of employees with specific responsibilities in the area of safety and health must meet minimum training in health and safety, corresponding to at least the minimum level.

The activities performed by the safety and health-CSSM, art. 58, the skilled staff and employer representatives responsible for occupational safety and health, representatives of employees with specific responsibility in safety and health, occupational medicine doctor.

The external services providing prevention and protection art. 15, applicants will submit a file that contains the following documents certifying of professional training and qualification, minimum 5 years experience in the field of safety and health personnel who will conduct prevention and protection.

Training activities are organized in several steps is performed differentially for different categories of training of various categories of personnel competent in health and safety at work.

Table 3
Training Responsibilities

General Introduction	Workplace	Periodicaly
a) the employer has assumed the duties of health and safety at work	Direct leader on job	Direct leader on job
b) nominated worker		
c) internal service for protection and prevention		
d) external service for prevention and protection.		

Assessment the risks of injury and occupational disease is realized by establishing a review team that will necessarily include authorized specialists, working knowledge of the processes analyzed, representatives of employees, employees assigned to safety and health.

The team shold be include: designers, ergonomists, medical specialists etc unit. This activity must be organized and coordinated by authorized assessor.

Research Commission of the events will be composed of at least three persons, one of them must be representative health an safety, internal service representative or representative of foreign service, with superior qualification. They must have adequate technical background and not be involved in the

organization and management of the workplace where the event took place and had no responsibility in the event. The results of research will sample and the of qualification, if performing an activity authorized permits victim papers prepared technical expertise during the event.

3. Conclusions

The requirements qualification mandatory by our national legislation come to support employers and candidates to a job to establish a common language on the job market. With all of these situations exist discrepancies between their positions and skill level of the organizations mainly with cases related to the lack of jobs and the price paid by employers for employee performance.

In the current economic context, particularly in deprived areas most important is finding a job at any cost and the employer finding people to assume their responsibility on both sides of the visor lose value addition to the organization but also for humans.

REFERENCES

Alexandru I., Alexandru A., *Occupational Risk Assessment.* Course notes, 2007.

Pece Şt., *Assessment of Risk Man-Machine System.* Ed. ATLAS PRESS, Bucharest 2003.

* * * *Explanatory Dictionary of the Romanian lan*guage.

* * * *Guidelines for Auditing Quality Management Systems and/or the Environment*. SR EN ISO 19011.

* * * H.G. no. 1.425 date 11 octomber 2006 Methodological Norms for the application of safety and health law no. 319/2006 as amended by H.G. No. 955 of 8 September 2010

* * * H.G.no.1.352/2010 regarding the structure-level Classification of Occupations in Romania based group, the International Standard Classification of Occupations ISCO-08, published in the Official nr. 894 / 30.12.2010,

* * * http://www.avocat-dreptul-muncii.eu

* * * http://www.mmuncii.ro/nou/index.php/ro/legislatie/munca2/

* * * Law no. 53 date 01/24/2003 : 30.04.2011, amended and supplemented (according to Law no. 40 / 31.03.2011 - date of entry into force: 30.04.2011,

* * * *Management Systems Occupational Health and Safety*. SR OHSAS 18001, ASRO, March 2008.

* * * O. no.1.832 Minister of Labour, Family and Social Protection and nr.856 President approving the National Institute of Statistics Classification of Occupations in Romania-level occupation (six characters), published in MO No. 561/2011.

COMPETENȚA PROFESIONALĂ ÎN DOMENIUL SECURITĂȚII ŞI SĂNĂTĂȚII ÎN MUNCĂ

(Rezumat)

Se prezintă cerințele de competență pentru lucrătorii care desfaşoară activități în domeniul securitatii si sanatatii ocupationale sau muncii. În prezent organizațiile dar şi aplicanții sunt constrânşi de diverse situații sau cerințe existente pe piața muncii.

Cerințele de calificare şi compentența în domeniul securități şi sănătății sunt puternic reglementate de legislația în domeniu şi a relațiilor de muncă. Lipsa îndeplinirii acestor cerințe conduce la încălcări ale legislației şi poate aduce sancțiuni pentru angajatori. Dar cel mai important este ca peste aceste ceerințe specialiştii în recrutare şi angajatorii trebuie să înțeleagă că un agajat competent care aduce plus valoare organizației îşi amortizează costurile pe termen lung.

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COSTS AND EFFECTS OF ACCIDENTS AT WORK

BY

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Abstract: Accidents at work must be viewed in perspective. The majority of people will go through their working lives without any injury or illness directly caused by the workplace. The data on the number of fatalities and injuries at work supports this. However some of us will go to work and be injured as a result, an even smaller number of us of will be fatally injured at work. The present studie afford an insight into published injury rates and accident data. They enable the reader to appreciate what an accident at work actually entails on the day weeks and in some cases, years after the event. It is hoped that all stakeholders including employers, employees, regulators, unions, insurers, professional bodies and safety practitioners will reinvigorate their efforts to prevent the pain, suffering and financial losses brought about by accidents at work.

Keywords: workplace accidents; employer; employer costs; employee costs; psycho-social effects.

1. Introduction

The background and approach of this study is presented. The objectives, scope and structure of the report are outlined.

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2. Background and Objectives

The aim of the research was to investigate the impact of workplace accidents through use of a case study approach. The specific research objective was to identify, the financial, physical and psychological effects that workplace accidents can have for employers and employees. This information was intended to supplement findings from previous quantitative studies undertaken by the Health and Safety Authority and to inform the Authority's future promotional campaigns.

3. Scope and Focus of the Research

The research was exploratory in nature, based on a case study methodology and focused on the collection of qualitative and quantitative data. It was envisaged that the research findings would also inform the design of future cost studies by the Health and Safety Authority. The terms of reference for the project specified that the case studies should provide details of:

a) the accident;

b) financial costs incurred as a result of the accident;

c) the wider psycho-social effects of the accident.

The terms of reference also specified that data be collected from a range of different sized organisations and across different sectors. It also specified that the data collection methodology should build on research frameworks for identifying potential costs and effects previously used by the Health and Safety Authority.

Definitions

The following definitions and parameters of costs were used in the study:

Workplace accidents were defined as including accidents, assault and abuse related incidents and illness resulting from work related stress.

Employer included the employer or their representatives, including safety practitioners, occupational health staff or insurance executives.

Employer costs included productivity losses, lost business opportunities, salary of the injured employee or of a replacement employee or additional overtime costs, expenses re-imbursed to the injured employee, repair, rental or replacement costs, changes to insurance premiums, and legal costs.

Employee costs as a result of the accident included: loss of salary; loss of overtime payments; medical, travel or other expenses, compensation received; lost savings; retraining costs; pay differences from any new employer.

Psycho-social effects of accidents on the employee included aspects of work, family, leisure, and community life.

4. Research Design

Key elements of the research process included a review of literature, selection of case study employers and employees, design of an interview protocol, fieldwork, data analysis and report writing.

4.1. Review of Literature and Desk Research

National, European and international studies on the financial costs and psychological effects of workplace accidents were examined to provide context and to assist in identification of key issues for inclusion in this study.

4.2. Identification and Selection of Case Study Employers and Employees

The terms of reference for the project proposed that the following four sectors be included in the analysis: Construction, Health Care, Local Authority, Manufacturing.

These sectors were chosen because of the high proportion of the Romanian workforce employed in these sectors, the high proportion of reported injuries, and perceived ease of access to participants. In addition a geographical spread was required so that all regions of Romania were represented in the sample. In the first instance, over 120 companies will be invited to participate after being contacted by telephone. Employers were asked to nominate an employee that had experienced a workplace accident or injury as a potential case study participant. Where an employee name was given as a possible participant by a contact other than the employer, the relevant employer was first contacted to establish participation.

Twenty employers (one of whom was self-employed and injured) together with nineteen injured employees agreed to participate. The twenty employers (or employer representatives) were from sixteen different companies or organisations. One multi site employer provided three employees to interview; two other multi site employers provided two employees each to interview.

4.3. Design of Interview Protocol

An interview protocol was designed to gather data on both the financial costs and the psycho-social costs of workplace accidents.

The interview protocol covered three distinct areas:

a) costs and effects associated with the employer;

b) costs and effects associated with the employee;

c) the nature of the accident.

The interview protocol was based on available models designed to estimate the costs and effects of accidents. All previous models have concentrated either on the cost element of accidents or on the psycho-social effects of significant life events. This interview protocol combined the two areas to elicit a more holistic view of accidents and their effects.

Assessing the costs of the accident to the employer and employee

For this section of the research a number of models were assimilated and modified. The models were: Mottiar, (2004), HMSO, (1993), Mossink & De Greef, (2002). The costs data gathered can be summarised as follows:

1) Employer profile details including sector, number of employees, turnover etc.

Employer costs including:

a) lost business opportunities;
b) productivity losses;
c) salary of the absent injured employee;
d) expenses reimbursed to the injured employee;
e) repair, rental or replacement costs;
f) insurance premium changes and legal costs.

Any "PR","IR", reputational or corporate & social responsibility costs.

2) Additional training or supervisory costs:

a) employee costs including;
b) loss of salary;
c) loss of overtime payments;
d) medical, travel or other expenses;
e) compensation received;
f) lost savings;
g) retraining costs;
h) pay differences from any new employer.

Assessing the effects on the employer's safety management system

The model selected here was devised by Pérezgonzález (2005a). This model covers the following elements:

a) policies and goal-setting;
b) recruitment and selection of new staff;
c) safety training;
d) safety communication;
e) monitoring, auditing and carrying out risk assessments;
f) reporting of unsafe acts;
g) cooperation of staff on safety matters;
h) implementation of necessary safety procedures;
i) the overall safety management system.

Assessing the psycho-social effects of accidents on the employee

The model selected here was Dubin 1956 and 1976. This "Central Life Interests" model allows all relevant aspects of the injured employee's life to be

considered. It covers five specific "life spheres" of an individual. It also covers the psychological and emotional identification of these spheres and how important they are in the employee's life. Dubin's theory has been extensively used in organisational work psychology (See also Meaning of Work International Research Team 1987; Harpaz 1990; Díaz Vilela, 1997; Pérezgonzález & Díaz Vilela, 2005). These life spheres are as follows:

a) work sphere which covers all aspects of life at work;

b) family sphere which covers all aspects of family life;

c) leisure sphere which covers all aspects of sports and leisure time activities;

d) community sphere which covers all social and political responsibilities;

e) religious sphere which covers all aspects of religious and spiritual life.

The religious sphere was not assessed during the research due to its ethical connotations.

Obtaining a personal account of the accidents from employees was a key objective of the research. Therefore a semi-structured interview protocol was designed to allow a personal narrative from the employee to be elicited. It also allowed the interviewer to prompt relevant questions in those cases where the account could be improved.

Finally, questions about feelings toward the employer and colleagues were included. This section was designed in a prominent manner due to the informative data elicited on the consequences of accidents.

A Likert type five point scale was incorporated into each section of the protocol so that the interviewer could quantify, both objectively and subjectively, the effect of the accident on the employer and employee. (See original procedure in Pérezgonzález, 2005b)

Employers and employees were asked to respond to their relevant sections and the results were subsequently analysed using Excel and SPSS data packages. The protocol was piloted in one case study and after modification, used for all case studies.

Research Protocol

Employer Details

Details of Employer , product or service;

No of Employees;

No of staff injured person has in immediate section;

Turnover 2013;

Profit 2013;

Is there a safety professional within the company YES No if yes details….title and hours worked per week on safety issues;

Is safety advice bought in YES No if yes details ……

Cost of any advice given.

Organisational Costs and Effects of the Accident

Specific employer costs involving

What is your current employer liability insurance premium ……..

What is your current public liability insurance premium ..……..

Loss of customers orders or other opportunities YES NO if Yes any details …

Cost of any productivity loss resulting from injury YES NO if Yes any details ……

Replacement of persons by way of extra salary costs YES NO if Yes any details ……

New equipment costs YES NO if Yes any details……...

Rental costs YES NO if Yes any details……..

Damage to plant or equipment and repair costs YES NO if Yes any details ……

Sick pay YES NO if Yes any details……

Overtime wages YES NO if Yes any details……

Compensation to injured party YES NO if Yes any details ……

Lost production time in hours YES NO if Yes any details ……

Cost of external consultants to advise on work practice changes YES NO if Yes any details ……

Costs of resultant work practice changes YES NO if Yes any details ……

EFFECT ON COMPANY

Very little < €100 Amount if known	A small amount €100…€1, 000 Amount if known	A medium amount €1,000…€10,000 Amount if known	A significant amount €10K…€100K Amount if known	A large amount >€100K Amount if known

Specific Legal & Insurance Costs,

Legal costs or court expenses YES NO if Yes any details ……

Any fines or penalties YES NO if Yes any details……

Any pending legal actions by Health and Safety Authority YES NO

Any statutory directions from Health and Safety Authority or other State regulator YES NO if Yes any details;

Any pending personal injury claims YES NO;

Any excess charged by insurance company YES NO if Yes any details ……

Any increase in insurance premium after the accident YES NO if Yes any details ……

Any underwriting refusal YES NO if Yes any details……

Any additional insurance conditions attached before re-insurance YES NO if Yes any details

Any loss of no claims bonus YES NO if Yes any details……

Increased cost of insurance premium resulting from accident YES NO if Yes any details ……

Medical bills paid to injured person YES NO if Yes any details ……

Travel expenses paid to injured person YES NO if Yes any details ……

Reputation, Image, Public Relations, Industrial Relations or Corporate & Social

Responsibility Costs Specifically;

Effect on staff morale and productivity YES NO if Yes any details;

Ability to attract new employees YES NO if Yes any details;

Quality reduction YES NO if Yes any details;

Any loss of standing in the community YES NO if Yes any details;

Any perceived loss in the ability to comply with any future tender stipulations on health and safety YES NO; if Yes any details;

Any negative Industrial Relations consequences YES NO; if Yes any details.

Costs due to the investigation of the accident, specifically

Was the accident investigated YES NO if yes any details;

Number of approximate man hours spent investigating the accident……

Number of persons involved in investigating the accident……

Recruitment, selection and staffing changes including re-structuring of the workforce, or policies and practices for recruitment or selection of new staff, or the overall staffing of the company Specifically

Any new recruitment practices YES NO , if yes details;

Any new staff recruited as a result YES NO, if yes details.

Re-structuring of training including re-training and refresher training, investment in training materials, etc. Specifically

Has any retraining taken place YES NO if yes;

Time taken to retrain ……..

Numbers of persons retrained ……

Cost of any retraining……..

Re-structuring of Communication practices and channels (including awareness campaigns, investment in leaflets, posters, etc.; toolbox talks, etc.) Specifically;

Any communication changes YES NO , if yes details;

Cost of communication changes…….

Re-structuring of auditing activities (including changes in auditing practices, frequency, re-training of auditors, etc.) Specifically;

Any internal auditors assigned additional duties and time subsequently spent YES NO, if yes details…

Any internal auditors time subsequently spent;

Any external auditors/consultants appointed YES NO if yes any details;

Cost of external auditors appointed to date;

Re-structuring of reporting activities including implementation of new reporting systems;

Any new reporting systems or structures YES NO if Yes any details ….

Any additional time taken for new reporting system… YES NO if Yes time taken …..

Re-structuring of co-operation activities (including changes in supervision, toolbox talks co-operation among employees and with managers:

Any changes in time taken for any new supervision practices YES NO if Yes any details …

Any changes in time spent in collaborating with fellow employees YES NO if Yes time taken

Any other changes to the Health & Safety Management System Has re-organisation or re-structuring of policy and goals taken place. How much has it affected the organisation including time spent in meetings and at workshops in order to change health and safety policies and goals). Any recurrent or capital costs involving.

☐Any changes in safety policies

☐Any changes in any other safety procedures

☐Any changes in terms of organisational culture initiated by top management or shop floor workers YES NO if yes any details

☐Any changes to prevent the accident from happening again

EFFECT ON COMPANY

Very little	A small amount	A medium amount	A significant amount	A large amount

Accident circumstances to elicit a narrative account of the incident, specifically

The Person

Background of person, age and county of residence;

Job title;

Length of time in sector;

Length of time with employer;

Family status.

The Accident

Day and time of accident;

Circumstance leading up to accident;

Detail of accident and injury;

Immediate effect of injury on the employee, consciousness, motor kills, pain;

Detail of first aid;

Actions of co – workers;

Actions of management;

Removal to hospital and time;

Action of hospital on arrival;

Details of treatment;

Details of diagnosis and prognosis;

Initial contact with relatives;

Effect on relatives;

Time spent in hospital;

Details of release;

Any contact with co workers;

Any contact with employer;

Details of time spent at home after release from hospital;

Effect on family routine;

Immediate costs faced by injured person on return from hospital;

Subsequent non envisaged costs faced by injured person on return from hospital;

Effect on family and relatives of injury;

Any permanent changes to family activities;

Any permanent changes to injured person activities;

Effect on injured person activities taking a longer term outlook any overriding memories challenges or feelings of the accident;

Any permanent non injury effects of the accidents;

Any message to co workers management state bodies and government.

Individual costs and effects Direct costs to the individual specifically

Number of working days absent …….

Period of time for which salary was not received from company YES NO if Yes any details;

Annual/ salary;

Any other payments received for example sick pay, social security YES NO if Yes any details;

Any medical costs YES NO; if Yes any details;

Any travel costs YES NO; if Yes any details;

Any overtime bonus premium or unsociable hours payments lost YES NO;

What is the probability of injury/illness leading to future absence and loss of earnings?;

Value and date of compensation received YES NO if Yes any details …

Retraining costs for any new career YES NO if Yes any details……

New clothing or new equipment purchased YES NO if Yes any details ……

Any modifications to the home made and costs involved YES NO; if Yes any details;

Effect on spouse's/partners/other resident family members participation in the workforce and take-home pay YES NO;

Any long term medical consequences or effects from the accident YES NO; if Yes any details

Any lost savings YES NO; if Yes any details;

Days spent in hospital A&E and No of visits as outpatient.

Work sphere, including working life, motivation, promotion opportunities, etc.Has the accident affected any of the following areas of your life and in what manner? Specifically: Recurrent / Capital costs:

Any changes in working life Yes No; if yes any details;

Any lost promotion opportunities with the employer Yes No; if yes any details.

Where individual has returned to work with different employer as a result of injury or illness, then detail

New salary and start date;

Value of loss of benefits (*e.g*. pension entitlements, leisure, creche facilities);

Comparison of promotional prospects;

Value of disability pension received.

Leisure and social sphere effect

Including hobbies sports, time spent in other activities than home, work and community life; sport and recreation; time spent with friends, etc.

Effect on Individual

Very little	A small amount	A medium amount	A significant amount	A large amount

Family sphere Effect of accident on family life

Very little	A small amount	A medium amount	A significant amount	A large amount

The community sphere, community life, political associations, unions and cultural groups, neighbour associations,etc.

