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ERGONOMICS APPROACH TO EVALUATE SAFETY RISKS WITHIN THE UK FOOD INDUSTRY, PRELIMINARY RESULTS

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Abstract: *Generally ergonomics, a science concerned with the 'fit' between people and their work, could considerably reduce injury risks improving productivity and reducing wastes. To assess the fit between a person and its work, a range of factors have to be considered including: job task, individual both physical and psychological characteristics, organization and social environment. In this paper the authors aim to understand how ergonomics and human factors can improve health and safety within the UK food industry. The aim was to identify hazards and risk within the industry and ways to reduce or eliminate dangerous situation. In conclusion author observed that ergonomics has both a social goal (well-being) and an economic goal (total system performance); that ergonomics considers both physical and psychological human aspects; and that ergonomics is looking for solutions in both technical and organizational domains.*

Key words: *ergonomics; health & safety; injury; work related illness.*

1. INTRODUCTION

1.1 Ergonomics evolution

Over the last 50 *year*s, ergonomics, a term that is used here synonymously with human factors (HFE) has been evolving as a unique and independent discipline. Today, HFE is the discipline that focuses on the nature of human-artefact interactions, in terms of unified perspective of the science, engineering, design, technology and management of human-compatible systems.

Historically, the philosophical framework for the unique discipline of ergonomics (ergon + nomos), or the study of work, was introduced by the Polish scientist W.B.

Jastrzebowski (1857). Ergonomics was proposed as a scientific discipline with a very broad scope and a wide area of interests and applications, encompassing all aspects of human activity, including labour, entertainment, reasoning and dedication (Karwowski (1991, 2001).

The contemporary ergonomics discipline, independently introduced by Murrell in 1949 (Edholm and Murrell 1974), was viewed at that time as the applied science or technology, or both. The ergonomics discipline promotes a holistic, human-centred approach to work systems design that considers physical, cognitive, social, organizational, environmental and other relevant factors (Grandjean 1986, Wilson and Corlett 1990, Sanders and McCormick 1993, Chapanis 1996, 1999, Salvendy 1997, Karwowski 2001, Vicente 2004, Stanton et al. 2004). The International Ergonomics Association (2003) defined ergonomics or HSE as: *"...the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human wellbeing and overall system performance".*

1.2. Occupational Ergonomic

In the view of the IEA ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people (IEA, 2003).

HFE aims to optimize human well-being and overall system performance. HFE discovers and applies information about human behavior, abilities, limitations and other characteristics to the design of tools, machines, systems, tasks, jobs and environments for productive, safe, comfortable and effective human use (Sanders and McCormick 1993, Helander 1997). In this context, HFE deals with a broad scope of problems relevant to the design and evaluation of work systems, and working environments in which human-machine interactions affect human performance and product usability.

1.3. Ergonomics Health and Safety

The HFE discipline advocates: *". . . systematic use of the knowledge concerning relevant human characteristics in order to achieve compatibility in the design of interactive systems of people, machines, environments, and devices of all kinds to ensure specific goals . . ."* (Human Factors and Ergonomics Society 2004).

Typically, such goals include improved (system) effectiveness, productivity, safety, ease of performance and the contribution to overall human well-being and quality of life.

The quality of working life and the system (enterprise) performance is affected by matching of the positive and negative outcomes of the complex compatibility relationships between the human operator, technology and environment. Positive outcomes include such measures as work productivity, product quality human well-being, etc. The negative outcomes include both human and system-related errors, accidents, injuries, physiological stresses and subjective psychological (undesirable) behavioral outcomes job/occupational stress, etc.

1.4. Objectives and Aims

It is proposed this would be achieved by the following objectives:

- to observe and analyze how small medium and large companies carry out risk assessment in the workplace, prevent accidents and cases of work- related ill health;
- to observe if the extent of participation of workers helps the Companies to identify and spot risks and hazard; and
- analyze the risk assessment from the point of view of both managers and workers.

The aim of this paper is to highlight that ergonomic principles applied to risk assessment and health and safety management influence the behavior at work in a way which can prevent and avoid risk that might affect workers' health and safety.

2. MATERIAL AND METHODS

In order to better understand how ergonomics and human factors can improve health and safety within the UK food industry the authors visited a number of different companies involved in food and drink production to observe current working practices and obtain information, via questionnaires, about the risks and solutions adopted within the working environment from relevant personnel including workers, health and safety officers and management.

