HUMAN FACTORS

BRIEFING NOTE No. 23

Workload and staffing levels

Workload can refer to the physical or mental effort required to carry out a task. Staffing level is concerned with ensuring the correct number and type of personnel are in post for all tasks.

Why workload and staffing levels?

High workload and inadequate staffing, and the effects these have on fatigue and decision making, have been cited as causes of major accidents (see Case Study 1). Organisations should ensure adequate staffing levels in order to effectively manage workload – not just physical workload but also mental workload.

Does your company have problems with workload or staffing levels?

If the answer to any of the following questions is 'Yes', then you should take action!	Yes	No
1. Are you/colleagues regularly involved in physical work that leaves you/colleagues 'overloaded' meaning:		
• too much effort is required – at the limits of strength or endurance?		
• workload is constant – no, or few, breaks?		
• task location is cramped or physically difficult to work in?		
• tasks require a lot of walking, climbing (stairs/ladders), carrying tools or equipment or other strenuous physical activity even before the job starts?		
• no tools are provided to reduce workload or inadequate tools are provided?		
2. Do any of your/colleagues' regular tasks require 'mental' activity, for example, making calculations, multi-tasking, creative thinking or problem-solving, and:		
• the tasks are very demanding (require much concentration)?		
• tasks need to be done simultaneously or closely in time?		
• you/colleagues feel stressed performing these tasks (failure would be a significant problem)?		
• you/colleagues are not fully trained or competent in all these tasks?		
• there are no tools or job aids to help you/colleagues?		
3. Have you or others conducting such work committed major errors in making calculations, decisions, judgements or planning?		
4. Are operators sometimes 'under-loaded', that is, do not have enough to do to maintain their interest in the job and may just 'switch off'?		
5. Is there generally too much work such that safety-important tasks are:		
• carried out too quickly or steps in the task are skipped?		
• carried out by unskilled or inexperienced operators?		
• frequently postponed or missed altogether?		
6. Is workload and staffing estimated on the basis of 'steady-state' operations only, and not on requirements for abnormal or emergency operations?		

What's the problem?

Some industrial tasks involve high physical workload: lifting, carrying, pushing, pulling or other sustained physical effort or a large number of physical tasks that have to be done in a given time. Such tasks could result in fatigue, injury or ill-health or the inability to work any longer. Working in a cramped or restricted environment can add to physical workload.

Some tasks require more mental than physical effort: problem solving, decision making, judging, analysing or activity requiring sustained attention or vigilance. These can be taxing and cannot be sustained successfully for a long period of time. The presence of time pressure or other stressors can increase such workload leading to poor quality of problem-solving, decision-making and, thus, errors. Mental workload can also be too low: the operator may become bored or demotivated and fail to perform effectively when carrying out an unstimulating or repetitive task.

Staffing levels – meaning both the number and type of people required – should be matched to the work required. Reference 1 describes staffing as 'having the right people in the right place at the right time. Having staff in sufficient numbers and with suitable competencies, knowledge, skill and experience to work safely'. Staffing arrangements also need to consider the balance in sharing tasks; overload of one or more team members or assigning the 'best' jobs to one group can lead to resentment, demotivation and dissatisfaction.

All of these aspects of work planning are important to ensure safe reliable operation. Physical workload can be estimated or measured fairly easily and objectively; staffing can be determined also fairly easily and is the subject of Reference 1 and Reference 2; hence, the focus of this briefing note is on mental workload which can be more difficult and subjective to estimate.

CASE STUDY 1

Issues identified to the Independent Safety Review Panel for Texas City included:

'[. . .] management of fatigue. Our information indicates that on the day of the incident, some BP operators had worked 30 days straight, 12 hours per day, some with two-hour commute times.

[. . .] the downsizing of both supervision and training. For example, BP Texas City went from 38 trainers in 1998 to just nine in 2005. And on the day of the incident there was no supervisor with appropriate experience overseeing key phases of the start-up operation.

[. . .] workload management. On March 23, a single board operator was responsible for simultaneously running the controls of three different complex process units, including the isom unit that was starting up.'

Source: statement for the BP Independent Safety Review Panel, Carolyn W. Merritt, Chairman & CEO, U.S. Chemical Safety and Hazard Investigation Board, Houston, Texas, November 10, 2005, *http://www.csb.gov/statement-from-carolyn-w-merritt-chairman-and-ceo-u-s-chemical-safety-board-on-the-release-of-the-bp-refineries-independent-safety-review-panel-report/*

CASE STUDY 2

'The ops manager of a petrochemical plant requested a stress management course for control room operators. He explained that the stress problems had occurred since they combined two control rooms into one, and reduced staff numbers. A cursory visit to the 'new' control room revealed it was an ergonomic nightmare, with one screen in front of the operator and another behind him. The third display needed binoculars to read, it was so far away. It was a 'cognitive disaster area'. The manager requested a study to confirm staffing levels required but was [advised that no study was required] it was clear he needed one more person in the control room. He obtained an additional person in the control room, and with some minor ergonomic changes, the problem went away.'