EFFECT ON INDIVIDUAL

Very little	A small amount	A medium amount	A significant amount	A large amount

Severall effect on individual

Feelings towards the employer

Contact with employer management after the accident

Very little	A small amount	A medium amount	A significant amount	A large amount

Contact with workmates after the accident

Very little	A small amount	A medium amount	A significant amount	A large amount

Change in any level of resentment towards the employer

Very little No Change	A small amount	A medium amount	A significant amount	A large amount

4.4. Interview Process

Interviews were carried out with the twenty employers (one of which one was self employed and injured) and nineteen injured employees between. Once the employer (or their representatives) and the relevant employee had agreed to participate, arrangements were made for interviews to be carried out in a location chosen by the participants. Venues included participants own homes, hotels or workplaces. One interview with an employer representative was carried out over the telephone. Employer representatives included safety practitioners, occupational health staff or insurance executives. At all stages of the recruitment process, subsequent contact and field-work period, the participants were informed that they could withdraw from the process at any point. No employers or employees withdrew once they agreed to participate.

Paraphrased records of interviews were given to participants to check for accuracy, and with their agreement, were then given to their employers to check accuracy. All employees and employers indicated that they were satisfied with the representation of the situation in the interview scripts, (with some minor changes by employees). All employee participants were informed that as a gesture of thanks for their involvement, a donation to a charity would be made by the Health and Safety Authority. A draft final report was also sent to all participants for approval. Again only minor changes by employees were subsequently requested from any of the participants. One injured employee did not receive the final draft due to leave of absence abroad.

5. Summary of the Research Process

A summary outline of the research process and the number of participants is shown in the Table 1.

Table 1
Summary Research Process

Process	Sectors and participants
Literature review and design of interview protocol	–
Identification of sectors to be researched	Manufacturing, Health Care, Construction, Local Authority
Identification of study population	120 companies
Piloting of interview protocol	1 injured employee and 1 employer
Selection of employers	20 employers (or their representatives) from 16 companies or organisations
Case study interviews carried out	20 employers, 1 injured self-employed person and 19 injured employees
Analysis and presentation of results	–

6. Costs and Effects of Workplace Accidents

The most significant costs that can be expected from workplace accidents are summarized by Mossink & De Greef (2002) in Table 2 below.

Table 2
Expected Employer Costs from Accidents

Cost variable	Description
Fatalities, injuries and absenteeism	Cost of lost work time, production, fines and legal payments
Staff turnover	Replacement training and recruitment costs
Early retirement and disability	Costs associated with retirement, fines and payments to the injured person
Non-medical rehabilitation	Counselling, retraining and workplace changes
Administration duties	Time and effort spent investigating the accident
Damaged equipment	Repair and replacement costs
Insurance premiums	Any increases, refusal, changes in cover or conditions attached
Legal liabilities	Fines, regulatory activity, settlements and associated fees
Lost production time	Losses in production
Opportunity losses	Lost orders, inability to start or finish orders on time
Present income losses	Loss of income from present and second jobs
Loss of potential future earnings	Loss of income from present and second jobs
Expenses not covered	Medical, travel, new clothing

7. Psychological Effects of Workplace Accidents

Mossink & De Greef (2002) reported that the cost of accidents is not just a burden to businesses but also to the injured workers, their families and society in general. They reported that consequences for employees included loss of quality of life and human suffering (see also Rikhardsson & Impgaard, 2004). Mossink and De Greef identified significant psychological effects in terms of health, grief and suffering and quality of life as a result of workplace accidents. These are outlined in the Table 3.

Table 3
Expected Psychological Effects from Accidents

Effect	Description
Health	Hospitalisation, medical care, permanent disability, rehabilitation
Quality of life	Life expectancy, quality and disability adjusted life years issues
Grief and suffering	To the injured person, their friends and relatives

The Health and Safety Executive has broadened the debate on the social, psychological and financial impact of workplace accidents on the individuals involved and their families. This research has produced compelling evidence-based data on the possible range of negative consequences arising from workplace accidents and ill health. The data was collected in three ways. Firstly through telephone interviews with over 200 individuals who had suffered a serious work related accident or illness in the construction or health care sector. Secondly, personal home-based interviews were carried out with eighty individuals drawn from this group, including family members. Thirdly, "follow up" interviews were undertaken with forty individuals.

The study found that "*serious work related accidents and illness can have a widespread impact on individuals and their families*" and that "*many will find their working life is significantly affected*"

Psychological consequences included:

a) high levels of psychiatric morbidity;

b) a significant proportion of accident cases at risk of post traumatic stress disorder;

c) a higher number of cases of anxiety and depression compared to a control group.

Behavioural consequences included;

a) common instances of disturbed sleep and noticeable changes in temperament;

b) cognitive changes for example in concentration and decision making;

c) socialising patterns changed among male outdoor construction workers;

d) behavioural changes that could last for several months;
e) detrimental changes in the behaviour of children.

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e) detrimental changes in the behaviour of children.

Social consequences included:

a) a pervasive and damaging impact on personal and family life;

b) feelings of frustration, depression and social isolation;

c) frustration and anxiety about the future;

d) additional social consequences for those living alone.

Vocational consequences included:

a) over half the cases reported that their working life is or will be significantly affected;

b) a lack of formal return or remain at work schemes.

Economic consequences included:

a) a serious loss of income among construction workers;

b) additional medical and travel expenses;

c) family and friends losing pay and time from work;

d) a high level of compensation claims as individuals saw their employer as responsible.

Amati & Scaife (2006) provide a further overview of the links between psychological ill health, stress and safety

9. Measurement of Costs in Workplace Accidents

When analysing the costs of accidents it has been a common practice to present the mathematical relationship between different types of costs. Heinrich's frequently depicted iceberg model (as quoted by Rikhardsson & Impgaard, 2004) is often used to convey the concept of a relationship between direct costs such as repairs and indirect costs such as lost business opportunities. The ratio between these two types of costs has been found to vary across work sectors (Mottiar, 2004) and cannot be directly compared between studies (Grimaldi & Simonds, 1984; HMSO, 1993; Larsson & Betts, 1996; Monnery, 1998). Hence this iceberg model is a poor predictor of the actual negative cost consequences an organisation is likely to face from workplace accidents.

There are methods available to approximate the potential indirect costs based on direct costs. Both the Occupational Health and Safety Administration in the US and the Health and Safety Executive in the UK present such "calculators" retrievable at;

http://www.hse.gov.uk/costs/index.asp

http://www.osha.gov/SLTC/etools/safetyhealth/mod1_estimating_costs.html

http://www.thezenith.com/zenith_web/webui/employers/emp_pi_accidentcost.jsp).

The Zenith insurance company also presents a “calculator” retrievable at; The disadvantage of this type of research is that it focuses on gathering data to inform academic theories. It tends to lack any practical application to the workplace. Researchers focus either on calculating the costs associated with specific accidents, or on estimating the ratio between direct and indirect costs. Researchers have tended to approach companies with predefined categories of accident costs or use secondary evidence, such as insurance statistics, in order to gather their data. Therefore, while the methods are all essentially the same, they have limited predictive capabilities (Rikhardsson & Impgaard, 2004).

A second line of research has tried to develop a more practical method for estimation of the total costs of workplace accidents in a quick and accurate manner, while at the same time documenting the consequences of accidents for society, the organisation and the injured person (see Aaltonen et al, 1996 and Aaltonen, 1996 quoted by Rikhardsson & Impgaard, 2004). This line of research uses predefined forms for documenting the consequences of each occupational accident at individual, organisational and societal levels. However this approach suffers from the same methodological problems as previous research (Aaltonen et al., 1996) and a solution has not yet been achieved (Rikhardsson & Impgaard, 2004).

REFERENCES

Aaltonen M.V.P., *A Consequence and Cost Analysis of Occupational Accidents in the Furniture Industry*. Ph. D. Diss., People and Work 6. Finnish Institute of Occupational Health, Helsinki, 1996.

Amati. C.A., Scaife R., *Investigation of the Links between Psychological IllHealth, Stress and Safety*. Research Report 488. Prepared by The Keil Centre for theHealth and Safety Executive, 2006. Retrievable at; http://www.hse.gov.uk/ RESEARCH/rrhtm/index.htm

Dalley J., *On behalf of the Health and Safety Authority*. An *Assessment of the Cost of Reported Accidents in High-Risk Workplaces*, Ireland, 2005. Retrievable athttp://www.hsa.ie.

Dorman P., *The Economics of Safety, Health and Well-being at Work: an Overview*. In Focus Program on Safe Work, International Labor Organization. The Evergreen State College, 2000. Retrieved from http://www.ilo.org.

Dubin R., *Handbook of Work*. Organization and Society. Chicago: Rand McNally College Publ. Co., 1976.

Grimaldi J.V, Simmonds R.H., *Safety Management*. Richard D. Irwin, NewYork, 1984.

Hale A.R., Guldemund F., Bellamy L., Wilson C., *IRMA: Integrated Risk Management Audit for Major Hazard Sites*. In Schueller G.I. & Kafka P. (Eds.), Safety and Reliability, Rotterdam , The Netherlands, Balkema., 1315-1320, 1999.

Heinrich H.W., *Industrial Accident Prevention. A Scientific Approach*, (4th ed). McGraw Hill, New York, 1959.

Larrson T.J., Betts N.J., *The Variation of Occupational Injury Cost in Australia; Estimates Based on a Small Empirical Study*. Safety Science, **24**, *2*, 143-155 (1996).

Mossink J., De Greef M., *Inventory of Socioeconomic Costs of Work Accidents*. European Agency for Safety and Health at Work, 2002. Retrievable at http://agency.osha.eu.int.

Pérezgonzález J.D., *Construction Safety Management, A Systems Approach* (Knowledge Management Edition™). USA, Lulu Press, 2005b.

Rikhardsson PM., Impgaard M., *Corporate Cost of Occupational Accidents: an Activity-Based Analysis*. Accident Analysis and Prevention, **36**, 2004, 173-182.

COSTURILE ŞI EFECTELE ACCIDENTELOR LA LOCUL DE MUNCĂ

(Rezumat)

Scopul acestui raport este să ofere un ghid pentru efectuarea estimării costurilor accidentelor precum şi ale beneficiilor activităților de prevenire. Astfel, se prezintă un inventar al costurilor şi discuțiilor despre modul în care costurile sunt distribuite pe categorii de factori implicați, se descrie unele aspecte referitoare la efectuarea estimărilor de costuri. Se acordă atenție estimării valorii (exprimarea în bani) a sănătății, stării de bine şi vieții umane, cauzei şi efectelor determinate de relații şi de factorul timp. De asemenea, sunt dezbătute pe scurt efectele cadrului legislativ național şi a sistemului de asigurări sociale. Lucrarea are mai mult o orientare practică, fiind prezentate unele îndrumări pentru pregătirea şi efectuarea estimărilor de costuri.

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ŞTIINȚA ŞI INGINERIA MATERIALELOR

TECHNICAL DEVELOPMENT OF MANUFACTURING AS A STRATEGIC INSTRUMENT FOR IMPROVING THE EFFICIENCY OF A MOTOR TRANSPORT ENTERPRISE

BY

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Abstract: The paper considers the issue of implementing the technical development for increasing the motor transport enterprises' efficiency. There had been determined the typical strategies of production development for complex motor transport enterprises as well as their feature and feasibilities had been analyzed.

Keywords: motor transport enterprise; technical development; strategy; rolling stock; production and technical base.

1. Urgency of an Issue

The main objective of any enterprise is the maximum profit from its activity. The complex motor transport enterprises (MTE) are not the exceptions, the main goal of which is to receive profit by rendering services on trucking activities. The contemporary state of some MTE however does not enable them function efficiently and receive profit under the conditions of competing environment due to some reasons.

One of the reasons is the significant aging of the production facilities, especially their active part – the rolling stock. Depriciated and morally aged

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rolling stock cannot compete with the modern samples of car industry, especially with the foreign one. Besides, the modern manufacturing and the logistic network set forth the new conditions to the rolling stock, which may make the use of these cars inappropriate, therefore, the modern cars for long distance traffic differ from cars which operate as the distribution vehicle in the cities.

This is necessary to note that for the complex MTE, that is, those, which maintain the operable state of the cars, the structure and the state of the passive part of the production facilities, production and technical facilities (PTF) also influence the traffic handling costs, and, consequently, the efficiency of the MTE itself. The modern PTF in the majority of MTE, as well as the rolling stock, is in unsatisfactory state due to its wearing out and aging of the technological processes on maintenance operations (MO) and car repair.

Thus, one of the ways to improve the efficiency and competitiveness of the modern MTE is the technical development, that is the complex renovation of both, rolling stock and PTF on the base of system approach, determined by close connections between the rolling stock and PTF. For example, the change of the car park for the modern samples, which by their design and MO technology differ from those available on MTE, require the improvement of PTF, which needs the additional funds for the PTF development and, correspondingly, influences the final economic effect from the renovation of the rolling stock.

2. Analysis of Scientific Works

The scientific works pay very little attention to the issue of the development the motor transport enterprises on the system approach. Most of the scientific works consider the question of the rolling stock renewal and the PTF development as “almost” independent from each other, that is, without examining their relationships in complex renewal. Therefore, it is worth noting the following outstanding national and foreign scholars, such as G.F. Babushkin, M.N. Budnyak, V.N. Varfolomeyev, M.Y. Govorushchenko, V.E. Kanarchuk, E.S. Kuznetsov, I.P. Kurnikov, O.A. Ludchenko and many other scholars who works on these issues.

But many of these works are based on a planned economy’s principles, which operated in the USSR, that rather complicates their use under market conditions prevailing in modern Ukraine. Therefore, among the contemporary works that consider this issue under market conditions, it is necessary to emphasize the work (Bidnyak, 2000) that studies the economical aspects of the MTE’s rolling stock renewal. In addition, the works (Radonova, 2001; Mazorchuk, 2003) on industrial enterprises’ technical development should be highlighted, however, considering the automotive industry’s specificity, these works have a limited use.

3. Problem Statement

The technical development of motor transport enterprises requires a strategic planning, *i.e.* building up technical development strategies. Strategic planning enables business leaders to determine the direction and pace of business development, determine the global market trends, understand what organizational and structural changes must occur at the enterprise to make it competitive, understand its advantages and what tools are necessary for its successful development (Ansoff, 1989).

The technical development strategy is a complex and potentially powerful mechanism that can allow motor transport enterprises to resist changes in the external environment and sustain the competition in the transport services market. However, the strategies' mechanism of technological development, as a perspective managing the MTE's development, today is little-invesigated. This requires the development of modern methods for determining the effective strategies for technological development and research of the practical aspects of their implementation.

4. The Main Part

The use of strategic approach requires a perspective on the company in terms of "an open" system , the major preconditions of which are not in the middle, but outside the system. Apparently, the performance of the operating company depends on how effectively it can adapt to the market. MTE, that operates on a specific transport market (or segment) will meet the requirements of the market if it provides transportation services, depending on the market potential and certain transportation costs (both services are competitive, and traffic volumes will provide the expected profit) (Bilichenko, 2006; Smirnov, 2010). Therefore, while choosing a strategy for technological development, one should be guided either by the potential profits from the strategy or the data on the market share, which the company can take , considering the company's internal structure and competitors productivity.

The strategy realization shall be considered as a certain set of organizational and technical measures put into life to achieve the goals and objectives having been regarded before. The set of measures for implementing the strategy comprises a combination of renewed rolling stock and the development of PTF and, accordingly, it may include the following options:

a) simple replenishment of the car park that requires the modernization of the existing PTF;

b) simple replenishment of the car park that requires technical re-equipment of the existing PTF;

c) simple replenishment of the car park that requires the reconstruction of the existing PTF;

d) complex replenishment of the car park that requires the modernization of the existing PTF;

e) complex replenishment of the car park that requires technical renovation of the existing PTF;

f) complex replenishment of the car park that requires reconstruction of the existing PTF;

g) identical replacement of the rolling stock that requires the modernization of the existing PTF;

h) identical replacement of the rolling stock requires technical upgrading of the existing PTF;

i) identical replacement of the rolling stock that requires the reconstruction of the existing PTF;

j) modernization of the rolling stock that requires upgrading of existing VTB;

k) modernization of the rolling stock that requires technical upgrading of the existing PTF;

l) modernization of the rolling stock that requires the reconstruction of the existing PTF.

Additionally, for each strategy there may be offered several options for its implementation, that will differ from each other in the way of using various rolling stock. Considering the above, the amount of the initial investment required for the implementation of the *i*-th alternative of the technical development shall be determined by the formula

$$\mathrm{IC}_i = \sum_j \mathrm{IC}_{ij}^{\mathrm{RS}} + \sum_j \mathrm{IC}_{ij}^{\mathrm{PTB}}, \qquad (1)$$

where $\mathrm{IC}_{ij}^{\mathrm{RS}}$ is the initial investment required to purchase the *j*-th type of rolling stock at the *i*-th option; $\mathrm{IC}_{ij}^{\mathrm{PTB}}$ – the initial investment required for the development of the company's industrial and technological base the for the *j*-th type of rolling stock at the *i*-th option.

Strategies for technical development, providing easy replenishment of the park make sense when the operating at the enterprise rolling stock is modern enough, or the rolling stock meets at least the requirements to freighting, and the capacity of the existing rolling stock is insufficient for meet the existing demand for transport services market. In this case, there will be no differences between the existing rolling stock and vehicles that are to be purchased once. However, the existing capacity of PTF may be insufficient to provide the maintenance for the rolling stock on condition of a significant increase in the

number of cars. It may therefore be necessary to modernize it, renovate all the facilities that will lead to the existing production equipment refurbishment and productive patterns improvement, or even reconstruction of the enterprise, due to the need of construction of new stations or reconstruction of the existing. Under these circumstances the last two strategies in this group may be inexpedient due to the need of attracting the substantial funds for the development of PTF.

Strategies for technical development, providing for the complex (extended) replenishment of the park stipulates for the purchase of new cars that have never been used by this enterprise. The purchase of new cars is due to the availability of the market share, which the company is trying to capture. Moreover, new cars can meet the requirements for transportation more substantially and, in turn, be more effective compared to the existing ones . Depending on the degree of differences between the new cars and the available motor-vehicles and the capacity of the existing PTF there might be necessary to upgrade, modernize or reconstruct the latter.

Strategies for technological development, providing identical replacement of the rolling stock can be implemented only once the company takes a definite market share in transportation services and is active against competing users. In this case, the aged rolling stock will be ineffective, although it fits the traffic profile. The purchase of new cars that will not differ structurally from the existing ones, (but their effectiveness will be considerably higher), is required to succeed. One may need to upgrade or revamp the PTF with the purchase of new cars. Under these conditions the reconstruction may take place but hereby its effectiveness is questionable because of the need to attract much money.

