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PROTECTION OF HUMAN IN THE WORKING ENVIRONMENT

Danijela Tadic, Marko Djapan, Mirjana Misita, Miladin Stefanovic & Dragan D. Milanovic. *A Fuzzy Model for Assessing Risk of Occupational Safety in the Processing Industry*. S. 115-126.

Managing occupational safety in any kind of industry, especially in processing, is very important and complex. This paper develops a new method for occupational risk assessment in the presence of uncertainties. Uncertain values of hazardous factors and consequence frequencies are described with linguistic expressions defined by a safety management team. They are modeled with fuzzy sets. Consequence severities depend on current hazardous factors, and their values are calculated with the proposed procedure. The proposed model is tested with real-life data from fruit processing firms in Central Serbia.

Miladin Stefanovic, Danijela Tadic, Marko Djapan & Ivan Macuzic. *Software for Occupational Health and Safety Risk Analysis Based on a Fuzzy Model*. S. 127-136.

Risk and safety management are very important issues in healthcare systems. Those are complex systems with many entities, hazards and uncertainties. In such an environment, it is very hard to introduce a system for evaluating and simulating significant hazards. In this paper, we analyzed different types of hazards in healthcare systems and we introduced a new fuzzy model for evaluating and ranking hazards. Finally, we presented a developed software solution, based on the suggested fuzzy model for evaluating and monitoring risk.

Leena Korpinen, Rauno Pääkkönen & Fabriziomaria Gobba. *White-Collar Workers' Self-Reported Physical Symptoms Associated With Using Computers*. S. 137-147.

The aim of our work was to study the physical symptoms of upper- and lower-level white-collar workers using a questionnaire. The study was cross-sectional with a questionnaire posted to 15 000 working-age persons. The responses (6121) included 970 upper- and 1150 lower-level white-collar workers. In the upper- and lower-level white-collar worker groups, 45.7 and 56.0%, respectively, had experienced pain, numbness

and aches in the neck either pretty often or more frequently. When comparing daily computer users and nonusers, there were significant differences in pain, numbness and aches in the neck or in the shoulders. In addition, age and gender influenced some physical symptoms. In the future, it is essential to take into account that working with computers can be especially associated with physical symptoms in the neck and in the shoulders when workers use computers daily.

Blaž Valič, Bor Kos & Peter Gajšek. *Occupational Exposure Assessment on an FM Mast: Electric Field and SAR Values*. S. 149-159.

Electric field strengths normally exceed the reference levels for occupational exposure in close vicinity to large frequency modulation (FM) transmitters. Thus, a detailed investigation on compliance with basic restrictions is needed before any administrative protection measures are applied. We prepared a detailed numerical model of a 20-kW FM transmitter on a 32-m mast. An electrically isolated anatomical human model was placed in 3 different positions inside the mast in the region where the values of the electric field were highest. The electric field strengths in this region were up to 700 V/m. The highest calculated whole-body specific absorption rate (SAR) was 0.48 W/kg, whereas the maximum 10-g average SAR in the head and trunk was 1.66 W/kg. The results show that the reference levels in the FM frequency range are very conservative for near field exposure. SAR values are not exceeded even for fields 10 times stronger than the reference levels.

Blaž Valič, Bor Kos & Peter Gajšek. *Simultaneous Occupational Exposure to FM and UHF Transmitters*. S. 161-170.

Occupational exposure caused by large broadcasting transmitters exceeds current reference levels. As it is common for different radio and TV transmitters to share the location, we analysed combined exposure on a 40-m high mast. The frequency modulation (FM) transmitter, located between the 10th and 30th metre, had the power of 25 kW, whereas an ultra-high frequency (UHF) transmitter of 5 kW occupied the top 8 m of the mast. Measured and calculated values of the electric field strength exceeded the reference levels up to 10 times; however, the results for the specific absorption rate (SAR) values show that the reference levels are very conservative for FM exposure, i.e., basic restrictions are not exceeded even when the reference levels are exceeded 10 times. However, for UHF exposure the reference levels are not conservative; they give a good prediction of real exposure.