Source: personal experience of a human factors specialist

What should my company do about it?

Management should identify, measure (see methods for workload analysis) and bring under control any situations where cognitive workload is high, such as when an individual is required to:

- diagnose a problem and develop an effective solution to the problem, where the problem is complex or there are a lot of problems to solve;
- process multiple sources of information and make difficult decisions;
- apply fine judgement or discrimination;
- remember (store) or recall (retrieve from memory) lots of facts or pieces of information;
- apply sustained attention or vigilance/monitoring, and
- maintain a high level of situational awareness – of the current state of a process and of the correct response if plant state changes.

Management should be aware that the above are made more difficult if:

- performed under time pressure (the task is required in a short space of time or has to be sustained for a long period of time);
- operators are required to multi-task;
- operators are not yet fully competent in the task, for example, they have not been able to practise skills acquired in classroom training;
- conducted in unusual or emergency conditions;
- information available is unclear or ambiguous, provided late or requires some form of conversion or pre-processing;
- the result of the activity is critical to safety, environmental protection or financial success, and
- the operator is fatigued or distracted – for example, by the work environment or personal circumstances.

Mental overload can result in:

- errors – poor judgements, inappropriate plans or actions leading to incidents or accidents;
- stress or mental health issues – anxiety, depression;
- dissatisfaction, poor morale and commitment – possibly leading to absenteeism or high staff turnover, and
- poor performance.

(See also Reference 3.)

Cognitive 'under-loading' can lead to:

- boredom, loss of job satisfaction, demotivation and errors;
- 'thrill seeking' or creating/finding (inappropriate) tasks to make the job more interesting, and
- de-skilling through lack of practice or mental exercise.

Management should ensure that:

- staffing levels are appropriate for normal situations – that there are sufficient staff to carry out all required tasks;
- staffing levels are appropriate for unusual or emergency situations, in which more personnel may be required than normal conditions, and personnel must have the skills to carry out their emergency role;
- downsizing considers how all functions are to be carried out effectively by remaining staff and that remaining staff are not overloaded (see also Reference 4), and
- they do not rely on only the 'local catchment area' for staff but employ operators who are well-matched to the tasks (plant in remote, lightly populated areas may not have a readily available skilled workforce).

Management responsibility

Management should understand the key drivers of physical and mental workload – as outlined in this briefing note – and be aware of the need to optimise workload and staffing levels. They should gather sufficient information to gauge the problem in their own areas of responsibility and recognise the effect of their decisions, or those of other managers or supervisors, on these topics. For example, changes in work content or changes to the organisation – whether temporary or permanent – can lead to higher workload or a shortage of skilled and experienced staff, particularly in safety-critical tasks. They should also be aware that small, gradual, changes can add up unnoticed and without proper consideration of the likely impact on workload.

To achieve this, management should have in place sufficient means of gathering and processing data (for example: adequate performance measures; reporting systems; discussion and observation; review of incident records, and workforce involvement) to establish the extent of the problem.

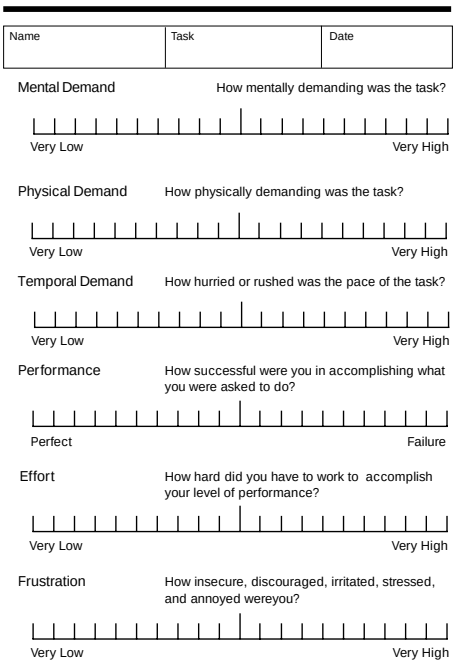
Management should also be familiar with and able to apply (with external help if necessary) specific methods for analysing workload and staffing. Some of these are described below.

Methods for workload analysis

The following methods – chosen on the basis that they are well-known and likely to be applicable to the process industries – enable cognitive workload to be estimated.

NASA TLX (National Aeronautics and Space Administration task load index) – is a method for rating tasks by the person carrying out the tasks. It is available as a 'pencil and paper' method or as a computer application. The task performer is required to rate the task on scales such as mental-, physical- and temporal- 'demand', performance, effort and frustration. As well as the rating of the scale, the operator must weight each scale to indicate its impact on a particular task or tasks. For example, in one set of tasks, mental demand may be the most important contributor to task workload; frustration may be the next most important, and so on. The overall score for workload is a combination of the rating and the weighting on each scale and the overall score for all scales added together. Simplified versions of the method such as RTLX (raw TLX) have been developed.