Strategies for technological development, that envisage the upgrading of rolling stock, are used in terms of replacement of old and inefficient rolling stock for new models, which totally meet the requirements of traffic. In this case, a new rolling stock may differ from the existing one significantly. There are the strategies, the implementation of which involve both, PTF upgrading and reconstruction, depending on the degree of difference between the new and the used cars. Usually, PTF modernization will be unlikely in this group of strategies, since it is assumed to purchase cars different from the existing ones.

The source of strategies' cost-effectiveness for technological development is increasing in traffic revenue due to the use of the new, more efficient rolling stock as well as the optimization of the PTF structure. This will result in provision of the required level of the performance of the maintenance and repair of motor vehicles while reducing the cost of the work. To evaluate the economic impact from the implementation of this or that technical plan of development , it is worth using the indicators of the payback period , net present value and internal rate of return (Bidnyak, 2000; Radonova, 2001; Mazorchuk, 2003; Ansoff, 1989; Bilichenko, 2006; Smirnov, 2010; Bilichenko, 2009):

$$\mathrm{PBP} = \frac{\mathrm{IC}}{\sum_t \mathrm{CF}_t / T}, \tag{2}$$

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{\mathrm{CF}_t}{(1+r)^t} - \mathrm{IC}, \tag{3}$$

$$\sum_{t=1}^{T} \frac{\mathrm{CF}_t}{(1+\mathrm{IRR})^t} - \mathrm{IC} = 0, \tag{4}$$

where: PBP is the pay-back period of the variant, years; IC – invested capital, [$]; T – the term of the variant, years; CF_t – the cash flow from the realization of the variant in the t-th period, [year]; r – the discount rate for the lifetime of the variant; NPV – the net present value, [$]; IRR – the internal rate of return.

Options for which at least one of the following three conditions will not come true shall be considered as economically feasible:

1) the pay-back period is larger than the term of the variant: PBP > T;

2) the net present value NPV ≤ 0;

3) the internal rate of return is lower than the minimum acceptable rate of return: IRR < MARR.

Besides, the implementation of technological development strategies allows the company to strengthen its position on the market of transport services and improve its competitiveness. Primarily, this can be achieved by the selection and use of a constructively new and more specialized rolling stock which is better adapted to the transportation conditions. Furthermore, new cars have lower maintenance costs, that allows the company to pursue a more aggressive tariff policy.

Strategies, the implementation of which involves the purchase of new cars, which differ significantly from the available car park, usually require the development of PTF, that is associated with the attraction of sufficiant funds. That's why these strategies are more capital-intensive (see eq. (1)), and therefore their use will be expedient if the efficiency of new cars exceeds the performance of existing car fleet significantly or the cars being purchased for the other purposes and spend less on PTF. That is, even at much higher efficiency of new cars can be a situation where the final effect of the strategy is not worth the initial investment.

The company ought to attract additional funds from external sources (loans, leasing, emission of securities, IPO, etc.) that have their value as well as availability, since the implementation of technological development strategies corresponds to additional investments with quite high cash flow. Therefore, when developing the overall effectiveness such an issue must be considered.

In addition to the economic benefits, the implementation strategies of technological development accepts several other consequences such as improving the working conditions for drivers through the use of new vehicles equipped with systems that help the driver, improving conditions and encouraging the workers productivity by renovating PTF, bringing the clients satisfaction by improving their quality, increasing its credibility on the transport market.

5. Conclusions

Taking into account the current state of road transport Ukraine it is possible to assert that the technical development of production is one of the most appropriate ways to increase the efficiency of complex motor transport enterprises. Considering the specificity of technological development, its implementation on the motor transport enterprise requires a strategic approach. The implementation of the technological development strategies usually involves the renewal of the enterprises' system – i.e. the renewal of both the rolling stock and the PTF n complex. Due to this, there had been determined the typical strategies of technical development that are based on simultaneous renewal of the rolling stock and the operational and technical base as well as their characteristics and feasibility had been analyzed.

REFERENCES

Ansoff I., *Strategic Planning* (transl. from Engl). Under the edition of L.I. Evenko. – M.: Ekonomika, 1989, 358.

Bidnyak M.N., *Investment Planning on Motor Transport*. M.N.Bidnyak, N.M. Bodnar., K.B.V., 2000, 118.

Bilichenko V.V., *Determination of the Efficiency of the Projects for Technical Development of the Manufacturing on the Automobile Transport*. Naukovi prazi Vinnytskogo Nazionzlnogo Tehnichnogo Universytety, *2*, 2009, access mode: http://archive.nbuv.gov.ua/e-journals/vntu/2009-2/2009-2.files/uk/09vvboat_ua.pdf.

Bilichenko V.V., *Simulation of the Strategies for Technical Development of the Manufacturing on the Enterprises of Automobile Transport*. Visnyk Donetskogo Instytutu Avtombilnogo Transportu, *2-3*, 22-26, 2006.

Mazorchuk M.S., *Simulation of the Development of the Enterprise Considering the Attraction of Additional Investmnents*. Ph. D. Diss., National Aerospace Institute named after M. Zhykovskyi "Khark. aviat. Inst.", 2003, 20.

Radonova S.V., *Controlling over Technological Renovation of the Industrial Enterprises in Conditions of the Economy in Transition.* Ph. D. Diss., Institute of regional studies of NAS of Ukraine, 2001, 24.

Smirnov E.V., *Contriolling over the Determination of the Strategy of Technical Development of Manufacturing on the Automobile Transport.* Naukovi notatky. Mizhvusivskyi zbirnuk , Lutsk, *28*, 503-508, 2010.

DEZVOLTAREA TEHNICILOR DE PRELUCRARE CA INSTRUMENT STRATEGIC PENTRU ÎMBUNĂTĂȚIREA EFICIEȚEI UNEI ÎNTREPRINDERI DE TRANSPORT

(Rezumat)

Se abordează chestiunea implementării progresului tehnic pentru creşterea eficienței unei întreprinderi transport. S-au determinate strategii tipice de dezvoltare pentru intreprinderi complexe de transport motorizat şi s-au analizat fezabilitatea acestora precum şi perspectivele.

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IDENTIFICATION OF THE RISK FACTORS OF OCCUPATIONAL INJURIES AND DISEASES ASSOCIATED TO SENSITIVE RISK GROUPS

BY

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Abstract: The obligation of employers to carry out risk assessments and to adopt appropriate preventive measures for sensitive or vulnerable groups can be accomplished by filling out the “*Cheklist to identify the risks associated with sensitive groups*”, the employer having the possibility to immediately implement corrective measures, in parallel with the identification of the risk factors of occupational injuries and diseases associated to sensitive or vulnerable groups.

Keywords: sensitive groups; occupational safety and health; risks identification.

1. Legislative Provisions for Sensitive/Vulnerable Groups at Risks

Legislation on occupational safety and health requires employers to carry out risk assessments and take appropriate preventive measures. Concurrently with the general requirements which apply to all types of risks and for all workers, employers have the following obligations: to protect particularly

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the most sensitive groups against the dangers which specifically affect them; to organise the workplaces by "taking account of the employees with disabilities, if necessary"; to provide an appropriate technical equipment for the work, so that it could be used by workers without affecting their safety and health.

Anti-discrimination legislation may also require adjustments to the workplace and utilities. Employers are required to provide the following: reasonable arrangements for disabled people in order to facilitate access to a job, to pursue a profession and promote, as well as participation in training courses; effective and practical measures intended for the arrangement of the workplace based on the type of disability, for example, adapting the premises and equipment, the patterns of working time, the distribution of tasks, and providing resources of training or integration into the workplace. The framework directive on equal opportunities in the field of labour and employment prohibits direct or indirect discrimination, caused by the existence of a disability.

The legislative provisions for sensitive/vulnerable groups at risks are as follows:

1. Government Decision No. *116*9/November 2011 for amending and supplementing the Government Decision No. *355*/2007 on the surveillance and protection of workers' health: the special surveillance means prophylactic medical examination carried out by the occupational physician in order to establish the work capacity of certain categories of workers, such as: persons aged between 15 and 18 years old, persons over 60 years old, people with disabilities and with chronic diseases, pregnant women, workers with monocular vision, alcohol/drugs addicted persons, left handed persons, etc.

2. Law No. *448*/2006, republished and updated, on the protection and promotion of the rights of disabled persons: "Art. 78 (1): Disabled persons may be employed according to their professional background and labour capacity, attested by the handicap degree certificate, issued by the evaluation commissions at a county level or at the level of Bucharest municipality sectors".

3. Government Decision No. *600* of 13 June 2007 on the protection of young people at work.

4. Law No. *319*/2006 on safety and health at work:

Art. 12

(1) The employer has the following obligations:

a) to perform and be in possession of an assessment of the risks to safety and health at work, including for those sensitive risk groups.

Art. 35

Sensitive risk groups, such as: pregnant women, women who have recently birthed a child or breastfeeding women, young people, as well as

disabled persons, must be protected against the dangers which specifically affect them;

Art. 36

Employers shall organize the workplaces taking account of the presence of sensitive risks groups.

2. Sensitive Risks Groups

Sensitive risk groups, such as: pregnant women, women employee who have recently birthed a child or breastfeeding women employee, young people, as well as disabled persons, must be protected against the dangers which specifically affect them.

Employers shall organize the workplaces taking account of the presence of sensitive risks groups.

2.1. Terminology

Pregnant employee: it is the woman who shall notify the employer, in writing, about her physiological condition of pregnancy, enclosing a medical document issued by a GP (General Practitioner) or a SP (Specialist Practitioner) to certify such condition.

Woman employee who has recently birthed a child: it is the woman who has resumed work after her period of confinement and asks the employer in writing of the protective measures provided by law, enclosing a medical document issued by a GP (General Practitioner), but not later than six months after the date on which she has birthed.

Breastfeeding woman employee: it is the woman who is breastfeeding her child, and upon the resumption of the activity after the confinement leave informs her employer thereof in writing on the presumed beginning and end of the breastfeeding period, enclosing medical documents issued by a GP (General Practitioner).

Young people: any person aged at least 15 years and not more than 18 years old.

Disabled persons: they are those persons who, due to physical, mental or sensory disorders, lack the abilities to perform normal day-to-day activities, requiring protective measures to support recovery, integration and social inclusion.

3. Cheklist to Identify the Risks Associated with Sensitive Groups

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
A	***Pregnant employees and/or women employees who have recently birthed a child or breastfeeding women employees - General Provisions***			
1	Are the pregnant employees, women employees who have recently birthed a child or breastfeeding women employees performing routinely a work of insalubrious or awkward nature?			• they cannot perform a work of insalubrious or awkward nature. • such employees must be assigned to another job or given the opportunity to transfer to a different position that they can perform. If such a transfer position is available, it must be with the same seniority, status, rate of pay, and other job benefits the employee had just prior to such transfer.
2	At work there are conditions of exposure to physical agents which can cause damage to the fetus and/or detachment of the placenta, in particular:			• avoid exposure; • they must not be constrained to carry out a task that is harmful to their health, pregnancy or newborn child; • proper adjustments to their working conditions and/or working time; or • they must be assigned another position, which entails no risk to their health or safety, with the same salary; • based on the recommendation of an Occupational Physician or a General Practitioner; • the employer is obliged to assess on an annual basis, as well as upon any changes in working conditions, the nature, degree and duration of exposure, in order to determine both any risk to their safety or health and any repercussion on their pregnancy or breastfeeding.
	2.1. shocks, vibrations or sudden movements;			
	2.2. manual handling of heavy weights, entailing a risk especially in the dorsolumbar spine;			
	2.3. noise;			
	2.4. ionizing radiation;			
	2.5. non-ionizing radiation;			
	2.6. extreme thermal environments, cold or heat;			
	2.7. work movements and postures;			
	2.8. travelling (either inside or outside the establishment);			
	2.9. mental and physical fatigue;			
	2.10. other physical burdens connected with the women employees activity work;			
	2.11. are the pregnant employees and/or the women employees who have recently birthed a child or the breastfeeding women employees working night shifts?			• they may not be required to perform night work • the employer is obliged, on the basis of a written request of the employee, to transfer her to a daytime job, with the same gross monthly salary; such request is accompanied by a medical document which mentions the period in which her health is affected by the night shift.

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
3	Are there any biological agents at the workplace belonging to Risk Groups 2, 3 and 4?			• avoid exposure; • they must not be constrained to carry out a task that is harmful to their health, pregnancy or newborn child; • proper adjustments to their working conditions and/or working time; or • they must be assigned another position, which entails no risk to their health or safety, with the same salary; • based on the recommendation of an Occupational Physician or a General Practitioner; • the employer is obliged to assess on an annual basis, as well as upon any changes in working conditions, the nature, degree and duration of exposure, in order to determine both any risk to their safety or health and any repercussion on their pregnancy or breastfeeding.
4	At the workplace there are chemicals, such as: carcinogens and/or mutagens;			
	4.1.chemical agents from the list of occupational exposure limit values;			
	4.2.mercury and its derivatives;			
	4.3.antimicotic drugs (which stop cell multiplication);			
	4.4.carbon monoxide;			
	4.5.hazardous chemical agents with percutaneous absorption.			
5	Are there any industrial processes at the workplace that can lead to cancer?			
6	At the workplace there are performed underground mining activities.			
B	***Pregnant Employees:***			
7	Has the employee submitted a written notice to the employer together with medical evidence proving her condition?			• Within 10 working days from the date on which the employer has been notified in writing by an employee that she is in one of the situations referred to in point A) it is required to inform: - The Occupational Physician; - The Local Labour Inspectorate in whose jurisdiction they operate. • The internal regulations of the institutions must: - contain measures relating to hygiene, health protection and safety at work; - prevent exposure of female employees; - avoid to constrain female employees to carry out tasks that are harmful to their health, pregnancy or newborn child.
8	Woman Employee's activity takes place: **8.1.**in hyperbaric atmosphere;			• women employees may not be required by the employer to carry out the activities referred to above.
	8.2.in the presence of biological agents, such as: toxoplasma, rubella virus;			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
	8.3.in the presence of Pb (lead) and its derivatives;			
	8.4.in underground mining workplaces.			
C	***Pregnant employees and women employees who have recently birthed a child (up to six months)***			
9	Is the pregnant employee or the woman employee who has recently birthed a child working only in orthostatic position or in a sitting position?			• change their workplace so that they be provided at regular intervals of time, breaks and facilities for rest in sitting position, or, for movement respectively. • the Occupational Physician shall determine the intervals of time it is necessary to change the working position, the periods of activity, as well as duration of the periods for resting in the sitting position, or for movement, respectively. • if providing appropriate working conditions and/or working programme is not technically and/or objectively possible, or it cannot be required, for duly substantiated reasons, than the employers shall take all the necessary actions to change the place of work of the employee concerned.
D	***Breastfeeding Women Employees***			
10	Are there any breastfeeding women employees at the workplace?			• the internal regulation of the institution shall contain measures on the hygiene, health protection and safety of the women who are breastfeeding after birth; • female employees are required to perform a minimum of 42 days maternity (postnatal) leave; • breastfeeding female employees cannot be required to perform night work; • they must receive during the programme of work, two breastfeeding breaks for one hour each, up to the age of one year of the child.

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
	10.1.Is the employer providing special rooms for breastfeeding within the institution?			• Yes, the special rooms for breastfeeding meet the hygiene requirements corresponding to the sanitary standards in force.
				• No, employers are required to provide to their breastfeeding women employees two nursing breaks of one hour each, during the working hours.
	10.2. The activities performed at the workplace include: exposure to Pb (lead) and its derivatives;			• women employees may not be required by the employer to carry out the activities referred to above.
	10.3.underground mining			
E	***Young People, up to 18 years old***			
11	At the workplace there are risks: specific to the safety, health and development of young people;			• the employers shall assess the specific risks and take the necessary measures to ensure the safety and protect the health of young people, before young people starting work and upon any significant change in working conditions, particularly aiming at the following elements: - work equipment and organization of the workplace and the workstation; - nature, level and duration of exposure to physical, chemical and biological agents; - organization, category and use of work equipment, machinery, apparatus and appliances, and their handling; - establishment of work procedures and conduct of labour, as well as their interaction, namely the organisation of work; - professional education and training provided to young people. • the employers shall provide surveillance of young employees health at regular intervals, free of charge and appropriately; • they shall inform young people, in writing, both on the possible risks and all measures taken in relation to their safety and health; • they shall notify, in writing, the parents or legal representatives of young people employed in accordance with the law, on all and any measures taken with regard to their safety and health.
	11.1.resulting from their lack of experience;			
	11.2.resulting from insufficient awareness of the existing or potential risks;			
	11.3.related to the fact that young people are still in development.			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
12	The employer runs activities that are likely to result in specific risks for young people through exposure to physical, biological and chemical agents: **12.1.**ionizing radiation;			It is prohibited to employ young people in these types of activities.
	12.2.work in hyperbaric atmosphere;			
	12.3.biological agents of Groups 3 and 4;			
	12.4.substances and preparations which are classified as toxic, very toxic, corrosive or explosive;			
	12.5.substances and preparations which are classified as hazardous, implying the following risks: - can cause very serious irreversible effects; - can cause irreversible effects; - may result in sensitization by inhalation; - may result in sensitization by skin contact; - can cause cancer; - may cause heritable genetic damage; - can have significant health effects in case of prolonged exposure; - may reduce fertility; - can determine, during the pregnancy, the appearance of harmful effects for the child;			
	12.6.substances and preparations which are classified as irritant, implying the following risks: - are flammable; - may result in sensitization by inhalation; - may result in sensitization by skin contact;			
	12.7.substances and preparations which are classified as carcinogens or mutagens agents;			
	12.8. Pb (lead) and its compounds;			
	12.9 Asbestos.			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
13	There are processes or activities that are likely to entail specific risks for the young people due to the working procedures with risk related to the exposure to carcinogens or mutagens at the workplace: - manufacture of auramine; - work involving exposure to PAHs (polycyclic aromatic hydrocarbons) present in coal soot, coal tar coal tar pitch; - work involving exposure to dusts, fumes and sprays produced during the roasting and - electro-refining of cupro-nickel mattes; - strong acid process in the manufacture of isopropyl alcohol; - work involving exposure to hardwood dusts; - excessive solar UV radiation; - ionizing radiations;			It is prohibited to employ young people in these types of activities.
	13.1.manufacturing and handling of devices, fireworks or other objects containing explosives;			
	13.2.from the menagerie of ferocious and venomous animals;			
	13.3.industrial cutting of animals;			
	13.4.involving handling of production devices, storage or use of compressed, liquefied or dissolved gases;			
	13.5.procedures that involve use of vats, tanks, reservoirs, vessels or canisters containing chemical agents;			
	13.6.involving risk of collapse, fall from height;			
	13.7.involving high voltage electrical risks;			
	13.8.whose rate is determined by machinery, being paid by results;			
14	They undergo activities that: **14.1.**are beyond the physical or psychological capacities of young people;			It is prohibited to employ young people in these types of activities.
	14.2.involve harmful exposure to agents, such as: - toxic, carcinogenic; - that determine heritable genetic damage, having harmful effects on the fetus during pregnancy or having any other chronic adverse effect on human health;			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
	14.3.involve harmful exposure to radiation;			
	14.4.present risks of accidents that are assumed that young people cannot identify or prevent, due to insufficient attention afforded to occupational safety issues or due to their lack of experience or training;			
	14.5.jeopardize their health because of extreme cold or heat or due to noise or vibrations;			
	14.6.involve additional work;			
	14.7.involve night shift.			
F	***Disabled Persons:***			
15	Are disabled persons undergoing working activities, or do they have acces to the workplace?			• workplace organiziation is carried out taking account of the workers with disabilities, by type of disability - entries; - means of communication; - stairwells; - showers, sinks, laundry facilities; - workstations used or occupied directly by disabled persons; - utilities; - adapting premises and equipment; - adapting patterns of working time; - distribution of tasks; - means of training and occupational integration. • making available technical equipment appropriate to the work concerned so that it can be used by workers without affecting their safety and health, taking into account the ergonomic principles
	15.1.is the job task designed for such persons?			Workplaces and Work Equipment • adapting workplaces and workstations - ramps; elevators; - light switches; - edges of the stairs painted in light colours; - tactile warning strips at the top of the stairs; - audible alarm or warning flags; - automatic opening devices at the gates;
	15.2.are the specific needs related to the disability provided?			
	15.3.the technical equipment and workstations are tailored to individual needs;			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
				- opening devices which are accessible to people in wheelchair and can easily be located by the blinds; - smooth and anti-slip flooring; • allocation of work areas, for example on the ground floor, in a room with easy work access or facilitating work at home; • acquiring or modifying equipment, for example Braille keypad, phones with hands-free control devices; • modification of the programme of work, including for those who are working part-time, if necessary, to facilitate the movement of people with disabilities outside the crowded hours; • ensuring implementation of rehabilitation programmes, analyses or treatment; • planning a gradual resumption of the work.
	15.4.the work environment, lighting, heating, access and escape routes are adapted to the type of disability;			
	15.5.labour organization and oranization of working hours;			
	15.6.are there any physical hazards or hazardous substances?			
	15.7.are there any psychosocial risks, stress or moral harassment?			
	15.8.the needs of information and training are provided through specific means;			
	15.9.is the employer ensuring the involvement of workers and their representatives, including consultations with them about the risks and prevention measures?			
16	Procedures in case of emergency: - is the employer providing storage areas for the evacuation equipment?			• The measures that aim to improve access to work should also contribute and facilitate evacuation in case of emergency. - workers with disabilities should work in certain parts of the building where they can be more easily evacuated in case of emergencies; - special equipment, such as an evacuation chair; - applying escape techniques, especially the mode of transport or support to persons using means of displacement; - the use of special equipment of evacuation.
	16.1.are they easily accessible?			
	16.2.in an emergency, are there any employees with duties of prevention and aid to the workers who have visual or motor deficiencies (evacuation assistants)?			
	16.3.is the employer providing illuminated signaling devices in case of fire or other visual or vibrating warning devices to supplement the audible alarms?			
	16.4.are audible alarms installed in all areas, including in the restrooms?			
	16.5. are the escape routes and procedures take into account the potentially slower movement of people with disabilities?			
	16.6.do all people with disabilities know the escape routes and have they received instructions and training on security procedures?			
	16.8.have the rescue areas and the immediate risk-free premises been established?			