Kalev Kuklane, Chuansi Gao, Faming Wang & Ingvar Holmér. *Parallel and Serial Methods of Calculating Thermal Insulation in European Manikin Standards*. S. 171-179.

Standard No. EN 15831:2004 provides 2 methods of calculating insulation: parallel and serial. The parallel method is similar to the global one defined in Standard No. ISO 9920:2007. Standards No. EN 342:2004, EN 14058:2004 and EN 13537:2002 refer to the methods defined in Standard No. EN ISO 15831:2004 for testing cold protective clothing or equipment. However, it is necessary to consider several issues, e.g., referring to measuring human subjects, when using the serial method. With one zone, there is no serial-parallel issue as the results are the same, while more zones increase the difference in insulation value between the methods. If insulation is evenly distributed, differences between the serial and parallel method are relatively small and proportional. However, with more insulation layers overlapping in heavy cold protective ensembles, the serial method produces higher insulation values than the parallel one and human studies. Therefore, the parallel method is recommended for standard testing.

Jan Rzepecki. *Cost and Benefits of Implementing an Occupational Safety and Health Management System (OSH MS) in Enterprises in Poland.* S. 181-193.

This article presents a method of assessing the economic outcome of implementing an occupational safety and health management system (OSH MS). Developed at the Central Institute for Labour Protection – National Research Institute (Poland), this method focuses on identifying the economic expenses comprising bookkeeping and alternative cost incurred to implement and improve an OSH MS. The method was next used in a study in 20 enterprises. While varying greatly among those enterprises, the alternative cost of implementing and maintaining an OSH MS was much higher than the bookkeeping cost, which was also much lower than the cost of statutory prevention measures. The implementation of an OSH MS resulted in both tangible and intangible benefits, including reduced premiums for work accident insurance.

PROTECTION OF HUMAN AT THE WORKSTATION

Alan H.S. Chan & Annie W.Y. Ng. *The Guessing of Mine Safety Signs Meaning: Effects of User Factors and Cognitive Sign Features.* S. 195-208.

This study investigated the effects of user factors and cognitive sign features on the guessability of mine safety signs. Sixty naïve participants guessed the meanings and rated the cognitive sign features of 42 Mainland Chinese mine safety signs. The results showed that some user factors were significant predictors of guessing performance, while some were not. As expected, guessability scores varied significantly with the cognitive sign features of familiarity, concreteness, simplicity, meaningfulness and semantic closeness. The findings emphasize the need to create awareness of the importance of mine safety and promote understanding of mine safety sign meanings amongst people in their work environments. To design more user-friendly mine safety signs, industrial designers should develop and evaluate signs with consideration of the significant user factors and the 5 sign features tested here.

Lluís Sanmiquel, Modesto Freijo & Josep M. Rossell. *Exploratory Analysis of Spanish Energetic Mining Accidents.* S. 209-219.

Using data on work accidents and annual mining statistics, the paper studies work-related accidents in the Spanish energetic mining sector in 1999–2008. The following 3 parameters are considered: age, experience and size of the mine (in number of workers) where the accident took place. The main objective of this paper is to show the relationship between different accident indicators: risk index (as an expression of the incidence), average duration index for the age and size of the mine variables (as a measure of the seriousness of an accident), and the gravity index for the various sizes of mines (which measures the seriousness of an accident, too). The conclusions of this study could be useful to develop suitable prevention policies that would contribute towards a decrease in work-related accidents in the Spanish energetic mining industry.

Eyal Byran & Issachar Gilad. *Design Considerations to Enhance the Safety of Patient Compartments in Ambulance Transporters.* S. 221-231.

