HUMAN FACTORS

BRIEFING NOTE No. 8

Ergonomics

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance. 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. Source: International Ergonomics Association (IEA), website: http://www.iea.cc

Why ergonomics?

In the introduction to *Ergonomics*, KFH Murrell makes it clear that it is a subject that continually incorporates information and technologies from other domains if they contribute to understanding and improving human performance. He goes on to say that ergonomics should create an awareness in industry of the importance of human factors when planning work and that the overall purpose of ergonomics is to increase the efficiency of human activity.
Source: Murrell, KHF (1965), *Ergonomics*. Chapman and Hall.

- Physical ergonomics is concerned with working postures, materials handling, repetitive movements, work related musculo-skeletal disorders, workplace layout, safety and health.
- Cognitive ergonomics is concerned with mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training.
- Organisational ergonomics is concerned with communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, virtual organisations, telework, and quality management. Source: Text edited – from IEA (http://www.iea.cc)

Cognitive and organisational ergonomics are explored in other briefing notes. This briefing note focuses on physical ergonomics.

Are you aware of any of these problems in your company?

If the answer to any of the following questions is 'Yes', then you should take action!	Yes	No
1. Is your company poor at giving training or advice on lifting and carrying heavy items?		
2. Is there pressure from management or others to get the job done and not be concerned about possible physical strains?		
3. Do members of the workforce get pains in their arms, legs, back or neck when they use certain tools or do certain jobs?		
4. Are a lot of maintenance (or other) jobs made more difficult because of the location and layout of the equipment or through having to work in an awkward position?		
5. When a job involves operating controls, is it sometimes unclear to the user what some of the controls do and what will happen when they operate them?		
6. Could a control be easily operated accidentally - by knocking into it, or through confusion (caused by where the control is positioned or how it is labelled)? Would it be dangerous if this happened?		
7. Are some controls and display devices in the wrong place so that it is difficult to reach or see them?		
8. Is it unclear how certain groups of controls and displays relate to each other and why they are grouped that way?		
9. Could the displays used – gauges, screens, logs etc. – provide more or better quality information?		
10. Are computer systems difficult to use to put information or commands into, or to get information out of?		
11. Are any of the areas where people work badly lit, noisy, too hot or cold, or cramped so that they can't do the job properly? (Poor lighting can mean too bright or too dark).		
12. Do management seem to give low priority to doing anything about reported ergonomic problems?		

What should my company do about it?

You may have heard the expression 'ergonomically designed', maybe in an advert or in a magazine. There is no strict definition of this term, but it generally means that designers of a workplace, tool or piece of equipment have made the effort to gather information on typical users – their size, strength, abilities and expectations – and designed the item to suit. They may even have carried out tests with a group of users to make sure that what they have designed is acceptable. No system will be perfect, though. In any group, some people find certain equipment difficult to use or in the wrong place, whilst others will have no problem. Your company should, however, be aware of the more serious problems and be prepared to change a design or the way people work to reduce the risk of discomfort, injury/health problems or errors that could have process or personal safety consequences.

Management responsibility

Management should act on problems caused by poor ergonomics, and improve working conditions and equipment. People working with poorly designed devices do get used to them and adapt, but this is not acceptable. Managers should get specialist advice and decide whether to change such systems or to leave well alone. Four ergonomic aspects should be considered: musculo-skeletal problems; problems with displays; problems with controls; and workplace and working environment.

Musculo-skeletal problems

Includes aches, pains and other discomfort from physical work, often where power tools are used. The terms repetitive strain injuries (RSIs) and work related upper limb disorders (WRULDs) are also used. The company should:

- Ensure that equipment is fit for use and does not produce excessive strain or vibration.
- Where equipment cannot be changed, provide additional protection or support equipment to reduce the problem.
- Review tasks that force or encourage employees into an uncomfortable posture for long periods (stooping, kneeling, crouching, twisting, stretching, bending etc.) or where heavy or awkward loads need to be lifted and carried; redesign tasks where possible or provide additional equipment and tools.
- Schedule work and rest breaks to allow recovery from unavoidably strenuous work or tasks that require the use of equipment that may not be ideal.

Problems with displays

A display is any device that provides information to the operator. Displays are mainly visual and include: status lights, dials, digital readouts, pen recorders, visual display unit (VDU) screens and mimic boards. Audible displays are pre-recorded messages or tones. Note that the information given here is similar to that for controls. The company should:

- Provide the correct type of display for the information to be passed e.g. avoid a 'pointer and dial' if you need to take an exact reading – a numeric display would be better for this.
- Displays should work as the user expects them to – e.g. a pointer moving clockwise or to the right means an increase in flow, temperature or pressure etc.
- Group displays logically, that is, put all the displays for one system near to each other and in the order they are to be used.

CASE STUDY 1

The valve photographed was originally designed to be mechanically rather than manually operated. A handle was added which could be, and was, put on incorrectly. In the position shown – handle at 90° to the valve – the valve appears closed but is actually open. When work was carried out on a pump believed to be protected by this 'closed' valve, pressurised alkylate was released and caught fire. Six employees were injured and damage to the refinery amounted to US$13m. Users expect consistency in the equipment they use. Here, they assumed the handle position meant 'closed'.