Crt. No.	SENSITIVE RISK GROUPS	Risks Factor Identification		RECOMMENDED ACTIONS
		YES	NO	
	16.9.have they obtained the necessary counseling?			
	16.10.do the written evacuation procedures also include the agreements concluded with disabled people?			
	16.11.are these agreements reviewed on a regular basis?			
	16.12.are the workers encouraged to draw up a list of medications, allergies, special equipment, names, addresses and phone numbers of doctors, pharmacies, family members and friends as well as other important information?			
	16.13.is there any first aid kit that includes suitable gloves (used to protect the hands of people who handle the wheelchair), tire repair kits and extra batteries for those who use motorized wheelchairs or scooters?			
G	**Are there any 60 years old employees?**			
17	Is the periodic health surveillance (periodical medical examination) carried out for all persons over 60 old?			• People over 60 years old will not run, under any circumstances, activities of work at height until after they have their periodic health surveillance done and only if in the job skill sheet it is stated "fit for work at a height", signed and initialled by the occupational physician. • People who have "apt-conditioned" in the job skill sheet will be monitored by the occupational physician and by their GP and will bring monthly to the occupational physician or to their supervisor a medical letter concerning the follow-up of the following treatment prescribed prescribed by the Specialty Physician. • The employer is required to assess risks on an annual basis through specific methods, as well as upon any changes in working conditions.
	17.1.Are the health issues that could lead to the risk of accidents or occupational diseases (diabetes, HBP - hypertension, etc.) found in due time			

REFERENCE

Bujor A., *Assessment of Occupational Safety and Health Risks for those Groups Sensitive to Specific Risks.*

IDENTIFICAREA FACTORILOR DE RISC DE ACCIDENTARE ŞI ÎMBOLNĂVIRE PROFESIONALĂ ASOCIATE GRUPURILOR SENSIBILE LA RISCURI

(Rezumat)

Obligaţia angajatorilor să realizeze evaluarea riscurilor şi să adopte măsuri de prevenire corespunzătoare pentru grupurile sensibile sau vulnerabile poate fi realizată prin completarea "*chek-listului pentru identificarea riscurilor asociate grupurilor sensibile*", angajatorul având în paralel cu identificarea riscurile de accidentare sau îmbolnăvire profesională asociate gupurilor sensibile sau vulnerabile şi posibilitatea de a implementa imediat măsurile corective.

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MODERN WATER DISINFECTION TECHNOLOGIES IN THE CHIRIŢA WATER PLANT (S.C. APAVITAL S.A. - IAŞI)

BY

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Abstract: Many areas on Earth are experiencing drinking water shortages while two thirds of this planet is covered with water. Unfortunately most of this water is sea water which is too saline to be consumed by humans or animals. By the other hand, most of the remaining fresh water is trapped in ice caps. Therefore, very little amounts of fresh water are available and, moreover, these reserves are affected by the rampant growth of world population and an increasing of modern man’s water needs of modern man, in parallel with an increase of wastewater amounts.

The large urban areas in developing countries which do not operate wastewater treatment plants have often faced epidemics caused by waterborne microorganisms. In these areas, frequently, wastewatera are polluting watercourses from which populations, downstreams, are drawing water that is used for drinking, cooking and washing. In other cases (Romania) an irrational forced industrialization has polluted waters by uncontrolled discharges of chemical and even nuclear wastes. Considering that water is an optimal environment for viral diseases pathogens, new technology able to remove such pathogens have been developed (physical and chemical disinfection). Among the most used disinfection processes we can recall the chlorination, the ultrafiltration, the high-energy radiation treatment, the ozonation, and the use of ultrasonic fields.

Chlorine, the most commonly used reagent for drinking water disinfection, in contact with organic matter, generates trihalomethanes, compounds that have

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cancerigen potental. Therefore, there is a trend to replace chlorine with disinfectant reagents, with superior properties, that would not generate toxic substances. One such a reagent is chlorine dioxide.

Comparative studies of effects obtained for Prut water after chlorine and chlorine dioxide treatments, revealed that chlorine dioxide leads to better results in oxidative and biocidal processes and provides a water with superior quality. Disinfection process is based on either redox processes (when strong oxidizing substances are used, forms of energy with high penetration power) or separation filtering processes associated with biological processes (that is, membrane processes in slow sand filters).

During water disinfection process several fundamental parameters are involved:

a) the amount of disinfectant that is effective in active form;

b) contact time between disinfectant and water to be disinfected;

c) own disinfectant's efficiency;

d) micro-organisms's susceptibility to be destroyed or inactive;

e) water's physical and chemical features factors (pH, temperature, ionic environment).

Keywords: chlorine; chlorine dioxide; disinfecting doses; trihalomethanes.

1. Introduction

Surface water is unfit for human consumption due to suspended substances and biological contamination, caused by the contact with the atmosphere, soil, and various polluters. The decreasing or the full elimination of microbial populations is to be achieved by water disinfection (sterilization) with strong oxidant reagents or physical agents, all with the same aim: to reduce or eliminate all microbial presence in drinking water (Noss *et al*., 1983; Olivier *et al*., 1985).

Disinfecting agents that are used are high penetration electromagnetic radiations, able to inactivate the enzymes involved in cellular metabolism. From this category, the most used are the gamma and the ultraviolet radiations (Sommer & Cabaj, 1993).

For water disinfection the most demanded reagents are those that are able to provide a 99% destruction of micro-organisms.

The efficiency of such agents is ranked as it follows:

$$O_3 < Cl_2 < Br_2 < ClO_2 > I_2 > Ag^{+2} > \text{R-NH} > KMnO_4 > H_2O_2.$$

The disinfection's performances, as it is shown in Fig. 1, depend on the water-reagent contact time and on the amount of used reagent, expressed in mg/L (Buiteman,1995; Teodosiu, 2001).

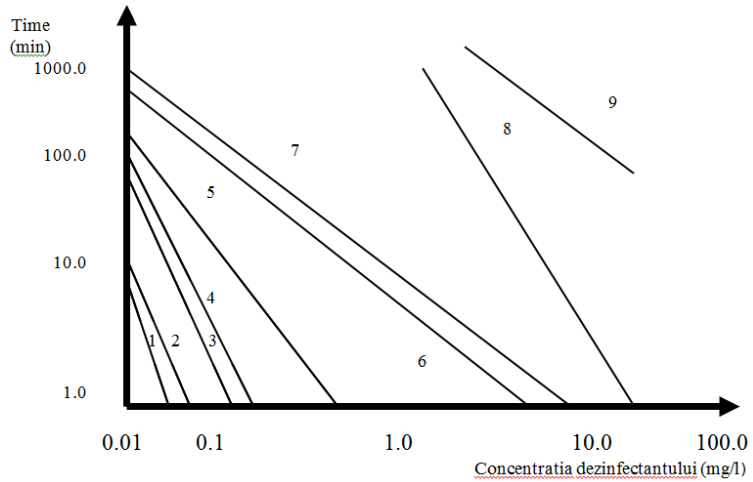


Fig. 1 – Efficiency of disinfecting reagents (Teodosiu, 2001): 1– ozone, 2 – chlorine, 3 – bromine, 4 – chlorine dioxide, 5 – iodine, 6 – ionic silver, 7 – chloramines, 8 – potassium permanganate, 9 – hydrogen peroxide.

Whatever the type of disinfectant agent, for its use the following features are considered: easy generation; concentration strict control and monitoring; broad efficiency spectrum for microbial disinfection; ensuring the necessary residual effect; a minimum corrosion effect on water networks.

Technologies that use chlorine and/or chlorine dioxide foresee their staged injection. The injection takes place in several places: in the preoxidation point with the aim to decrease the loads of organic matter and the number of micro-organisms; in the oxidation intermediate point, after the fast filters, in order to provide an advanced decreasing of microorganisms number, and inside the drinking water storage tank in order to reduce the total microbiological activity (Masschelein, 1992).

Gaseous chlorine is the most commonly known and used disinfectant in water treatment processes. The reaction with chlorine has been modelled by Saunier, (1976), and bears the name „break-point chlorination curve”.

The major disadvantage of gaseous chlorine disinfection are its reaction byproducts: the trihalomethanes (THM). These compounds result from the reaction that takes place when chlorine contacts the organic materials in water (*i.e*. bromine compounds, chlorates, chloroform, bromoform, bromodichloro-methane. These compounds are toxic and alleged carcinogens (Fielding, 1996; Teodosiu, 2001). An alternative to gaseous chlorine disinfection is the chlorine dioxide disinfection which provides superior biocidal features than chlorine without generating THM.

Chlorine dioxide is generated from reactions involving sodium chlorite, water, chlorine or hydrochloric acid, in plants installed at the consumption place (Pitochelli, 1995; Teodosiu, 2001). Literature data, shown in Fig. 3, obtained with the same chlorine and chlorine dioxide concentrations, for the same contact time shows clear the advantages brought by chlorine dioxide disinfection.

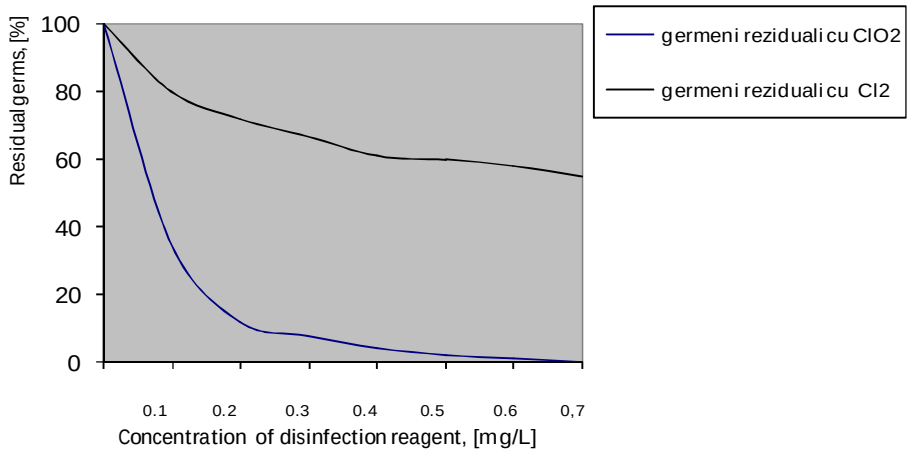


Fig. 3 – Efficency of chlorine dioxide against gaseous chlorine in terms of microbiological destruction capability (Grundfos Alldos, 2009).

The major advantage of using chlorine dioxide disinfection is the lack of generated trihalomethanes (THM), after the reaction with organic matter in water. Moreover, this reagent needs shorter contact times, features a wide range of operating conditions and in general its biocidal capacities are higher than chlorine's ones.

The main applications of this reagent are (Demers & Renner, 1992):

a) final water disinfection before pumping towards distribution network;

b) bacterial control in filters;

c) elimination of odors generated by fermentative phenomena in anaerobic conditions;

d) activated sludge conditioning;

e) elimination of dangerous pollutants: tetraethyl lead, cyanides, sulfides, aromatic phenols;

f) destruction of biofilms inside drinking water pipelines;

g) reduction of iron and manganese in drinking water (Knocke *et al.*, 1993);

h) superior disinfecting power compared to chlorine, especially as regards Cryptosporidium and Giardia (Hofmann *et al*., 1997);

i) biocidal properties not influenced by pH (Demers & Renner, 1992).

The purpose of this paper is to provide a comparative analysis of results obtained with chlorine and chlorine dioxide in water disinfection processes applied to Prut river water.

2. Work Procedure

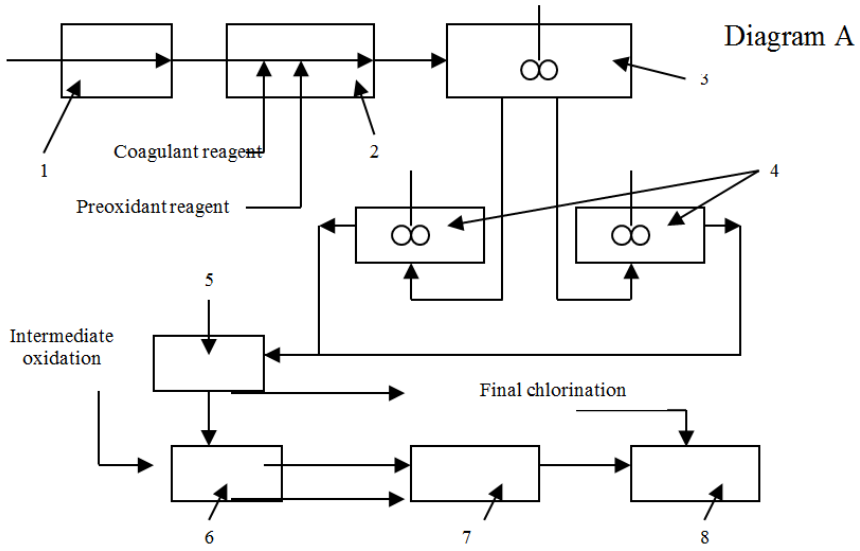
In order to test the efficiency of chlorine and chlorine dioxide during disinfection processes applied to Prut river water, the microbial pathogens loads and the pathogen species have been firstly determined. The procedure, in compliance to standard STAS 6329-1990 consists of seeding a water volume in a culture medium and applying the microbiological techniques for studying, isolating and identifying the existing microorganisms. Results are shown in Table 1, and show that the raw water features a microbiological load of 437.500 organisms/liter.

Table 1
Water Microbiological Load, Raw Prut Water, Disinfection Process Conducted with Chlorine and Chlorine Dioxide

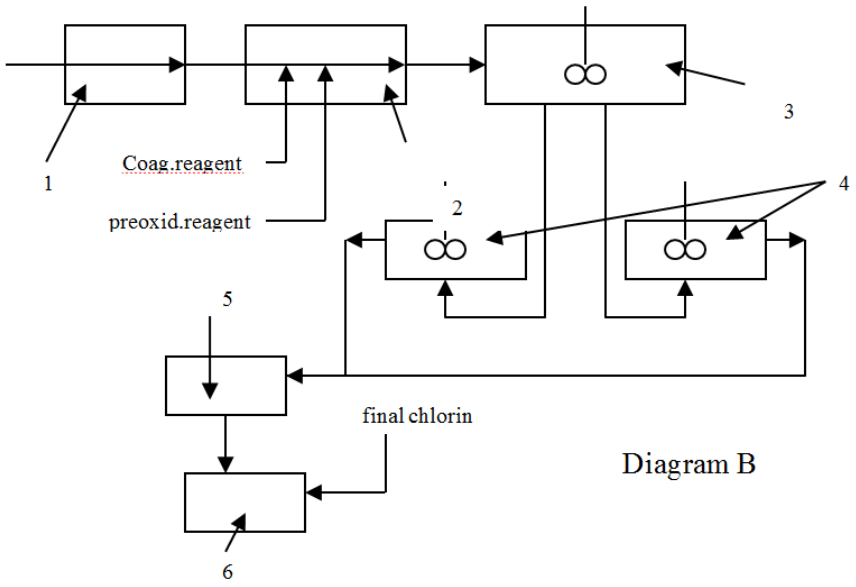
No	Identified taxon		Density organisms/liter
	Group	Species	
1	Bacillariophyta	Amphora ovalis	12,500
2	Bacillariophyta	Cyclotela ocellata	75,000
3	Bacillariophyta	Gomphonema acuminatum	37,500
4	Bacillariophyta	Gomphonema capitanum	87,500
5	Bacillariophyta	Navicula lanceolata	50,000
6	Bacillariophyta	Navicula lanceolata	37,500
7	Bacillariophyta	Nitzschia acicularis	25,000
8	Bacillariophyta	Rhoicosphaenia curvata	62,000
9	Chlorophyta	Monoraphhidium contortum	50,000
Density organisms/liter – total organisms			437,500

The disinfection process has been analyzed according to the used reagents (chlorine and chlorine dioxide) the final goal being the reduction of trihalomethanes and microbiological pollutants. The diagram that shows the disinfectant injection points and the flow route is given in Fig. 2.