2.1. Companies Selection

To collect data we planned to visit a number of different companies, involved in food production located in and around Milton Keynes and Melton Mowbray. In Milton Keynes, with the assistance of the local Councils' Enviroment Health Office, a list of companies that could provide assistance was produced. These companies were then contacted to enquire is they would be willing to participate in the project. A similar list was drawn up of companies in Melton Mowbray. The companies were of different sizes, some with more than 200 employees, others with less than 20 employees. They were also involved in food production including dairy, meat, bakery, brewery and soft drinks production.

2.2. Questionnaire

The aim was to identify hazards which affect workers' health and safety and we used two main method, one of the two used for data acquisition consisted of a questionnaire. Questions were prepared under several categories, with 67 questions divided into following general section: i) workers and company data, ii) feeling about health and safety, iii) relationship between job and health, iv) health and safety in their own organization, v) knowledge about mechanical hazards, plant and machinery, vi) risks during working.

We asked workers and H&S manager to agree/disagree with a series of questions under each section using a 5-point Likert scale and provide more extensive answers to others. Questionnaires were submitted to workers and health and safety managers, via email or personal contact.

2.3. Walk trough in site and discussion

Information was also gathered during walk-through of companies the study team was able to visit, in the company of a responsible of staff. During each visit was to observe

and record current work practices, both overt and covert, what safety notices were displayed, what mechanical guards were provided and whether notices were displayed. During the visit the company representative was also asked about their beliefs about health issues, working practices, company health and safety, and provision of personal protective equipment (PPE). In addition information was collected about current H&S procedures, plants and machinery, automation and control of manufacturing processes

2.4. Ethical Approval

The study was approved by Cranfield University's Science and Engineering Research Ethics Committee. All information collected through remains strictly confidential.

3. RESULTS AND DISCUSSION

Collected data were classified and analyzed together with the data from previous research and data from the literature in order to present some preliminary results of larger ongoing project. From analysis of the questionnaire data and from interview of health and safety manager it was possible to verify that on average, a risk management framework is frequently adopted by managers to guide the application of the principles of ergonomics to any particular problem.

From a healthy and safety managers' perspective, the emphasis for risk control is on elimination or reduction of risk through design controls rather than administrative controls such as training, selection or personal protective equipment PPE doing all reasonably practicable.

Most important, the risk management process also places emphasis on consultation with the people concerned at each step. This issue is at the heart of ''participative ergonomics'' approaches, which take as an underlying assumption the notion that the people involved are the ''experts'' and must be involved at each stage of the risk management cycle if the process is to be executed successfully.

In an occupational injury management context, this implies in particular that employees and management participate through hazard identification, risk assessment, risk control and review steps of the risk management cycle.

In the scientific literature there are several studies explaining why workers' participation is important in this step and in all challenge to make safety their life at work. Participative ergonomics has been used to create more human centered work and to improve work organizational climate, as well as to prevent musculoskeletal disorders associated with manual tasks.

Analyzing the preliminary data, risk factors are in jobs requiring repetitive, forceful, or prolonged exertions of the hands; frequent or heavy lifting, pushing, holding, pulling, or carrying of heavy objects; and prolonged awkward postures. All these activities are defined 'manual task'. Vibration and cold may add risk to these work conditions.

Jobs or working conditions presenting multiple risk factors will have a higher probability of causing occupational ill health as musculoskeletal problem work-related stress, which is often cited as a cause of mental ill health, occupational asthma and rhinitis, and noise-induced hearing loss. The level of risk depends on the intensity, frequency, and duration of the exposure to these conditions. Environmental work

conditions that affect risk include intensity, frequency and duration of activities, but in this paper we considering preliminary result on risk from exposure noise level.

Risks can be eliminated or reduced by application of ergonomics' best practice, reducing error and influencing behavior, such that have been observed during the visits.

We can thus distinguish and classify manual handing, activities that subject the workers to hazardous substances exposure or high levels of noise, we also consider working activities potentially dangerous because they took place in a work environment unsuitable.

All these work activities are able to affect workers' health and safety if companies don't control and make solutions about them.

3.1. Manual handling

The risk factors considered by health and safety managers and workers to be important in assessing the impact of manual handling, especially in terms of musculoskeletal disorders (MSD) are:
- Frequency and repetition,
- Force and
- Working posture.

3.1.1. Frequency and repetition

Repetitive tasks are typically found in assembly, production, processing, packaging, packing and sorting work, as well as work involving regular use of hand tools. Repetitive work contribute to the development MSDs. From the walk trough, and from questionnaire data we could observe that main repetitive tasks were:

- lifting and carrying sacks, ingredients, boxes, packaging;
- lifting and handling drums of liquid and casks.