Source: Centre for Chemical Process Safety 'Beacon' June 2006 http://sache.org/.

- Put the display devices near to any associated controls e.g. if a control increases flow, put the flow gauge next to it.
- Label each display and use colour or other coding to enhance displays e.g. show danger zones on dials, but don't rely on this as the only warning of danger.

Problems with controls

A control is anything that the operator uses to operate a system – switches, levers, handles, wheels, knobs, sliders, keyboards, joysticks etc. The company should:

- Provide the correct type of control for the job to be done – e.g. a foot pedal if a lot of force needs to be applied, switches or selector knobs for making settings, etc.
- Controls should work as the user expects them to – e.g. pushing a switch down turns the machine on, turning the wheel on a valve anti-clockwise opens it. Exceptions, e.g. reverse threads, should be made clear.
- Group the controls logically – that is, put all the controls for one system near to each other and arranged in the order they are to be used and according to frequency of use, if possible.
- Put controls where they can be easily reached and operated: protect any that should not be accidentally operated (cover with a flap, put in a recess or make the operation a double action – e.g. release with a key then turn).
- Label each control so that its function and the movement required to operate it is clear e.g. 'emergency shut down'; 'open flap and push down to operate'. Use appropriate colour coding – e.g. red buttons to stop.

Workplace and working environment problems

Physical workspace and conditions. The company should:

- Control temperature – not so warm as to encourage drowsiness; not so cold as to affect grip on tools or operation of equipment.
- Control air movement – to provide fresh air; to provide cooling if needed.
- Control vibration – to prevent annoyance, injury (white finger, carpal tunnel syndrome, back pain), or effects on vision – e.g. problems seeing displays in vehicles that vibrate whole body.
- Control lighting – not too dark to see; not too bright to cause glare (bright spots).
- Control noise – to allow good communications and reduce annoyance/ hearing damage.
- Control workspace – not too cramped to cause discomfort or injury, even if using personal protective equipment (PPE) or other safety equipment; equipment within easy reach and not spread over a large area.

Testing mice and keyboards - Chevron's Ergolab. Courtesy of Gavon Goulder.

CASE STUDY 2

A number of ergonomic design problems relating to the man-machine systems at the Texas City site contributed to the unsafe start-up of the isomerisation unit. These included: a poorly designed computerised control system that, "hindered the ability of operations personnel to determine…overfilling"; "on the day of the incident…the computerised control system display provided neither flow data in and out of the…unit on the same display screen, nor a material balance calculation"; "critical alarms and control instrumentation provided false indications that failed to alert the operators of the high level in the tower".

Source: Chemical Safety and Hazard Investigation Board's Report No. 2005-04-I-TX Refinery Explosion and Fire. http://www.csb.gov.

Measuring performance

Below is a sample of performance indicators that could potentially be used to monitor how effectively ergonomics issues are being managed, divided into leading indicators (showing that a problem may occur in future) and lagging indicators (showing that there is currently a problem). See Briefing note 17 *Performance indicators* for more information on using performance indicators.

Leading indicators	Lagging indicators
Strategy in place to integrate ergonomics in design projects and compliance with human factors integration plan, based on review of site activities, interviews, and documentation. Human factors assessment tools available and used within the organisation. Number of items of equipment non-compliant with ergonomic standards (based on spot check). Number or percentage of design reviews with defined team competencies including human factors/ergonomics specialist knowledge. Compliance of equipment/ workplaces with ergonomic environmental design requirements (lighting, noise, etc.) based on sample audits.	User feedback on systems identified as not fit for purpose or not user friendly. Human errors or 'workarounds' related to design problems. Task or equipment design-related injuries or ill-health reported. Number of items not accessible for maintenance (ergonomic considerations for accessibility have not been addressed). Number of repeat incidents/ accidents associated with specific equipment (NB: repeated problems may be indicative of a problem in the design). Number of design issues raised on issues register.

CASE STUDY 3

Users of video display terminals (VDT) in an organic chemicals company were suffering ergonomics-related injuries and illnesses. Changes to the VDT workstations improved matters but as the users and equipment changed constantly, improvements were short-lived.

The company decided that all VDT users should be required to have a certificate obtained following training and hands-on exercises.

Users are now responsible for their own VDT problems and have access to additional equipment, accessories and ergonomics experts to help.

VDT use has risen but related injuries and illnesses have decreased – to zero!

Source: OSHA – website - http://www.osha.gov.

Further reading

- The Institute of Ergonomics and Human Factors, http://www.ergonomics.org.uk.
- HSE, free leaflet *Understanding ergonomics at work*, http://www.hse.gov.uk/.
- HSE, *Control room design,* http://www.hse.gov.uk/comah/.
- HSE (1999), *Reducing error and influencing behaviour*, HSG48, HSE Books.
- HSE (2002), *Work-related upper limb disorders: a guide to prevention*, HSG60 HSE Books.
- HSE (1994), *Manual handling: solutions you can handle*, HSG115, HSE Books.
- ISO 11064-2000, *Ergonomic design of control centres* (in seven parts concerned with design principles, layout, workstation design, displays and controls, and, working environment).
- Defence Standard 00-25, *Human factors for designers of equipment* (various parts and publication dates).

For background information on this resource pack, please see Briefing note 1 *Introduction*.