Fig. 2 shows the diagrams for Prut river water treatment process, as it follows: Diagram A shows the disinfection process based on chlorine dioxide injected in treatment stages and final gaseous chlorine disinfection while Diagram B is the process that uses gaseous chlorine only in the pre-chlorination stage.



1. Raw water intake chamber, 2. Reagents dosing chamber camera, 3. Reaction Tank, 4.Clarifiers, 5.Sand filter, 6.Filtered water tank; 7. GAC filters, 8. Drinking water tank



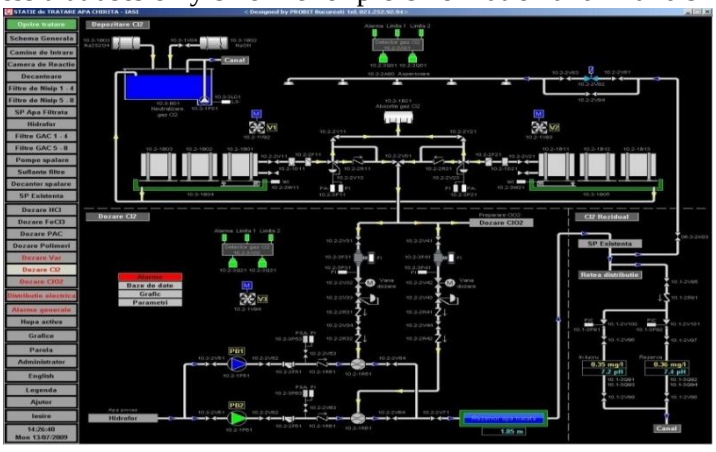
1-intake chamber, 2-reagent dos. chamber, 3 – reaction tank, 4-clarifiers , 5 – sand filters, 6 – filtered water tank.

Fig. 2 – Main process diagram – Chirița Water Plant (Prut River raw water).

The process includes the next items: plant raw water intake (1), reagents injection devices (coagulant, pre-desinfection reagent) (2), reaction tank where the reaction between reagents and raw water takes place (3), suspensional clarifiers (4), quartzy sand filters (5), filtered water tank, fitted with a chlorine dioxide injection device, that provides the intermediary oxidation (6), activated charcoal filters (7), drinking water tank, fitted with a gaseous chlorine injection device (8).

A. Process that uses chlorine dioxide in treatment stages and chlorine in final disinfection

B. Process that uses only chlorine for pre-chlorination and final disinfection

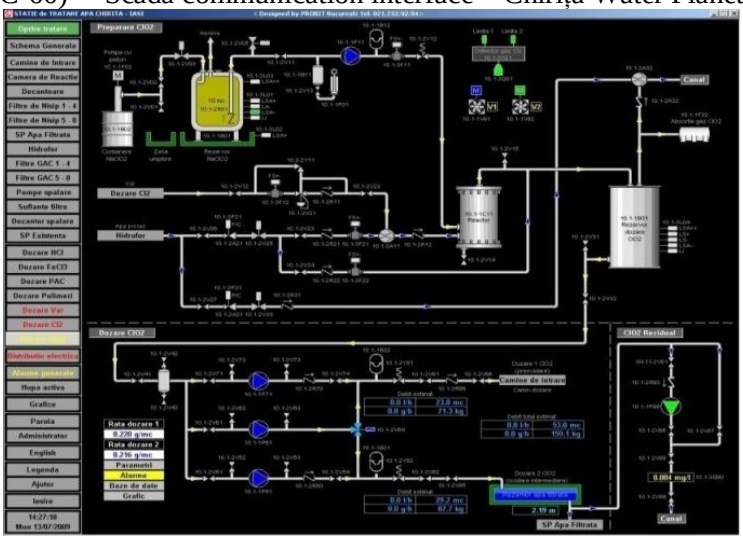


In diagram A it is to be noticed that the reagent (chlorine dioxide) is injected at two points on the treatment stages, that is: in the reagent injection

device (2) and in the filtered water tank (6), after the quartzy sand filters. The injection of gaseous chlorine for final disinfection takes place in the drinking water tank (8). In diagram B it can be seen that only gaseous chlorine is used, the reagent being injected with device (2) and in the drinking water tank (6), case in which a granular activated coal filter is used.

A – Automatic chlorination device – Scada communication interface – Chirița Water Planet

B – Chlorine dioxide producing and dosing device (Alldos Oxiperm C-60) – Scada communication interface – Chirița Water Planet



Determination of trihalomethanes (THM) in water has been performed with a Shimadzu gas chromatograph by means of the "static headspace" procedure. The method is based on the volatility difference, molecular weight, and polarity of analyzed trihalomethanes. The determination of water turbidity in reagent injection points has been conducted with a Hach-Lange portable turbidity-meter.

The method consists in measuring the transparency of the analyzed sample (water) in relation to a formazin based benchmark.

The determination of organic matter in water has been achieved by the KMnO4 oxidative method, according to standard STAS 3002/1985.

The determination of free residual chlorine in drinking water has been performed in laboratory by conducting a methyl orange titration, according to standard STAS 6364/1978.

The determination of residual chlorine dioxide inside the filtered water tank has been achieved by means of an on-line electro-chemical analysis, with ALLDOS Redox cells fitted with an EMIS electrode for ClO_2.

3. Results and Discussion

During the study, the trihalomethanes (THM) have been measured for the disinfection process that uses only gaseous chlorine in the pre-oxidation points and drinking water disinfection inside the storage water tank (and obtaining the values given in Table 2).

Experimental data given in Table 2 show that, when water is treated with gaseous chlorine, apart oxidative reactions and biological degradation of pollutants, certain side reactions also take place. These side reactions will generate trihalomethanes (THMs) which remain in drinking water as legally admitted loads, but which might generate secondary phenomena at users.

There is need to say that the use of chlorine as a disinfectant favors the occurrence of trihalomethanes as a result of reaction of organic substances in water with chlorine. Chlorine dioxide, due to its instability, is to be locally produced in an Oxiperm ALLDOS device, through reactions of sodium chlorite with a mixture of chlorine and water.

Trihalomethanes measurements have been carried out in the pre-oxidation point (2) and in the intermediate oxidation point (6), obtaining the values given in Table 3. Determinations of trihalomethanes have been performed in the disinfection process that uses chlorine dioxide in the pre-oxidation and intermediate oxidation points in the filtered water storage tank, obtaining the values given in Table 3.

Table 2
Trihalomethanes Values (THM) Obtained in a Process of Gaseous Chlorine Disinfection Carried Out in Pre-Oxidation Points and Inside the Drinking Water Storage Tank

Toxicological indicators (THM)	Chirița WTP post pre-chlorin	Chirița WTP drinking water post disinfection	STAS 1342/1991	EC regulations
THM, [µgCl/L]	11	27.08		
Chloroform, [µg/L]	11	27	max 30 µg/L	3...30
Bromodichloromethane, [µg/L]	4.17	11.31	Total THM max 100 µg/L	
Dibromochloromethane, [µg/L]	1.02	3.74		
Bromoform, [µg/L]	0.05	0.20		
Dichloromethane, [µg/L]	0. 05	<0.03		
Tetrachloromethane, [µg/L]	0.3	< 0.05		
1,1 dichloroethane, [µg/L]	< 0.05	< 0.05		
1,2 dichloroethane, [µg/L]	< 0.05	< 0.05		
1,1,1 trichloroethane, [µg/L]	< 0.05	< 0.05		
1,1,2 trichloroethane, [µg/L]	< 0.05	< 0.05		
1,1,2 trichloroethane, [µg/L]	< 0.05	< 0.05		
Trichlorothene, [µg/L]	< 0.05	< 0.05		3 – 30
Tetrachloroethene, [µg/L]	< 0.05	0.08	0.06	1 – 10
Total THM, [µg/L]	27.69	60.35		

Table 3
Trihalomethanes (THM) Values Obtained in a Disinfection a Process that Uses Chlorine Dioxide Injected in Pre-Oxidation and Intermediate Oxidation Points (in the Filtered Water Storage Tank)

No	Toxicological indicators	Achieved values		Law 311/2004	
		preoxidare	interoxidare	Max adm concentr	Used method
1	Chloroform, [µg/L]	absent	absent	–	EN ISO 10301/1997
2	Bromodichloromethane, [µg/L]	absent	absent	–	
3	Chlorodibromomethane, [µg/L]	absent	absent	–	
4	Bromoform, [µg/L]	absent	absent	–	
5	Total trihalomethanes, [µg/L]	absent	absent	0.00	

The analysis of results given in Table 3 did not reveal the presence of trihalomethanes in treatment stages, fact which can be explained considering that chlorine dioxide does not generate trihalomethanes after contact with organic substances in water. Moreover, chlorine dioxide is an excellent

sterilizing agent, the proof being the fact that no microbiological polluters have been detected after testing treated water.

Chlorine dioxide is a more powerful oxidizer than chlorine, fact that results in a decreasing of organic compounds loads by more than 75%. According to obtained data (and presented in Fig. 4), it follows that after the intermediate oxidation stage the organic content is 5 mg/L ($KMnO_4$).

The measurement of trihalomethanes concentrations inside the drinking water tank after gaseous chlorine disinfection (figures shown in Table 4) confirms that in a process when water is treated with chlorine dioxide (during main process) followed by a final treatment with gaseous chlorine the trihalomethanes concentrations are significantly decreased. If in gaseous chlorine treatment processes the total trihalomethanes concentrations are reaching values of the 70...75 μ/L. On treatment with chlorine dioxide and chlorine finally these values drop to 20...22 μ/L, giving a far superior water quality.

The intense reduction in organic content after the chlorine dioxide intermediate oxidation stage finally gives the possibility to obtain a drinking water at high quality. In the last stage, according to law, water is treated with gaseous chlorine in order to ensure the microbiological protection for water transport via mains. The low content in organic substances avoids the generation of highly concentrated trihalomethanes.

Table 4

Trihalomethanes Concentrations Inside Drinking Water Tank after Final Gaseous Chlorine Disinfection

No	Toxicological indicators	Achieved values	Law 311/2004	
			Adm. max. conc.	Used method
1	Chloroform, [μg/L]	3.531	–	EN ISO 10301/1997
2	Bromodichloromethane, [μg/L]	6.621	–	
3	Chlorodibromomethane, [μg/L]	8.326	–	
4	Bromoform, [μg/L]	2.657	–	
5	Total trihalomethanes, [μg/L]	21.135	100	

Other tests referred to the determination of organic matter concentrations in Prut River raw water and in the drinking water storage tank in order to monitor its decreasing rate after the chlorine dioxide intermediate oxidation process. The next variation graphs have been obtained (Fig. 4).

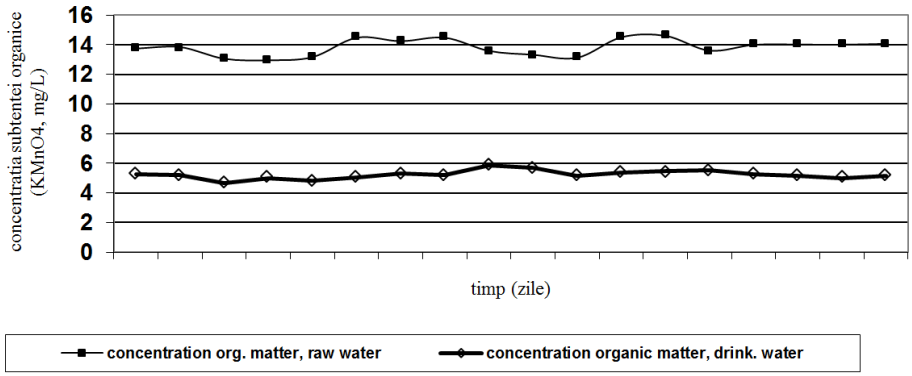


Fig. 4

The results of the comparative study for the efficiency of the two disinfection reagents, the chlorine and the chlorine dioxide, came up with the following conclusions:

a) gaseous chlorine reacts with organic substances in water and generates trihalomethanes, considered dangerous to human health;

b) as to achieve a proper disinfection there is need to reach the operating conditions that are specific for this reagent, according to Table 2;

c) contact time between chlorine and water is high (minimum 30 minutes);

d) chlorine dioxide has superior oxidative properties compared to gaseous chlorine The main advantage of this reagent is that it does not generate trihalomethanes;

e) if chlorine dioxide is used in treatment stages, the chlorine dose that is finally injected inside the drinking water tank needs to be much smaller than the dose for a process that uses only gaseous chlorine disinfection;

f) at the same disinfectant doses, the chlorine dioxide efficiency is superior;

g) chlorine dioxide: its use as pre-oxidant agent improves the settling process;

h) chlorine dioxide: Greatly reduces the organic substance loads in water;

i) chlorine dioxide: is able to remove odors caused by decaying algae due to eutrophication process in summertime;

j) chlorine dioxide: necessary contact time with water is much lower (maximum 15 min.);

k) chlorine dioxide: is less corrosive than chlorine;

l) chlorine dioxide: its biocidal properties are not influenced by temperature and pH;

m) chlorine dioxide: Is able to reduce the iron and manganese in water.

The studies that have been conducted on the two disinfection reagents, *i.e.* chlorine and chlorine dioxide, finally recommend he use of the last one in the treatment processes that are to be applied to the Prut River raw waters.

Inadequate working conditions for the personnel that operates the old chlorination facility incldes the next issues:

1. Due to unproper conditions in chlorination facilities, the personnel was subjected to high poisoning risks with gaseous chlorine (chlorination plant was outclassed, morally and technically, had improvised chlorine pipelines, rudimentary anti-chemical protection systems).

2. Lack of protective and safety devices for personnel and environment (no chlorine leaks electronic detection devices and no automatic systems for chlorine leaks neutralization).

3. Improvisations in the chlorination facility were made out of unproper materials fact that was daily exposing the personnel to serious risks of chemical contamination.

4. Due to unproper materials failures in the facility were frequently occuring. In such situations the operating personnel was not using their personal protective as intervention time had to be reduced to the maximum so as not to contaminate the workplace and the environment (especially in order to avoid plant damage due to frost effects generated by the contact of water with liquid chlorine).

5. Chlorine leaks were detected by means of rudimentary methods (the ammonia impregnated stick, technique with a high error rate).

6. The respiratory ways protection masks (with chlorine filtering cartridges) were nor providing sufficient protection and were very uncomfortable in use.

7. Lack of leak detection equipment.

8. Lack of work equipment decontamination systems.

9. Lack of personnel decontamination systems (emergency showers).

10. Lack of intervention and survival equipment in case of chemical incidents.

11. Lack of ventilation systems able to remove pollutants from the atmosphere and ale to maintain a proper work environment.

12. Inadequate lighting systems in the chlorination room.

13. Improperly sized neutralization pit and total lack of neutralizing reagents.

14. Lack of specialized lifting equipment for the chlorine drums, lack of chlorine drums unloading and loading platforms and lack of load limiters for the electric winches.

Harmful effects of gaseous chlorine on personnel's health and work environment:

1. Chlorine gas is harmful to human health at doses that exceed 6 ppm (risk of lung oedema and even death). The company considered this and hence

came up the need to modernize the facility as to protect the personnel and the environment (the neighborhood nearby the chlorination facility).

2. Gaseous chlorine density is greater than air density and therefore it accumulates near the ground surface. Hence, chlorine burns and kills all plants and animals caught in the chlorine cloud.

3. Gaseous chlorine, in contact with water generates hydrochloric acid, that is particularly aggressive (highly corrosive for all metallic structures inside chlorination building).

Following Romania's adhesion to the EU, the water company has adopted minimum health and safety regulations by retrofitting the facilities and by implementing new chlorination technologies. All implemented new processes are now fully compliant to EU rules and Romanian legislation related to health and safety.

The benefits brought by upgradings got reflected on the work environment and on the personnel's safety.

The adopted process equipment (ALLDOS) provides a fully computerized control of chlorine dosing in water and also work environment quality has been increased by means dedicated sensors.

The improved working conditions after facilities upgradings had beneficial effects on the personnel's hygiene and on work environment:

1. The total elimination of risks related to poisoning with gaseous chlorine due to specific modern materials used (high density polyethylene, Teflon, stainless steel components, plexiglas).

2. Implementation of a fully computerized control of chlorination equipment.

3. The chlorination equipments (generatio/dosing/chlorination) have been fitted with backup lines.

4. The chlorination facility has been fitted with various safety systems (inductive contactors, chlorine presence sensors, ultrasonic level detectors (that keep a constant chlorine level inside the reaction tanks, and fully avoiding any chlorine and chlorine dioxide contamination).

5. Activated Carbon Filters for full retention of chlorine dioxide and chlorine gas.

6. Grid automatic disconnection devices (they trip when major system malfunctions are detected).

7. New sprinkler systems able to reduce overall chlorine emissions inside work environment.

8. New automatic ventilation systems (with ground suction) for fast decontamination of work environment.

9. Ground installed electrochemical sensors for fast chlorine detection and control of neutralization systems against chlorine leaks inside work environment (devices include a microprocessor and an analyzing chip analysis, at costs of 500 Euro)

10. New chlorine drums neutralization pit, appropriately sized, fitted with specific neutralizing reagents (sodium thiosulfate, sodium hydroxide, calcium hydroxide, lime milk).

11. For quick personnel and protective gear decontamination the chlorination facility has been station equipped with an automatic emergency shower and, aslo with a special eye washing rescue shower.

12. Personnel has been fitted with survival gears (autonomous breathing systems, efficient against both chemical and nuclear contaminations).

13. Workplaces have been fitted with adequate lighting systems.

14. There is now the possibility to strictly control the daily amount of used chlorine by means of new drum weighing scales (that send a hydraulic signal towards display screens).

15. New lifting equipment has been installed (fitted with adequate drum lifting fixtures and load limiters).

Comparative images: the old and the new facility

a) The error risk.

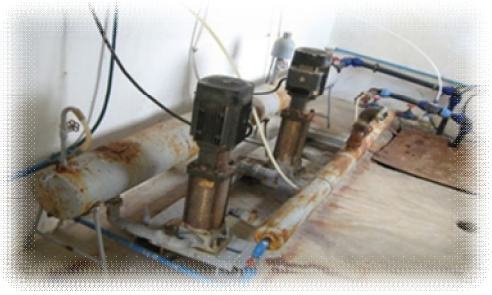
High in old facility

Decreased in new facility

b) The bulding and the installations.