The companies aware of task risks try to reduce the consequences.

In order to reduce the risk companies, especially large ones indicated they:

- use automation and mechanization to do the highly repetitive functions and leave more varied jobs for the workers;
- use Task rotation to manage the risk of repetitive work;
- reduce the number of repetitive movements and the rate at which they are made, especially when combined with applying force and/or in awkward postures.

Where mechanization is not possible, most of the companies involved in this project introduce measures to prevent injury, i.e. improved ergonomic design of work stations and work areas, job rotation, especially:

- power tools in place of manual tools;
- task design: break up long periods of frequent repetitions and static inactivity with frequent pauses;
- spread repetitive task elements and movements across both hands;
- share repetitive work through teamwork or task rotation;
- distribute the workload over different muscle groups and joints.

3.1.2. Force

We asked people if they use force in combination with poor posture in their work activities, and to describe manual handing they considering more fatiguing. From collected data results that the most activities are:

- hands lifting;
- putting down.

We could observe that companies involved apply ergonomics principles to reduce consequences of fatiguing work such as:

- reduce the forces required i.e. use other power sources rather than muscle power;
- reduce the frequency with which force needs to be applied;
- reduce the time spent applying force. This especially relates to static forces that applied and sustained for steadying or supporting items or gripping tools; and considering altering the position or orientation of work pieces or tools so that any force can be applied more easily and efficiently improves the posture of the workers when applying forces.

3.1.3. Working posture

From collected data, to reduce awkward posture, the ergonomics principles that companies involved apply are:

- reduce the time spent holding and/or repeating awkward postures;
- avoid using static postures for prolonged periods; and
- ensure workplaces and work equipment are designed or selected to account for difference in size, shape and strength of workers.

3.2. Workplace health and safety

3.2.1. Noise

Noise at work can cause hearing damage that is permanent and disabling. Hearing loss can be gradual because of exposure to noise over time, but also damage caused by sudden, extremely loud noises.

From collected data result that in the companies where there is noise, especially in drinks production and in large bakeries, they make sure the legal limits on noise exposure are not exceeded, complying the law and looking for alternative processes, equipment and/or working methods which would make the work quieter or mean people are exposed for shorter times. Large companies also took action to reduce noise exposure with a planned program of noise control, as ergonomics principles suggest.

Perceiving causal links among risk awareness, behavior, and exposure constitutes a very important issue in the control of exposure, either by avoiding it (whenever possible) or by using PPE.

The types of precautions companies took to reduce the workers' risks included:

- quieter equipment or a different, quieter process;
- engineering/technical controls to reduce, at source, the noise produced by a
- machine or process;
- using screens, barriers, enclosures and absorbent materials to reduce the noise on its path to the people exposed;
- designing and laying out the workplace to create quiet workstations;
- improved working techniques to reduce noise levels;
- limiting the time people spend in noisy areas.

Most of companies involved in our project, especially the larger ones, use all of the mentioned solutions.

There are different types of hearing protective used by the companies:

- earmuffs;
- earplugs;
- semi-inserts/canal caps.

Companies should take into account the hearing protectors has a suitable protection factor that is sufficient sufficient to eliminate risks from noise but not so much protection that wearers become isolated.

Walking trough we could observe that companies:

- identify hearing protection zones – areas of the workplace where access is restricted, and where wearing hearing protection is compulsory;
- provide employees with hearing protectors, and also they do that if they ask for them;
- consider the work and working environment, i.e. physical activity, comfort and hygiene compatibility with other protective equipment, i.e. hard hats, masks and eye protection;
- companies enforce wearing of ear defender, in fact during a walk through with H&S Officer, one member of staff was reprimanded for not wearing any protection and asked him to immediately leave the production area to where noise are not a H&S issue.

We consider that companies are very careful to ensure that employees wear hearing protector, fully and properly. By this way company must provide health surveillance for all your employees who are likely to be frequently exposed above the upper exposure action values, or are at risk for any reason, i.e. they already suffer from hearing loss or are particularly sensitive to damage.

Company should periodically review their arrangements and achievements in managing competence, and implement improvements as required.

3.3. Environment workplace health and safety

The term workplace also includes the common parts of shared buildings, private roads and paths on industrial estates and business parks, and temporary. The condition of the buildings needs to be monitored to ensure that they have appropriate stability and solidity for their use.

We were considered in the questions submitted: floors and traffic routes, slips and trips, falls from height.