For more information on the method, see http://humansystems.arc.nasa.gov/groups/TLX/



A NASA-TLX self-assessment form

ISA (instantaneous self-assessment of workload) – was developed for air traffic control but can be applied to other complex tasks. It can be used as a pencil and paper technique or run on 'smart' devices (tablets, etc.). Operators are asked to rate how busy they are on a five-point scale, from 'underutilised' to 'excessive'. The rating is done 'live' when undertaking a task: the operator chooses a rating at regular intervals (e.g. every five minutes). The ratings are logged to indicate how workload varies over time.

For more information on the method, see *http://www.skybrary.aero/bookshelf/books/1963.pdf*

SWAT (subjective workload analysis technique) is a method that can be used instead of NASA TLX. Using SWAT, there are three dimensions of workload: 'time', 'mental effort' and 'psychological stress' (TES). These are rated on a 3-point scale – for example, T1 ('often have spare time'); T2 ('occasionally have spare time') or T3 ('almost never have spare time'). This means 27 possible combinations of load can be generated on these scales. The

operator is required to rank these combinations from the one that represents, to them, the least workload to the one that represents the most workload. For one operator, '1, 1, 2' might rank lower in terms of workload than '1, 2, 1'. This ranking is converted by computer into a rating scale. An operator then scores specific tasks to determine the workload that task represents to the operator.

For further information, see Reference 5.

Methods for physical workload analysis

Physical workload can be measured in various ways; some can be used off the shelf, others require training or professional application. Examples are:

- manual assessment charts – for manual handling tasks; see http://www.hse.gov.uk/msd/mac/scoresheet.htm
- 'snook tables' – for manual handling; see https://libertymmhtables.libertymutual.com/CM_LMTablesWeb/pdf/LibertyMutualTables.pdf

Physical workload can also be measured using heart rate monitors, 'electromyograms' (muscle activity) and oxygen consumption measurements. These advanced work physiology measures would likely be used only in special cases.

Methods for determining staffing levels

- Timeline analysis – see Reference 6.
- Entec safe staffing – HSE http://www.hse.gov.uk/research/ crr_pdf/2001/crr01348.pdf (also see Reference 2).
- HSE briefing note (Reference 1).

Measuring performance

Below is a sample of performance indicators that could potentially be used to monitor problems with workload and staffing, 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
Workload measurements Enforced or unexpected changes to workload or staffing Observed behaviours or conditions in control rooms or other workplaces	Reports from workforce regarding problems (may need to seek these out and not wait for them to be reported) Staffing level assessment Incident and accident records Absence or resignation records

CASE STUDY 3

A study conducted by St George's University of London, based on almost 300 000 emergency admissions, found that a key factor determining whether a patient is likely to survive 30 days after emergency surgery is the number of consultant doctors and nurses working. Hospitals with higher staffing ratios had the best outcomes in terms of patients' survival rates.

In the study, the best performing hospitals in the study had 60 per cent fewer deaths. This was attributed to 40 per cent more surgeons per bed, 38 per cent more junior doctors per patient admitted, and 24 per cent more nurses per bed, even though the better performing hospitals treated a higher number of patients with significant pre-existing medical problems.

Source: BBC website, http://www.bbc.co.uk/news/health-35108282

References

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2. Energy Institute, *Safe staffing arrangements – user guide for CRR348/2001 methodology: Practical application of Entec/HSE process operations staffing assessment methodology and its extension to automated plant and/or equipment*.
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5. Potter, S. (1989), *Subjective workload assessment technique (SWAT): A user's guide*
6. Energy Institute, *Human factors briefing note 11: Task analysis*, https://publishing.energyinst.org/topics/process-safety/folder-example/human-factors-briefing-note-no.-11-task-analysis
7. HSE, *Assessing the safety of staffing arrangements for process operations in the chemical and allied industries*, http://www.hse.gov.uk/research/crr_pdf/2001/crr01348.pdf

Further reading

- Energy Institute, *Managing fatigue using a fatigue risk management plan (FRMP)*, https://www.energyinst.org/technical/human-and-organisational-factors/human-factors-fatigue
- Byers, JC, Bittner, AC Jr., Hill, SG (1989), *Traditional and raw task load index (TLX) correlations: Are paired comparisons necessary?*, in Advances in Industrial Ergonomics and Safety I, pp 481-485.
- HSE, Fatigue and risk index calculator, http://www.hse.gov.uk/research/rrhtm/rr446.htm
- HSE, RR107, *Development of internal company standards of good management practice and task-based risk assessment tool for offshore work-related stressors.*