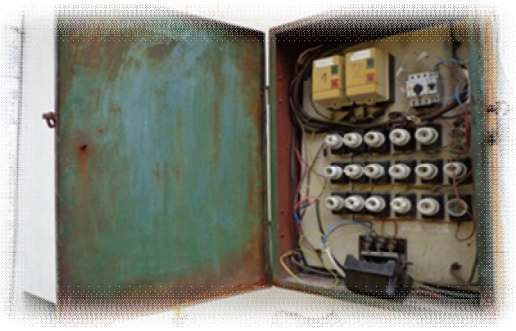
Plasterings damaged by reagents

Plasterings made out of modern resiliant materials



Improvised chlorine dosing devices (risk of chlorine poisoning)

Modern chlorine dosing plants



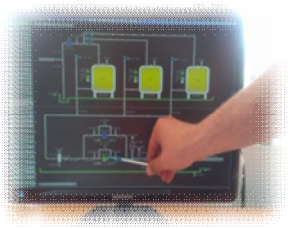
Electric panel, chlorine corroded, high risk of electric shocks

Modern electric panel

c) Chlorine leaks detection.

Rudimentary leak detection





New leak detection devices: Acustic and visual sensors – Scada systems

d) Neutralizing of chlorine leaks.

Water curtain made by worker
(old facility)

Automatic sprinklers in
new facility

e) Individual protective gear.

Unadequate gear

Modern chemical survival gear
(self-contained breathing system)

f) Protective gear drills/trainings.

No drills!

Periodic trainings/drills

g) Rescue eye washing emergency shower.

No eye shower in old facility

Special eye washing device in new facility

h) Emergency shower.

No emergency shower
in old facility

Modern emergency shower in
new facilty

REFERENCES

Buiteman J.P., *Water Treatment Methodes and Process*. IHE lectures notes, Delft The Netherlands, 1995.

Demers L.D., Renner R., *Alternative Disinfectant Technologies for Small Drinking Water Systems*. AWWARF, Denver CO, 1992.

Fielding M., *La desinfection,ses soaus – produits et leur controles*. Techn. Sci. Methodes Genie Urbain Genie Rural, *7-8*, 524-529 (1996).

Gallagher D.L., Hoehn R.C., Dietrich A.M., *Sources, Occurrence and Control of Chlorine Dioxide By-Product Residuals in Drinking Water*. AWWARF, Denver CO, 1994.

Hofman R., Andrews R.C.,Ye Q., *Chlorite Formation when Desinfecting Drinking Water to Giardia Inactivation Requirements Using Chlorine Dioxide*. Conf. Proc., ASCE/CSCE, Edmonton, Alberta, 1997.

Knocke W.R., Iatrou A., *Chlorite Ion Reduction by Ferrous Ion Addition*. AWWARF, Denver CO, 1993.

Massschlein W.J., *Unit Process in Drinking Water Treatment*. Marcel Decker D.C. New York, Brussels, Hong Kong, 1992.

Noss C.I., Dennis W.H., Olivieri V.P., *Reactivity of Chlorine Dioxide with Nucleic Acids and Proteins*. Water Chlorination: Environmental Impact and Health Effects Jolley R.L. et al., (editors) Lewis Publishers, Clesea, MI, 1983.

Pitochelli A., *Chlorine Dioxide Generation Chemistry Conference Proceedings.* Third Internat. Symp., *Chlorine Dioxide: Drinking Water, Process Water, and Wastewater Isues.* New Orleans, LA, 1995.

Roberts P.V., Aieta E.M., Berg J.D., Chow B.M., *Chlorine Dioxide for Wasterwater Disinfection: A Feasibility Evaluation.* Stanford Univ. Techn. Rep., October, 251- 257, 1980.

Sommer R., Cabaj A., *Evaluation of the Efficiency of UV Plant for Drinking Water Disinfection.* Water Sci. Techn., *27*, 357- 362 (1993).

Teodosiu C., *Water Disinfection, Industrial and Drinking Water Technology* (in Romanian). Matrix Rom Press, Bucharest, Romania, 168-171, 2001.

TEHNOLOGII MODERNE ÎN PROCESUL DE DEZINFECŢIE A APEI DIN CADRUL COMPLEXULUI CHIRIŢA S.C. APAVITAL S.A.

(Rezumat)

Multe zone de pe Pamânt se confruntă cu lipsa apei potabile în timp ce planeta este acoperită cu apă în proporţie de 2/3.

Majoritatea acestei ape este, binenţeles, apa de mare care este prea salină pentru a putea fi consumată de către oameni sau animale, şi din puţina apă "proaspată" care rămâne majoritatea, este prinsă în calotele glaciare.

În concluzie ne rămâne foarte puţină apă dulce la dispoziţie şi pe deasupra, aceste rezerve se confruntă cu creşterea galopantă a populaţiei

globului şi cu creşterea necesităților de apă ale omului modern în paralel cu creşterea cantității de apă uzată.

Marile aglomerări urbane din țările în curs de dezvoltare care nu dețin unități de tratare a apelor reziduale s-au confruntat adeseori cu epidemii generate de microorganisme care se transmit prin intermediul apei. În aceste zone apele reziduale sau menajere contaminează adesea cursurile de apă folosite în aval de către alți oameni pentru băut, gătit şi spălat. În alte cazuri (România) industrializarea forțată şi nerațională a dus la contaminarea apelor prin deversarea necontrolată a deşeurilor chimice şi chiar nucleare.

Este cunoscut faptul că apa este un mediul facil de transmitere a bolilor virale, pentru indepărtarea agenților patogeni au fost create şi dezvlotate tehnologii avansate de dezinfecție atât chimice cât în special fizice. Dintre cele mai utilizate procedee de dezinfecție amintim: clorarea, ultrafiltrarea , iradierea cu radiații de mare energie, ozonarea, câmpul ultrasonic.

Clorul, reactivul cel mai utilizat în procesele de dezinfecție a apelor potabile, generează din nefericire cu substanțele organice din apă, trihalometani, incriminați de efect cancerigen. Din aceste considerente, se tinde la înlocuirea clorului cu reactivi cu proprietăți dezinfectante superioare ce nu generează substanțe toxice.

Un astfel de reactiv este dioxidul de clor. Studiul comparativ al efectelor obținute la tratarea apei de Prut cu clor şi dioxid de clor, evidențiază faptul că dioxidul de clor conduce la rezultate superioare în procesele oxidative şi biocide şi oferă o apă cu cu calități superioare.

Procesul de dezinfecție are la bază, fie procese de oxido-reducere, ca efect al utilizării unor substanțe oxidante foarte puternice, forme de energie cu putere mare de penetrație, fie procese de separație prin filtrare, asociată cu procese biologice, adică procese de membrană la filtrele lente cu nisip.

În procesul de dezinfecție al apei intervin mai mulți parametri fundamentali cum ar fi:

a) cantitatea de dezinfectant care este eficientă sub forma active;

b) timpul de contact între dezinfectant şi apa de dezinfectat;

c) eficiența proprie a dezinfectantului;

d) usceptibilitatea microorganismului la distrugere sau inactivare;

e) factorii fizico-chimici ai apei de dezinfectat, adică pH-ul, temperatura, mediul ionic.

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THE EXPERIMENTAL DETERMINATION OF THE FRICTION STRESS BETWEEN THE SEMI-PRODUCT AND THE ACTIVE PLATE AT THE MULTIAXIAL FORGING OF ALUMINUM, Al_99.5

BY

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Abstract: The paper aims the determination of the friction force by means of external friction stress, at the severe plastic deformation processing using the cylindrical pressing method in a close die. It is known that the total force used at the severe plastic deformation by the method of multiaxial forging is being composed by the deformation force itself and the friction force between the semi-product and the deformation tools. Once the friction stresses known, for a certain material, one can determine the friction force corresponding for a given deformation of a semi-product of a particular shape and sizes. By means of the flowing curve of the semi-product material one can determine the deformation force, which together with the friction force give the total necessary force for a deformation and so one can choose the necessary equipment for the processing of the material by severe plastic deformation. For this purpose it has been severely plastic deformed by the method of multiaxial forging, a semi-product having the sizes 10 × 10 × 20 mm, the finished part having the same sizes and shape. It has been measured the deformation force and the extraction force of the finished part from the cavity of the active plate, the late being used for the determination of the friction stress between the semi-product and the active plate.

Keywords: severe plastic deformation; multiaxial forging; friction force; friction stresses.

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1. Introduction

Severe plastic deformation (SPD) is a generic term to describe a group of techniques of materials processing implying very large stresses, without including significant changes of the total sizes of the model or of the part to be processed by Valiev *et al*., (2000) and Rosochowski *et al*., (2004).

The most used procedures for severe plastic deformation are: equal channel angular pressing (ECAP), high pressure torsion (HPT), accumulative roll bonding (ARB), cyclic extrusion compression (CEC), cyclic closed-die forging (CCDF), repetitive corrugated and straightening (RCS) and severe torsion straining (STS) (Comăneci *et al*., 2006).

For obtaining the experimental results, in the paper we have used the cyclic closed-die forging method.

The main objective of the severe plastic processing was to obtain parts and components with higher mechanical resistance properties with low sizes and low specific weight, without damaging in any way the environment conditions.

The deformation in volume of materials, for obtaining severe plastic deformation, uses frequently the multiple axial compression test, given its simplicity and the favorable stress state in the deformation zone. The metallic material is being deformed by compression, successively, in vertical and horizontal plan.

At the multiaxial forging, a semi-product is firstly forged in a vertical position and then in a horizontal direction (Zherebtsov *et al*., 2004; Kuziak *et al*., 2005).

Aluminum and its alloys multiaxialy forged have a wide range of utilities because the high mechanical characteristics obtained and its reduced density. It is known that pure aluminum has a good deformability both for cold and hot procedures.

2. Experimental Conditions

The material used is aluminum 99.5% purity, having the chemical composition shown in Table 1, composition determined at the The "Politehnica" University from Bucharest in the Laboratory of chemical spectral and biocompatibility analysis, from the Faculty of Materials Science and Engineering.

The semi-product. There have been used parallelepiped shaped semi-products with square basis a = 10 mm and height h = 20 mm, so with a dimensional factor $h_0/d_0 = 2$.

Preparation of semi-product includes turning and grinding.

Equipment and apparatus. For deformation it has been used the Romanian hydraulic press Hydramold of 750 kN.

Table 1
Chemical Composition of Aluminum, Al_99.5

Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ni	Ti
Percent	0.143	0.213	0.021	0.004	0.050	0.003	0.021	0.008	0.006

Element	Pb	Sn	B	Ca	Co	V	Na	P	Al
Percent	0.005	0.011	0.000	0.003	0.002	0.011	0.004	0.000	99.495

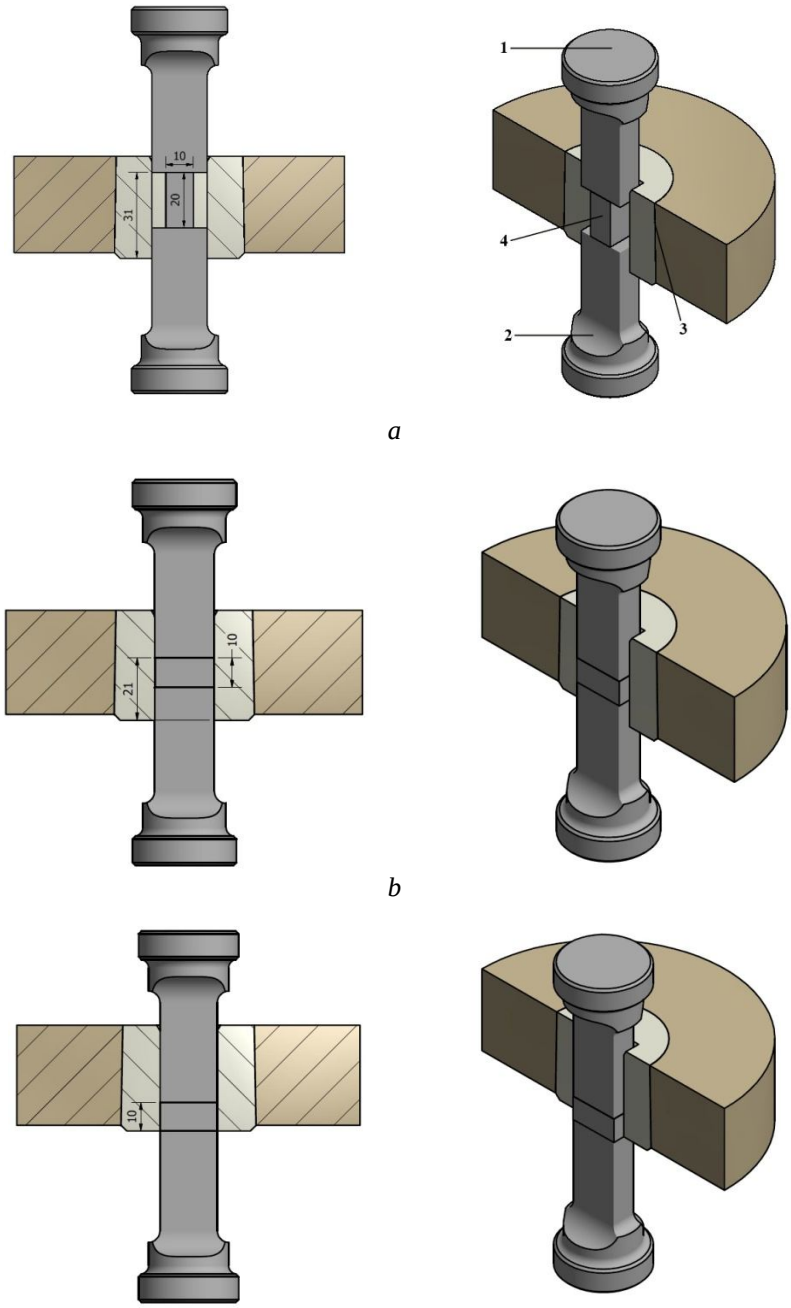
In view of determination of the extraction force there have been used a data acquisition system made by a full equipped master unit, force transducer of 1000kN and displacement transducer with a travel of 0…100 mm.

The master unit is a System Traveler 1, model MUT-1 type 1016-S (Fig. 1), having the following elements: 8 tensometric amplification channels type SG-2 with 1 kHz bandwidth; 4 channels for optoisolated digital inputs with possibilities of external clock and trigger; 8 channels for direct high signal analogical input; max sampling frequency 100,000 Hz; software package E.S.A.M (Electronic Signal Acquisition Module) for Windows.

Fig. 1 – General view of the deformation installation: 1 – hydraulic unit; 2 – displacement transducer; 3 – load cell; 4 – deformation–extraction device; 5 – hydraulic press; 6 – notebook; 7 – Traveler 1 system.

3. Experimental Results

For achieving the multiaxial forging we have used the deformation-extraction device, shown in Fig. 2 *a*. The device is made from an active plate



a

b

c

Fig. 2 – Schematic presentation of the deformation-extraction device: 1 – punch; 2 – counterpunch; 3 – active plate; 4 – semi-product in the initial stage; 5 – deformed semi-product; 6 – semi-product during the extraction stage.

having the external sizes ∅140 × 120 mm, a punch and a counter punch having the same sizes and shapes.

The semi-product is being introduced in the center of the die over the counter punch in a vertical position. The punch is being placed on the semi-product as shown in Fig. 2 *a*, and then the deformation is being made.

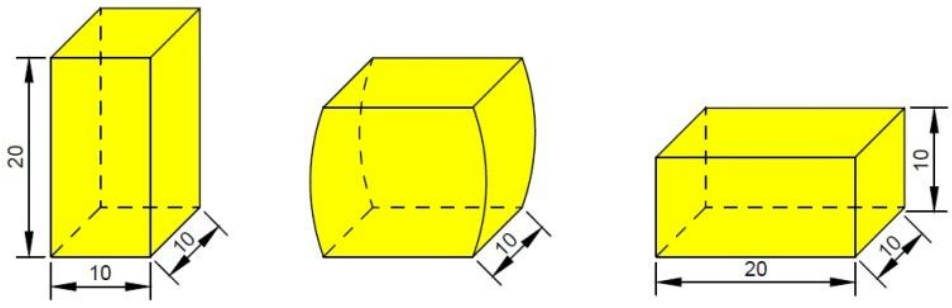
The punch moves on the vertical direction in the interior of the active plate cavity. The punch travel has 10 mm and is imposed by an especially designed check piece. Fig. 2 *b* shows the semi-product after deformation.

After the process, the extraction of the deformed part follows. Fig. 2 *c* shows the semi-product during the extraction process.

After being extracted from the die, the part is being rotated with 90° in the vertical plan and after that with 90° in the horizontal plan and then is being reintroduced in the die for a new severe deformation.

The cycle repeats until the nanometric structure of the material is being obtained.

In Fig. 3 there are shown the phases of multiaxial forging at a passage of the semi-product used in the experiment.



a *b* *c*

Fig. 3 – Stages of multiaxial forging at a single passage: *a* – semi-product; *b* – semi-product deformation; *c* – deformed part.

Together with the deformation of the semi-product it takes place the measurement of the total deformation force using the acquisition system shown in Fig. 1.

The E.S.A.M. software generates the variation of the deformation force versus the travel of the punch, variation shown in Fig. 4.

After deformation the extraction of the part from the die is being made in the same device and the variation of the extraction force is being taken on a length of 11 mm.

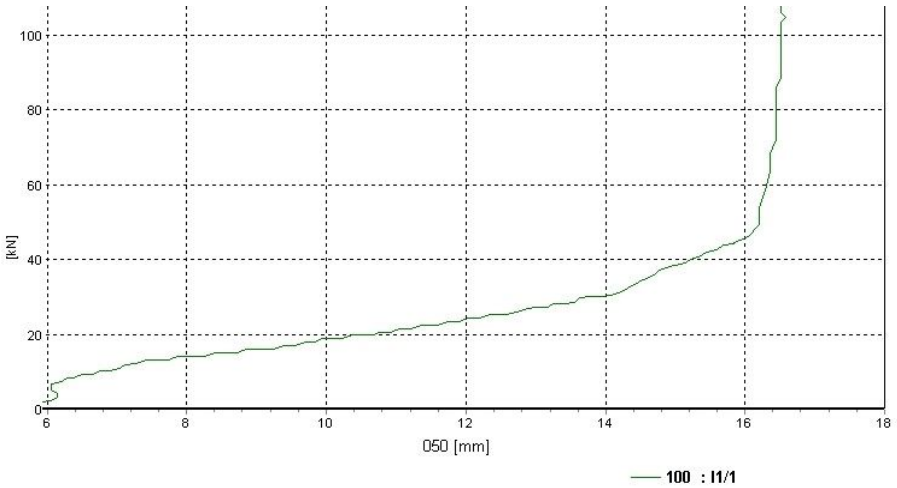


Fig. 4 – Deformation force variation versus the punch travel.