3.3.1. Traffic routes and floors

Walking through we could observe as the big company to allow people and vehicles to move safely, keep vehicles and pedestrians apart by ensuring that they use entirely separate routes. If people and vehicles have to share a traffic route, they use kerbs, barriers or clear markings to designate a safe walkway and, where pedestrians need to cross a vehicle route, provide clearly marked crossing points with good visibility, bridges or subways. Signs were also present telling drivers of vehicles to sound their horns warning pedestrians of their presence. We consider that the best approach ensuring safety workplace.

Floors and traffic routes should be sound and strong enough for the loads placed on them and the traffic expected to use them. The surfaces should not have holes or be

uneven or slippery, and should be kept free of obstructions and from any article or substance which may cause a person to slip, trip or fall.

We observed in one company that took best practice to ensure safety traffic routes, that in an area where they were cleaning machinery they neglected to put 'Wet Floor' warning signs in place to attract attention of the hazard to the workers to avert potential risks to slipping or tripping. The authors also walked through the area without being told to take care, although it was patently obvious the floor was wet and potentially dangerous.

From data collected data, it was evident that workers and H&S officers received health and safety advice about slips and trips, and consider their work environment susceptible to slips and trips hazard. About precautions that company takes to reduce slips and trips hazard the most common answers were:

a) cleaning regime that ensures floors are kept free of contamination;
b) if the floor is too slippery, anti slip trips are put down.

3.3.2 Ventilation

General working environment of people in the workplace take into account environmental factors such as humidity and sources of heat in the workplace combined with personal factors such as the clothing a worker is wearing and how physically demanding their work is to influence what is called someone's 'thermal comfort'.

Walking through with H&S Officer at one company, we were told of one situation where high concentrations of CO_2 accumulated due to large number of people working in an unventilated area, leading to increased drowsiness especially in the afternoon, and as a consequence they increased ventilation.

CONCLUSIONS

When address human factors in relation to health and safety, aim to optimize human performance and reduce human failures. Organizations need to take a proportionate approach to human factors in risk assessment based on their hazard and risk profile. Identifying the potential for human failure in preventing an accident or exposure to substances hazardous to health requires having a thorough understanding of the task the person is carrying out.

To prevent or reduce the chance of such failures you have to know what the failures are and what causes them. These failures form a 'chain' that leads from people in the company who made decisions long before an incident or accident to the person who seems to be immediately responsible. The understanding of this chain is needed in order to move logically forwards along it – to do risk assessments; and backwards – to do accident investigations.

Applying ergonomics to the workplace can reduce the potential for accidents, reduce the potential for injury and ill health and improve performance and productivity.

Taking account of ergonomics and human factors can reduce the likelihood of an accident. Ergonomics can also reduce the potential for ill health at work, such as aches, pains and damage to the wrists, shoulders and back, noise-induced hearing loss and work-related asthma. The layout of controls and equipment – they should be considered positioned in relation to how they are used. Placing those used most often where they are easy to reach without the need to stoop, stretch or haunch. Making sure protective

measures such as extraction hoods or respirators are easy and comfortable to use means they are more likely to be effective at reducing exposure to hazardous substances.

The information collected highlights how companies involved in the our project avoid many well-known accidents following ergonomics principles, but sometimes they don't pay much attention to the potential risk of hazards, such as in the case of the missed signboard "wet floor". Many accidents might have been prevented if ergonomics and human factors had been considered in designing people's jobs and the systems they worked in.

The conclusion is that proper consideration of 'human factors' is a key ingredient of effective health and safety management. Human factors interventions will not be effective if they consider these aspects in isolation. The scope of what we mean by human factors includes organizational systems and is considerably broader than traditional views of human factors/ergonomics. Human factors can, and should, be included within a good safety management system and so can be examined in a similar way to any other risk control system.