The safety of the interior of ambulances is dubious and, in the event of sudden impact during emergency transport, potentially perilous to patients they carry. The workplace ergonomics of the interior of the passenger cabin is lacking. This article discusses an improved ergonomic interior design based on study findings, observations and subjective perception. It suggests design aspects and safety concepts aimed at increasing the safety of patients and paramedic staff inside the ambulance as a mobile workstation.

Paweł Bartuzi, Danuta Roman-Liu & Tomasz Wiśniewski. *The Influence of Fatigue on Muscle Temperature*. S. 233-243.

The aim of the study was to investigate the possibility of using infrared (IR) thermography for assessing muscle fatigue during low effort. Three tests at constant levels of load 5, 15 and 30% of maximum voluntary contraction (MVC) lasting 5 min each were performed on a group of 10 men. Temperature and electromyographic (EMG) signal were registered from biceps brachii (BB). Analysis focused on the influence of load on the values and changes in time of muscle temperature. Correlations between temperature and EMG parameters (RMS, MPF and MF) were also analysed. Constant load sustained during the tests resulted in an increase in the temperature of BB. There were statistically significant correlations between temperature and EMG parameters for most subjects. Results of the study suggest that IR thermography can be an alternative or supplementary method for assessing muscle fatigue at low levels of contraction.

François Gauthier, Serge Lambert & Yuvin Chinniah. *Experimental Analysis of 31 Risk Estimation Tools Applied to Safety of Machinery*. S. 245-265.

This article studies differences in the results of using different risk estimation tools in the same hazardous situations involving dangerous machinery. We investigated how (a) types of risk estimation parameters and methods of constructing tools, (b) the number of levels of each parameter, and (c) the number of risk levels influence the results. Consequently, 31 risk estimation tools were compared by using them to estimate risk levels associated with 20 hazardous situations. Risk estimation appears to be tool-dependent, as different tools give different results with identical hazardous situations. The scope of the tool, its use, and construction could explain these differences. This article also proposes a series of rules for constructing tools to alleviate many problems associated with the variability of risk estimations.

Byungjoon B.J. Kim. *Effect of Ergonomic Design Changes in Hand Tools on Physiological Cost and Subjective Ratings*. S. 267-277.

Users of hand tools expect that tools after ergonomic changes in design will require less muscular activity and cause fewer musculoskeletal disorders than conventional tools. Reports on evaluation of ergonomic design changes in hand tools are controversial. In this study, we measured the effect of changes in tool design with physiological cost of performance and subjective ratings in a simulated setting. We determined physiological cost of performance by measuring muscle activity of the right and left forearm (flexor carpi ulnaris) with electromyography. We collected a questionnaire with subjective ratings before and after each experimental task. Before the tests, ergonomically reconfigured hacksaws received better rating scores than original hacksaws. However, we found no differences in subjective ratings of the hacksaws after the tests. In addition, electromyographic activity did not show any significant differences between the original and modified tools.

Małgorzata Pawlaczyk-Łuszczynska, Adam Dudarewicz, Małgorzata Zamojska & Mariola Śliwinska-Kowalska. *Self-Assessment of Hearing Status and Risk of Noise-Induced Hearing Loss in Workers in a Rolling Stock Plant*. S. 279-296.

Noise measurements and questionnaire inquiries were carried out for 124 workers of a rolling stock plant to develop a hearing conservation program. On the basis of that data, the risk of noise-induced hearing loss (NIHL) was evaluated. Additionally, the workers' hearing ability was assessed with the (modified) Amsterdam inventory for auditory disability and handicap, (m)AIADH. The workers had been exposed to noise at A-

weighted daily noise exposure levels of 74–110 dB for 1-40 years. Almost one third of the workers complained of hearing impairment and the (m)AIADH results showed some hearing difficulties in over half of them. The estimated risk of hearing loss over 25 dB in the frequency range of 3-6 kHz was 41–50% when the standard method of predicting NIHL specified in Standard No. ISO 1999:1990 was used. This risk increased to 50-67% when noise impulsiveness, coexposure to organic solvents, elevated blood pressure and smoking were included in calculations.