The variation curve of the extraction force is shown in Fig. 5.

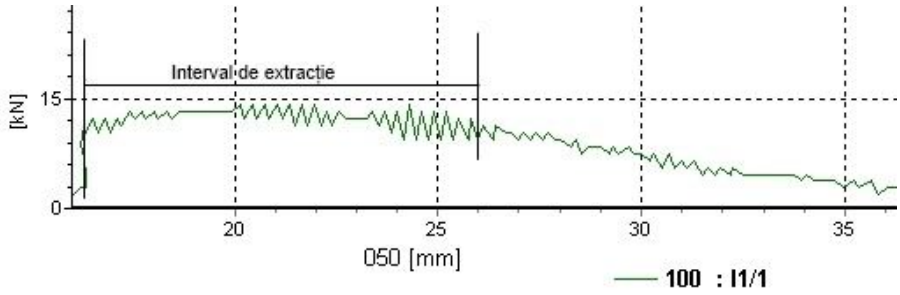


Fig. 5 – Variation of the extraction force.

The external surface of the part remains constant and depends on its sizes. The variation of the friction stress on the extraction travel is shown in Table 2, where: D is the displacement during extraction, [mm]; F – extraction force taken from Fig. 5, [kN]; S – friction surface between the part and the active plate, [mm^2]; σ_f, in [kN/mm^2] or [MPa], represents the friction stress determined with the relation $\sigma_f = F/S$.

On the basis of the values for the friction stress σ_f, [MPa], obtained at various values of the extraction travel, the average friction stress is being determined $\overline{\sigma}_f$.

Table 2
Variation of the Friction Stress on the Extraction Travel

Crt. no.	D mm	F kN	S mm^2	σ_f kN/mm^2	σ_f MPa
1	0	11.41	600	0.0190	19.02
2	1	13.15	600	0.0219	21.92
3	2	12.25	600	0.0204	20.42
4	3	13.15	600	0.0219	21.92
5	4	12.25	600	0.0204	20.42
6	5	11.29	600	0.0188	18.82
7	6	13.15	600	0.0219	21.92
8	7	11.29	600	0.0188	18.82
9	8	13.15	600	0.0219	21.92
10	9	12.25	600	0.0204	20.42
11	10	10.32	600	0.0172	17.20
12	11	10.32	600	0.0172	17.20
Average friction stress, $\overline{\sigma}_f$					20.00

From Table 2 one can see that in the case of severe plastic deformation of aluminum having the composition given in Table 1 an average friction stress of $\overline{\sigma}_f$ = 20 MPa is obtained.

4. Conclusions

The total force of severe plastic deformation by the method of multiaxial forging is composed by the deformation force and by the friction force between the blank and the deformation tools. By determining the friction stress for a certain material one can determine the friction force corresponding for a deformation of a semi-product of given sizes and shape. On the other hand, by means of the curve of material flowing one can determine the actual deformation force which together with the friction force give the total neccessary force for a deformation and so one can choose the necessary equipment for severe plastic deformation of the material.

For the severe plastic deformation of aluminum Al_99.5, the average external friction stress has the value $\overline{\sigma}_f$ = 20 MPa.

REFERENCES

Comăneci R., Chelariu R., Zaharia L., *Obtaining Nanostructured Materials by Severe Plastic Deformation.* 2006.

Kuziak R.M., Zalecki W., Pietrzyk M., Weglarczyk S., *New Possibilities of Achieving Ultra-fine Grained Microstructure in Metals and Alloys Employing MaxStrain Technology*. Bulk and Graded Nanometals, *101-102*, 43-48 (2005).

Rosochowski A., Olejnik L., Richert M., *Metal Forming Technology for Producing Bulk Nanostructured Metals.* Steel Grips, *2*, 35-44 (2004).

Valiev R.Z., Islamgaliev R.K., Alexandrov I.V., *Bulk Nanostructured Materials from Severe Plastic Deformation*. Progress in Mater. Sci., **45**, *2*, 103-189 (2000).

Zherebtsov S.V., Salishchev G.A., Galeyev R.M., Valiakhmetov O.R., Semiatin S.L., *Formation of Submicroncrystalline Structure under Warm Severe Plastic Deformation in Ti–6Al–V Large-Scale Billets*. Proc. of the Conf. ‘‘Nanomaterials by Severe Plastic Deformation’’, 835-840, 2004.

DETERMINAREA EXPERIMENTALĂ A TENSIUNII DE FRECARE DINTRE SEMIFABRICAT ŞI PLACA ACTIVĂ LA FORJAREA MULTIAXIALĂ A ALUMINIULUI, Al_99.5

(Rezumat)

Se urmăreşte determinarea forţei de frecare, prin intermediul tensiunilor de frecare externă, la prelucrarea prin deformare plastică severă utilizând metoda presării ciclice în matriţă închisă. Se ştie faptul că forţa totală de deformare plastică severă prin metoda forjării multiaxiale este compusă din forţa de deformare propriu-zisă şi din forţa de frecare dintre semifabricat şi sculele de deformare. Odată cunoscute tensiunile de frecare pentru un anumit material se poate determina forţa de frecare corespunzătoare unei deformări pentru un semifabricat de configuraţie şi dimensiuni date. Prin intermediul curbei de curgere a materialului semifabricatului se poate determina forţa de deformare propriu-zisă, care împreună cu forţa de frecare dau forţa totală necesară unei deformări şi astfel se poate alege utilajul necesar procesării materialului prin deformare plastică severă. În acest scop s-a deformat plastic sever, prin metoda forjării multiaxiale, un semifabricat cu dimensiunile 10 × 10 × 20 mm, piesa finită având aceeali configuraţie şi dimensiuni. S-a măsurat forţa de deformare şi forţa de extracţie a piesei finite din cavitatea plăcii active, aceasta din urmă fiind utilizată în determinarea tensiunii de frecare dintre semifabricat şi placa activă.

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WORKERS' EXPOSURE TO SOLAR RADIATIONS

BY

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ITM Vaslui

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Abstract: In certain periods the values of solar radiation values exceed the maximum allowed limit, so it is important for employers and employees to take measures in order to limit the exposure. On the short term, the consequences are not seen, but on the long term, the powerful impact of solar radiations on human body can be fatal.

Keywords: solar radiation; risk assessment; effects of solar radiation; sunlight exposure prevention measures; exposed workers.

1. Introduction

The sun burns increasingly worse, the heat wave raises temperature especially in the urban agglomerations and the solar radiation bombard us without noticing. The ultraviolet radiation (UV) is a component of the electromagnetic radiation spectrum emitted by the sun.

Experts say that, in mid-summer, already, the UV radiation exceeds in Romania the permissible level.

The reasons for this phenomenon are the climate change, the thinning of the ozone layer, pollution and deforestation. At the seaside, the ultraviolet radiation level doubles as both the sand and the water strongly reflect the sunlight. Also in the mountains, in the areas which are not covered by forests, the danger is present, as the ultraviolet radiation index (UV) reaches extreme values.

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The ultraviolet radiations are radiations with small and very small wavelength, produced by the sun and they have huge energy power. They are invisible, and in the absence of the ozone layer they can reach the earth's surface. When they exceed the limit values, they can destroy all life forms.

In Romania, the ultraviolet (UV) radiation index reaches values from 1 to 11, the most dangerous level being 11. From this value on, vegetation dries and people are beginning to face serious health problems. The UV index is an international assessment of the ultraviolet radiation level at the Earth's surface. It is calculated to help population (workers) to protect from the UV radiation, with a device called actinometer. The calculation is based on the position of the sun and on the degree of sky coverage with clouds. At noon when the sun shines, ultraviolet radiations are also more powerful and the clouds do not always protect us from radiations. The thin, translucent clouds enhance radiation values and in order to consider ourselves somewhat protected, the sky should be covered with a thick blanket of clouds.

Experts say that between 11.00 and 16.00 summer hour when UV index exceeds 6 it is recorded the highest risk. Ultraviolet rays pass through water and even penetrate through windows of cars or of buildings, if they are not provided with protective filter.

2. Effects of Workers' Exposure to Solar Radiation

On short-term exposure to the sun can lead to sunburns and eye injury. The burn is a painful skin lesion skin due to sun exposure, if we do not use a sunscreen product. The years of overexposure to sunlight can lead to premature wrinkling, aging of the skin, age spots, as well as an increased risk of skin cancer. In addition compared to skin, eyes can be affected by exposure to sun, becoming red and painful. Chronic exposure of the eyes to sunlight can cause cataract, tissue growth that leads to blindness. Unlike a thermal burn, sunburn is not immediately obvious. Symptoms usually begin about 4 hours after sun exposure and worsen in 24...36 h. Effects of sunburn include redness of the skin, blistering, swelling, and later peeling. Symptoms showing that your eyes were exposed to UV radiation include painful sensation in the eyes, excessive blinking and tears, sensation of foreign body in eyes, difficulty looking at bright lights, and eye swelling. Even in cloudy days, the UV radiation level may be sufficient to be harmful. People with fair skin, having freckles are exposed to a higher risk than those with darker skin. Outdoor workers may have a 60% higher risk of developing skin cancer than people who work indoors.

1. *Acute Effects*.

a) sunburn

b) skin photosensitizing

c) photo-conjunctivitis

d) photo-keratitis

2. *Chronic effects*.
a) Premature aging of the skin
b) damage to the retina
c) cataract
d) Skin Cancer

3. Evaluation of Exposure to Solar Radiations

3.1. Workers Likely to be Exposed to Solar Radiations

Farmers and builders are the most exposed to UV radiation and the age group most affected is more than 50 years. Studies show that childhood sunburn caused before the age of 35 years increases the risk of cancer by 75%.

Occupational groups exposed to ultraviolet radiations:
a) farmers;
b) construction workers;
c) forestry and logging workers;
d) lifeguards;
e) fishermen;
f) athletes.

3.2. Factors Influencing Exposure to Ultraviolet Radiations

Factors influencing exposure to ultraviolet radiation are:

a) exposure period: summer between 11:00...16:00;

b) reflective surfaces like water, snow, metal, or any photosensitizing substances;

c) contact with plants or chemicals that have the potential to increase the absorption of UV;

d) how often the tasks are performed outdoors.

4. Obligations of Employers and Employees on Reducing Exposure to Solar Radiations

Health and safety regulations at work force employers to identify hazards faced by their employees and in case it is determined that a hazard is significant, to apply the hierarchy of actions–elimination, isolation and minimization, so as to ensure that significant risk does not generate negative effects on employees. If the hazard cannot be eliminated or isolated, and the danger minimized, the employer is obliged to provide protective equipment and monitor the exposure. Employers must also ensure that employees are provided with information on identified risks and measures to be taken to reduce the probability for the hazard to cause harm.

Employers have to provide employees with safe and healthy workplace. Employers have a clear responsibility to minimize the risk faced by those who are forced to work outdoors, but workers also have individual responsibilities to take care of their own health. Exposure to UV radiation takes place not only during working hours. Employer must take measures to protect workers by: providing shade, protective clothing, sunscreen substances, exposure monitoring, and regular medical examination.

Workers should report immediately to the managers any symptoms due to sunlight exposure.

5. Measures to Reduce Exposure to Solar Radiations

5.1. Activity and Job Organization

Employers must ensure that the risk posed by exposure to UV radiation is minimized. In some cases, this may be achieved by measures such as simply changing the period for taking an outdoor work tasks outside the period 11:00...16:00. Also to reduce exposure to solar radiation employer has to ensure, if the work can be done under shelters or movable shading structures or the daily movement of the shadow around the yard will be monitored. Values reached by ultraviolet radiation should be posted daily in public places and presented in media weather reports. It is important that workers and employers are warned when the index exceeds 6 and thus to be taken appropriate measures.

During breaks the workers will stay in the shade, especially at mealtimes.

5.2. Offering Personal Protective Equipment

Personal protective equipment should protect workers against solar radiations, should not cause discomfort, considering the ergonomic requirements and state of health , should fit the wearer correctly after all the necessary adjustments.

1. Protective clothing.

Factors that influence choosing of protective clothing:

a) tightness;

b) permeability of the material to ensure the elimination of perspiration;

c) design;

d) to be made of materials that ensure workers' comfort and to be cool;

e) to be provided with a collar to ensure some protection to the neck.

2. Protective hat.

Hats should protect the scalp, ears and forehead and partly the face, they also should be provided with flaps to protect the neck and ears.

3. Goggles (sun).

Sunglasses should leave to pass less than 5% of UV radiations and to ensure adequate protection from the sun.

Sunglasses should be worn by employees working outdoors between 11:00 and 16:00.

6. Sunscreen Products

Sunscreen products should provide additional protection for the skin. It is required the use of products with a minimum sun protection factor (STF) of 15.

Practically, this means that if a person uses a sunscreen SPF of 15, the person can remain in the sun 15 times longer than a person not using protective product.

If the work involves working with water, it is necessary to use a waterproof sunscreen.

Before sun exposure it is necessary to apply sunscreen at least 15 minutes before the activity and in accordance with manufacturer's instructions. Sunscreen products should be applied to all exposed skin, including: ears, scalp, face, neck and hands.

The performance of the sunscreen product is affected by wind, humidity, sweat, and proper applying. Sunscreen products should be re-applied every 2 hours while this may need to be done more frequently if sweating is profuse.

7. Teaching and Training

Workers will be informed about the risks they are exposed during any outdoor activities, what can be consequences of sun exposure and what are the protective measures that should be applied both at work and leisure.

8. Supervising Health Status

In order to detect early disease (skin cancer, spots, cataracts, etc.), having contraindications for outdoor activity, there should be carried out periodical medical examinations. Early detection of skin cancer is important in providing some preventive measures for treating diseases. Self-examination is very important as the dry brown spots demonstrate that the skin was subjected to UV radiation overdoses. Sun spots can turn occasionally into skin cancer. Early detection of skin cancer is important for it can be cured when discovered on early stage.

EXPUNEREA LUCRĂTORILOR LA RADIAȚII SOLARE

(Rezumat)

În anumite perioade valorile atinse de radiațiile solare depășesc limita maximă admisă, este important ca angajatorii şi lucrătorii să ia măsuri să limiteze expunerea. Pe termen scurt, consecințele nu se văd, dar pe termen lung, impactul puternic al radiațiilor solare asupra organismului poate fi fatal.

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ECONOMICAL AND TECHNICAL ASPECTS REGARDING THE DEPOSITS CARRIED OUT BY THERMAL SPRAYING IN ELECTRIC ARC

BY

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Abstract: This paper presents the effect of the velocity and temperature of sprayed particles on the properties of the steel deposits carried out by thermal spraying. In this sense, it was performed a study of the influence of various configurations of nozzles on the deposits properties. Finite element analysis, ANSYS CFD software, of the driving jet dynamics with the determinations performed on sprayed particles velocity and temperature, allowed the recording of their effect on the properties of the deposits: adhesion, the content of oxides and pores. This paper presents comparative studies between microstructures of deposits obtained in arc spraying, with a certain type of nozzle and microstructures of deposits obtained by the classical spraying process in electric arc. The results showed that the coatings obtained using the nozzle considered have better properties and economic efficiency.

Keywords: thermal-spray; adhesion; porosity.

1. Introduction

Wire arc spraying is an inexpensive thermal spray deposition process in which the materials to be deposited are introduced into the plasma as wires in the form of consumable arc electrodes. Arc spray coatings are normally denser

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and stronger than their equivalent combustion spray coatings. Low running costs, high spray rates and efficiency make it a good process for spraying large areas. Recent equipment and process developments have improved the quality and expanded the potential application range for thermally sprayed coatings. Typical general applications are thermal barriers, wear resistance, corrosion resistance, high dielectric strength, hard dense coating, decorative arts, etc. Arc sprayed coatings are used widely to fight both high and low temperature corrosion. Arc sprayed coatings also provide excellent resistance to atmospheric corrosion and are used on bridges and other infrastructure components. Most major aircraft engine manufacturers specify the use of the arc spray process for repairs of many aircraft engine components. Coatings are applied to various components for dimensional restoration, hot temperature erosion resistance, etc. It is possible to spray a wide range of metals, alloys and metal matrix composites (MMCs) (Huchin, 1998; Ducos & Durand, 2001; Rigney *et al*., 2001).

In arc spraying an arc is formed between two wires. The molten ends of the wires are dispersed and accelerated by a gas stream (air or inert gas). The temperature in the arc can reach 5,000°C. The particle velocity lies in the range of 100 to 300 m/s. A combination of high arc temperature and particle velocities gives arc sprayed coatings superior bond strengths and lower porosity levels when compared with flame sprayed coatings. However, use of compressed air for droplet atomization and propulsion gives rise to high coating oxide content.

2. Studies of the Flows of Jet by CFD

The software ANSYS CFD, was chosen for numerical calculation. Developed by Company ANSYS is a general programme of mechanics of the fluids intended for the simulation of all types of flows and heat exchange. The original gun exit is composed of a converging nozzle exhibiting a 6 mm exit diameter. The meeting point of the wires (where the electric arc is formed) is situated just at the center of the exit area. The changes that were made on nozzle geometry and were tested included additional extension of the original nozzle (Fig. 1). This approach was expected to lead to the first tendency (qualitative comparison) of the effect of these small changes. Many models of nozzles were tested (nozzle of Laval, nozzles with divergences or convergences). The flows of the six new nozzle configurations were modelled. The influence of transporting gas (air) speed, configuration of jet, temperature gradients in jet, enthalpy were calculated. All the results of modelling were compared with the process parameters of original nozzle.

Fig. 1 presents a view of these different nozzle exit designs. In each case, the results were compared to those obtained for the original geometry (Fig. 1 *a*). More precisely, criteria such as, the velocity magnitude and the jet divergence in the near exit region were retained. Fig. 1 *b* incorporates a

progressive change in the converging angle. Figs. 1 *c*,…,1 *e* show different lengths of constant area nozzle extensions whereas geometries on Figs. 1 *f* and 1 *g* were built up with a slightly diverging extension.

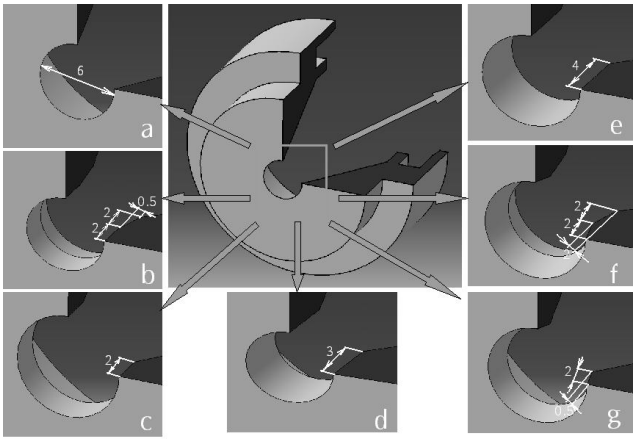


Fig. 1 – View of the tested diverging nozzles.