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REFERENCES

1. Bongers, P.M., Kremer, A.M., ter Laak, J. (2002): Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist? A review of the epidemiological literature. Am. J. Ind. Med. 41, pp. 315–342
2. Chapanis, A. (1996): Human Factors in Engineering, New York,Wiley
3. Chapanis, A. (1999): The Chapanis Chronicles: 50 Years of Human Factors Research, Education, and Design, Santa Barbara, CA: Aegean Publishing Co
4. Edolm, O.G. and Murrell, K.F.H. (1974): The Ergonomics Socicty: A History, 1949 – 1970, London, Taylor & Francis, Published as a supplement to Ergonomics
5. Ergonomics Abstrac, (2004): Ergonomics Information Analysis Centre (EIAC), School Of Manufacturing and Mechanical Engineering, University Of Birmingham, Birmingham, B15 2TT, UK
6. Grandjean, E. (1986): Fitting the task to the man: An ergonomic approach, London,Taylor & Francis
7. Griffin, R.W. (2001): Management, 7th edn, Boston, MA: Houghton Mifflin
8. Hagberg, M., Silverstein, B., Wells, R., Smith, M.J., Hendrick, H.W., Carayon, P., Perusse, M. (1995): Work Related Musculoskeletal Disorders (WMSDs): A Reference Book for Prevention, London Taylor & Francis
9. Haims, M.C., Carayon, P. (1998): Theory and practice for the implementation of 'in-house', continuous improvement participatory ergonomic programs, Appl. Ergon. 29, pp.461–472
10. Haines, H., Wilson, J.R., Koningsveld, E. (2002): Validating a framework for Participatory ergonomics (the PEF), Ergonomics 45, pp.309–327
11. Halpern, C.A., Dawson, K.D. (1997): Design and implementation of a participatory ergonomics program for machine sewing tasks, Int. J. Ind. Ergon. 20, pp.429–440
12. Helander, M.G. (1997): A forty years of IEA: some reflections on the evolution of ergonomics, Ergonomics, 40, pp.952 – 961
13. Helander, M.G. (1997b): The Human Factors profession, In Handbook of Human Factor and Ergonomics, G. Salvendy (Ed.), pp.3 – 16 (New York: Wiley)
14. International Ergonomics Assosiation (2003): IEA Triennial Report 2000 – 2003, Santa Monica, CA: IEA Press
15. International Ergonomics Assosiation (2004): www.iea.cc.
16. Jastrzebowski W.B. (1857) [1997]: An outline of ergonomics, or the science of work based upon the truths drawn from the science of nature, (Published in Polish, in four parts), Nature and Industry, 29,

pp.227 – 231; 30, pp.236 – 244; 31, pp.244 – 251; 32, pp.253 – 258, English translation published in 1997, Warsaw: Central Institute for Labour Protection
17. Karwowski, W. (1991): Complexity, fuzziness and ergonomic incompatibility issues the control of dynamic work environments, Ergonomics, 34, pp.671 – 686
18. Karwowski, W. (Ed). (2001): International Encyclopedia of Ergonomics and Human Factors, London,Taylor & Francis
19. Karwowski, W. (2005): Ergonomics and human factors: the paradigms for science, engineering, design, technology and management of human-compatible systems, Ergonomics, 48:5, pp.436-463
20. Karwowski, W. and Rodrik D. (2001): Physical tasks: analysis, design and operation, In Handbook of Industrial Engineering, 3rd edn., G. Salvendy (Ed), pp.1041 – 1110, New York: Wiley
21. Kuorinka, I. (1997): Tools and means of implementing participatory ergonomics, Int. J. Ind. Ergon,19, pp.267–270
22. Laitinen, H., Saari, J., Kivisto, M., Rasa, P.L. (1997b): Improving physical and psychosocial working conditions through a participatory ergonomic process: a before–after study at an engineering workshop, Int. J. Ind. Ergon, 21, pp.35–45.
23. Nagamachi, M., (1995): Requisites and practices of participatory ergonomics, Int. J. Ind. Ergon. 15, pp.371–377
24. Noro, K., Imada, A.S. (Eds.), (1991): Participatory Ergonomics, London, Taylor & Francis
25. Reynolds, J.L., Drury, C.G., Broderick, R.L. (1994): A field methodology for the control of musculoskeletal injuries, Appl. Ergon, 25, pp.3–16
26. Sanders M.S. & Mccormik E.J. (1987): Human Factors in Engineering and Design, 7th edn, New York: McGraw-Hill
27. Salvendy G. (Ed.), (1997): Handbook of Human Factor and Ergonomics, 2nd edn, New York,Wiley
28. Simon, S.I., Leik, M. (1999): Breaking the safety barrier: implementing culture change, Prof. Saf. 44, pp.20–25
29. Vincente K.J. (2004): The Human Factor, New York, Routledge
30. Wells, R., Norman, R., Frazer, M., Laing, A. (2004): University of Waterloo ergonomics program implementation blueprint, /http:// www.ergonomics.uwaterloo.ca/bprint.htmlS, (12 /05/2013)
31. Wilson, J.R. and Corlett, E.N. (Eds.), (1995): Evaluation of HumanWork: A Practical Ergonomics Methodology, 2nd edn. London, Taylor & Francis
32. Wilson, J.R., Haines, H.M. (1997): Participatory Ergonomics, In:Salvendy, G. (Ed.), Handbook of Human Factors and Ergonomics, Wiley, New York, pp. 490–513