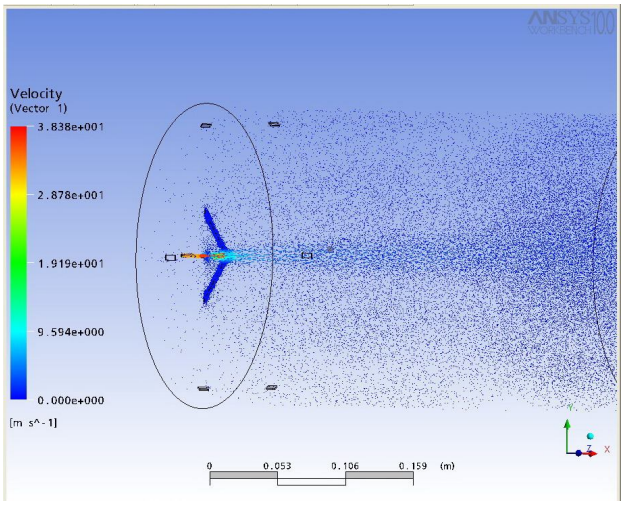


Fig. 2 – Vector of the speed.

For the same heating power, the calculated model of the jet temperature fields showed that temperature of jet flowing from origin TAFA nozzle is higher than jet temperature flowing from the modified nozzle. The rate of the flow of air is bigger from the modified nozzle. The speed vectors (Fig. 2) shows that the divergence of the jet of the modified nozzle is smaller, than for the jet of the origin nozzle, but the size of the speed vector in the area adjacent to electric arc is larger. This indication enables us to suppose, that the spray of the

modified nozzle accelerate particles. The calculations allowed estimate air blow velocity in *Y-Z* directions. For the modified nozzle the blow speed on the direction *Z* is higher and is smaller in the direction *Y*.

Finally, one of the modified designs was selected on the basis of the numerical modeling results and the corresponding nozzle was machined in order to be tested on the experimental way. The selected design has a 3 mm constant area extension (Fig. 1 *d*). The other designs were modeled to provide either a lower gas velocity or a larger jet divergence (if compared to the chosen one). From the presented results it seems reasonable to investigate dependence of sprayed matter characteristics (temperature, velocity and size of particles) from the nozzles, original and modified. The measurements were provided by measurements system DPV 2000. This system allow to measure size, temperature and velocity of particles in flight and estimate in what degree the measured parameters depend on nozzle orifice.

3. Experimental Procedure

3.1. Materials and Spray Guns

Commercially available Tafa's steel (95MXC) cored wire (1.6 mm. diameter) was used for the spray operations in this research. All the spray operations were performed by a TAFA 9910 *CoArc* arc spray system (Tafa Inc., Concord, NH), two different spray nozzles were studied to evaluate the effects of different nozzle geometries.

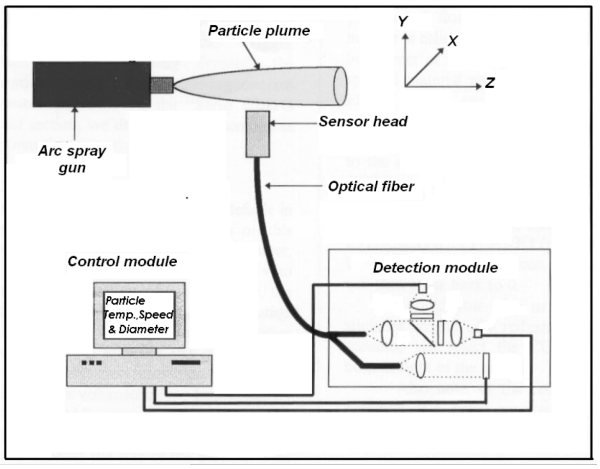


Fig. 3 – DPV2000 operation principle.

The first nozzle was the standard TAFA 9910 *CoArc* spray nozzle. The second one was the modified Tafa's nozzle. The process parameters remained fixed: voltage – 30 V, arc current – 150A, spraying distance – 15 cm.

3.2. Procedures and Measurements

The sprayed particles velocity, temperature and diameter were measured by the diagnostic system DVP-2000. On-line measurement of these parameters, as well as the particle trajectories, is thus an efficient diagnostic tool for characterizing the spray process. The complete monitoring system consists of three main components: a) the sensor head located near the arc spray torch collecting the thermal radiation from the hot sprayed particles, b) the detection module containing the optical components and photo detectors, and c) personal computer (control module) equipped with the required digitizing and computing boards. The sensor head is located near the arc spray gun collecting thermal radiation emitted by the hot in-flight particles. The collected light is transmitted to the detection module through an optical fiber bundle. The radiation from the particles is collected by a 6-element lens specially designed for the present application in order to minimize chromatic and spherical aberrations for wavelengths ranging from 700 to 1,000 nm. The collected light is focused on the end of the optical fiber bundle constituted of two distinct arrangements of fibers. The first arrangement consists of a group if 50 optical fibers (200 mm core) whose ends are aligned along a straight line forming a 12 mm long linear array. The second arrangement consists of a 200 mm core fiber, located on the sensor head axis, whose end is covered by an optical mask. Only the light impinging on the two transparent slits engraved on the opaque mask can reach the end of the optical fiber and thus be transmitted to the detection module. The light emitted by a hot particle traveling near the focal plane of the collection optics will then be collected twice as the particle moves from the first slit field of view to the second one. The distance between the slits images being known, the velocity of the particle can be computed from its transit time. The particle temperature is determined by measuring the thermal radiation intensity at two different wavelengths (Moreau *et al*., 1994; Gougeon & Moreau, 1993). Additionally, the sprayed particles microstructures and performance of the coatings were studied by scanning electron microscopy (SEM).

Coating adhesion was measured in accordance with the ASTM C 633-79 standard pull-off tensile test. This is a common method of characterizing the comparable bond strength of thermally sprayed coatings. The results of the tests determine the degree of adhesion of a coating to a substrate in tension normal to the surface. 25 mm diameter coupon was stuck onto two sample holders for testing. The latter ones were set into a tensile machine. A progressive force at a constant speed of 0.075 cm/min was applied to set up until the spallation occurred. Four samples were used for eight spraying conditions. Polished cross section of the spray deposit was digitized by using a Nikon EPIPHOT optical microscope with a Nikon Coolpix E955 digital camera. Computer image analysis program Scion Image_based on the image processing toolbox was used

to analyses the true color image. Instead of using grey level as threshold, the RGB value of the pixels was utilized as criterion to distinguish the different features of the coating microstructure. In this way, the area fraction and distribution of oxide and porosity (Table 2) can by defined with high accuracy.

4. Results and Discussions

The sprayed coating is built up particle by particle and, therefore, higher atomizing air pressure results in higher impact velocity of smaller particles on the substrate. Air atomization is commonly used in the wire arc spray process. The major advantages are the availability and economy of compressed air. In the air atomization wire-arc spray process, the oxide content of the sprayed coating is relatively high due to oxidation of the molten wire material. This higher oxide content can increase the coating hardness so that the abrasion and wear resistance of the coatings is improved. However, the oxide content may also be detrimental to coating properties because oxides may reduce the adhesion strength between coating and substrate. Also, hard oxide particles embedded in sprayed coatings impose problems during machining. Furthermore, coatings sprayed with air atomization often contain relatively high porosity, which is frequently detrimental. Another disadvantage of air atomization is related to the burn off of alloying elements contained in parent wires. These elements are essential ingredients to produce the required coating characteristics. As a consequence, coatings with specified characteristics cannot be produced reliably (Wang *et* al., 1999; Wang *et* al., 1996). The adhesion of the coatings depends upon the interactions between individual lamellae and between lamellae and substrate. The bond strength of a coating is affected by the extent of both physical and chemical interactions between the coating and the substrate material and on the microstructure of the interfacial region. Poor adhesion can be attributed to poor interfacial interlocking, low degree of metallurgical bonding, and high internal stresses. The degradation modes of the coating depend on both the nature of the coating-substrate interface and on the chemical phenomena that occur at the interface during deposition and solidification. The results of particles measurements in-flight are presents in the Table 1.

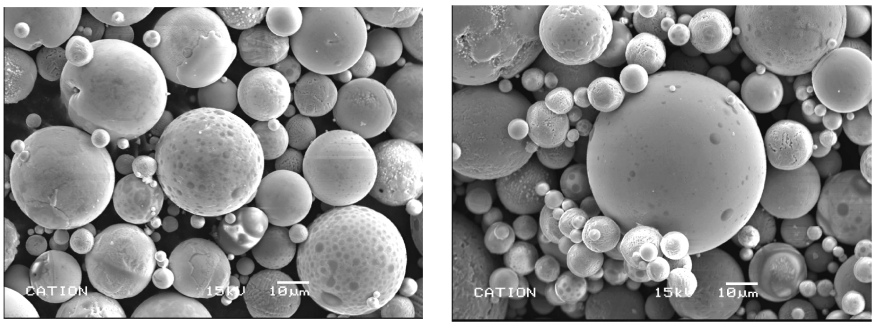
Table 1
Results of Measurements of Particles in Flight

Spray gun nozzle	Air debit m^3/h	Particle speed, [m/s]	Temperature ^0C	Diameter, [μm]
TAFA	90	118	2,185	32
	110	141	2,210	28
	130	157	2,220	25
Modified	90	136	2,191	29
	110	175	2,217	24
	130	189	2,217	20

The samples for the tensile test were glued up together to sample holders by the polymer glue POXIPOL. For the glue polymerization the samples that had been assembled were treated by the two - hour heating under the temperature 170 0C. After the glue final hardening prepared samples were ruptured by standard tensile test procedure. The results of these tests are presented in Table 2. It sometimes happened during the test that spallation did not take place at the interface coating /substrate but within the coating or in the glue. For instance, when rupture occurred in the glue, the real adhesion of the coating onto its substrate was higher than the recorded value. The " > " sing was then used to point it out. Sprayed coatings are formed by the impact, deformation, and rapid solidification of individual molten droplets so that coating structure consists of a series of overlapping lamellae. Faster molten particles with higher kinetic energy spread and deform more readily on impact, thus increasing coating density and reducing porosity. The particle velocity and the particle temperature determine the coating structure at the instant of impact on the substrate. Completely molten particles impinging on the substrate spread out radially in the form of thin disks. In reality, however, the deposit is not uniform in thickness, and the periphery of the flattened particle is not circular.

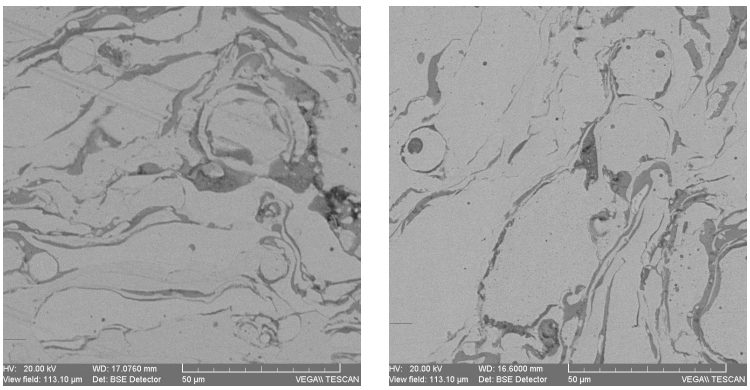
Table 2
Coatings Proprieties

Spray gun nozzle	Air debit m^3/h	Particle speed m/s	Porosity %	Oxides %	Adesion, [MPa]
TAFA	90	118	13.1	0.77	52.7; 49.2; 62.0; 53.8
	110	141	15	0.57	>59.4; >63.1; >55.5; 57.2
	130	157	14.2	0.37	>67.1; >68.3; 56.0; 48.8
Modi-fied	90	136	12.3	1.23	>54.0; >64.3; 50.9; 67.0
	110	175	14.4	0.63	>71.0; >68.6; >55.0; >50.5
	130	189	15	0.31	>53.2; >58.9; >51.8; 63.9



a *b*

Fig. 4 – SEM photographs of the sprayed particles (air debit 130m3/h, particles quenched in water): *a* – standard TAFA 9910 nozzle; *b* – modified Tafa's nozzle.



a *b*

Fig. 5 – SEM photographs of micro sections of sprayed coatings:
a – standard TAFA 9910 nozzle; *b* – modified Tafa's nozzle.

Arc sprayed metal coatings contain a certain amount of oxides. During spraying, the effect of atomizing air and the entrainment of the surrounding air into the spray stream caused significant in flight oxidation of the molten metal particles.

Increasing the atomizing air pressure leads to higher gas stream velocities, which in turn break up the molten particles into smaller droplets. The smaller droplets react more readily with oxygen than the larger droplets, because of their greater specific surface area. The Table 1 shows that size of particles is evidently decreasing whereas air debit increases and the temperature of particles varieties very insignificantly within possible error range in measurement. That allows stating that the temperature remains constant. Fig. 5 confirms that under constant air debit the particles sprayed by Modified gun nozzle are smaller than ones by TAFA 9910 CoArc .

Investigation of coatings microstructure revealed dependence of structure morphology on sprayed particles velocity. The density and dispersity of the lamellar structure increases with the increase of particles velocity. With the increase of particles velocity the size of droplets decreases. Small size droplets have a relatively big surface area; during the flight they are oxidized on bigger degree in comparison with big size droplets, and in these coatings bigger probability of increase of oxide inclusions is possible. On the other hand, the small particles have bigger velocity, shorter fly duration and less time for oxidation reactions. The more particles velocity is, the bigger coating density and less developed porosity is. The optimal selection of spray parameters in matching with the degree of oxidation and adhesion of coating allows reaching the highest strength of adhesion. The optimal coatings were produced when the spray operations were performed by Modified TAFA spray guns with 110 and 130 m^3/h air debits

5. Conclusions

1. CFD models can predict the influence of nozzle geometry on flows of jet ant heat transfer. It also helps to choose an optimal nozzle configuration.

2. The spray gun nozzle design has a strong influence on spray geometry, its dynamics characteristics and coating properties. The minor modification of spray gun nozzle design can strongly improve the coating characteristics.

3. Modified configuration of the nozzle allows the increase of the speed of the particles by ~18% and kinetic energy of particles impacts by ~43%.

4. The precise estimation of adhesion quality of thin coatings is a difficult task. Sample preparation, sort of glue, heating time to polymerize the glue is of the prime importance to obtain good results of the bond tensile test.

5. In the case of optimal spray process characteristics in several specimens it was difficult to estimate the coatings adhesion strength. This happened when the strength of coating adhesion was bigger than glue bond between sample holder and substrate.

REFERENCES

Dickey H.C., Meek T.T., *Active Electronic Devices Fabricated by DC Plasma Arc Spray Process*. Vacuum, October (2000).

Ducos M., Durand J.P., *Thermal coatings in Europe: a Business Prospective*. Thermal Spray 2001: New Surfaces for New Milennium, Ohio, USA, 2001.

Gougeon P., Moreau C., *In-Flight Particle Surface Temperature Measurement: Influence of the Plasma Light Scattered by the Particles*. Proc. of the 1993 Nat. Thermal Spray Conf., June 7-11 ,1993.

Huchin J.P., *The Place of Thermal Spraying in Industry Today and the Prospects for the Future*. Proc. of 15th Internat. Thermal Spray Conf., May 25-29, 1998.

Liu G., Roniatowski K., Kurzydowski K.J., *Quantitative Characteristics of FeCrAl Films Deposited by Arc and High-Velocity Arc Spraying.* Materials Characterization, February - March (2001).

Moreau C., Gougeon P., Lamontagne M., Lacasse V., Vaudreuil G., Cielo P., *On-Line Control of the Plasma Spraying Process by Monitoring the Temperature, Velocity, and Trajectory of In-Flight Particles*. Proc. of 7th Internat. Thermal Spray Conf., June 20-24, 1994.

Newbery P., Grant P.S., *Droplet Splashing During Arc Spraying of Steel and the Effect on Deposit Microstructure*. J. of Thermal Spray Technol., June (2000).

Rigney R.W., Grubowski A., McCaw R., Scandell K., *Component Repair and Chrome Plating Replacement with New Thermal Spray in the United States Navy: Successes and the Future*. Materials Characterization, February–March, 2001.

Steffens H.D., Nassenstein K., *Influence of the Spray Velocity on Arc-Sprayed Coating Structures*. J. of Thermal Spray Technol., September (1999).

Toma St.L., Bejinariu C., Baciu R., Radu S., *The Effect of Frontal Nozzle Geometry and Gas Pressure on the Steel Coating Properties, Obtained by Wire Arc Spraying*. Surf & Coat. Technol., *220*, 266-270 (2013).

Toma St.L., *The Influence of Jet Gas Temperature on the Characteristics of Steel Coating Obtained by Wire Arc Spraying.* Surf & Coat. Technol., *220*, 261-265 (2013).

Wang X., Heberlein J., Pfender E., Gerberich W., *Effect of Gas Velocity and Particle Velocity on Coating Adhesion in Wire Arc Spraying*. Thermal Spray: Practical Solutions for Engineering Problems, Ohio-USA, 1996.

Wang X., Heberlein J., Pfender E., Gerberich W., *Effect of Nozzle Configuration, Gas Pressure, and Gas Type on Coating Properties in Wire Arc Spray*. J. of Thermal Spray Technol., December (1999).

ASPECTE ECONOMICE ŞI TEHNICE PRIVIND DEPUNERILE REALIZATE PRIN PULVERIZARE TERMICĂ ÎN ARC ELECTRIC

(Rezumat)

Se prezintă efectul vitezei şi a temperaturii particulelor pulverizate asupra proprietarilor depunerilor din oţel realizate prin pulverizare termică. În acest sens a fost efectuat un studiu al influenţei diferitor configuraţii de duze asupra proprietăţilor depunerilor. Analiza cu elemente finite, programul ANSYS CFD, a dinamicii jetului de antrenare împreună cu determinările efectuate asupra vitezei şi a temperaturii particulelor pulverizate au permis înregistrarea efectului lor asupra proprietăţilor depunerii: aderenţa, conţinut de oxizi şi pori. Lucrarea prezintă studii comparative între microstructuri ale depunerilor obţinute prin pulverizare in arc electric, cu un anumit tip de duză şi microstructuri ale depunerilor obţinute prin procedeul clasic de pulverizare în arc electric. Rezultatele obţinute au arătat că acoperirile obţinute, cu ajutorul duzei considerate, prezintă proprietăţi mai bune şi eficienţă economică.