IMPROVING ALERTNESS THROUGH EFFECTIVE FATIGUE MANAGEMENT

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FOREWORD

According to the Health and Safety Executive (HSE), fatigue from shiftwork and overtime is one of the 'top ten' key human factors topics to be addressed by onshore major hazards industries[1].

Recognising the importance of this issue, HSE has published HSE *Managing shift work,* as an aid to industry. It includes information and advice on fatigue issues including: legal obligations; how to conduct a risk assessment; and how to plan and organise shiftwork.

HSE's publication is clear and helpful and should enable all employers and employees to understand the problems of fatigue – in particular, those specifically relating to shiftwork – and to develop practical solutions.

The EI Human Factors Working Group has also identified fatigue as one of its priority issues for attention and has already developed some resources to help the industry understand and deal with fatigue; for example, IP *Workshop on fatigue* and IP *Human factors briefing note No.5: Fatigue*.

This publication has been developed to supplement HSE's work with information derived from the latest research, practical applications and case studies on alertness and fatigue relevant to all sectors of the petroleum industry from offshore exploration and drilling to distribution. It will also be useful for allied industries and draws on examples from many different industries to illustrate the problem and some potential solutions. The steps taken to manage fatigue risk will need to be as multi-faceted as the problem itself.

A key objective of this publication is to bring together the most accurate and industry-relevant information in one place so that employers and employees can:

— Identify factors in their own workplace that could lead to fatigue/reduced alertness.
— Identify means of avoiding fatigue or reducing its likelihood (e.g. using checklists).
— Where fatigue is unavoidable, consider a number of 'coping' strategies that they could use.
— Perform risk assessments and accident investigations that take into account possible fatigue-induced problems.

Readers should note that, according to recent research, publications, such as this one, on their own are rarely sufficient to change the habits and behaviours of people. To make lasting changes, participation between employers and employees within a campaign of education – using publications as key sources of information – is likely to be required.

[1] The HSE's Hazardous Installations Division's Human Factors team identified the following priority human factors issues for major hazards industries as:

— Organisational change.
— Staffing levels and workload.
— Managing human failures.
— Fatigue from shiftwork and overtime.
— Procedures.
— Training and competence.
— Communications and interfaces.
— Organisational culture.
— Integration of human factors into risk assessment and investigations.
— Human factors in design.

Also see IP *Top ten human factors issues facing major hazard sites*.

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1

INTRODUCTION

This section describes the problem of fatigue and how that problem manifests itself in health and safety consequences using case studies and research findings. It offers two definitions of fatigue and describes the overall structure and purpose of this publication.

1.1 BACKGROUND

HSE *Managing shift work* provides a comprehensive review of the issues relating to shiftwork in industry in general. It sets out the duty of employers and employees under UK and European law, describes the key issues relating to shiftwork and sets out a risk assessment method based on HSE *Successful health and safety management*. The publication includes appendices describing various tools and strategies that could be used to avoid or reduce the adverse effects of shiftwork and suggests a number of sources of information and help.

The purpose of this publication is to supplement the HSE publication but with a more direct focus on fatigue and alertness issues within the petroleum and allied industries. It is a stand-alone publication referencing industry-specific research and case studies; however, the HSE publication should also be consulted by anyone interested in current fatigue and alertness issues.

1.2 THE FATIGUE PROBLEM

Fatigue can lead to accidents because it directly affects a number of the key physical and mental abilities needed to carry out even fairly simple tasks; for example, fatigue can result in:

— impaired concentration;
— irritability;
— poor judgment;
— reduced hand-eye coordination;
— reduced visual perception;
— reduced vigilance; and
— slower reaction times.

These effects occur when a person is fatigued – they are not permanent and may be reduced or eliminated when the person is fully rested.

Fatigued people are less able to respond to unusual or emergency conditions effectively. They are also more likely to take risks.

Clearly, this is a problem in a workforce responsible for controlling major hazard installations, but a fatigued person could be a danger to themselves and others, for example, dangerous goods tanker drivers.

There have been several high-profile accidents where fatigue was identified as either causal or contributory. For example, although alcohol is often cited as the central reason in the Exxon Valdez marine grounding, the National Transportation Safety Board investigation identified fatigue as one of the probable causes of the accident. Similarly, circadian[1] factors were identified as contributing to the errors that resulted in the nuclear accidents at Three Mile Island and Chernobyl. Fatigue resulting from the work–rest patterns of managers was

also acknowledged as an important component of the flawed decision-making that contributed to the space shuttle Challenger accident.
Howard et al (2002)

As a more everyday example of the problem, most drivers will have experienced fatigue while driving:

A survey of car drivers in the United Kingdom found that 29% admitted to having felt close to falling asleep while driving in the previous year.

Among New York drivers about a quarter reported having at some time fallen asleep at the wheel.

About a third of truck drivers responding to a national survey in Australia reported that fatigue was a substantial problem.

A French study showed that 10% of almost 68 000 serious road crashes in good conditions affecting only one vehicle were related to fatigue.
Philip (2001)
Courtesy of British Medical Journal

This publication will show that shiftwork has been identified as a major contributor to fatigue problems and that shiftwork may also have other untoward effects on the shiftworker. This is a problem because shiftwork is unavoidable in many industries.

Shift work is essential for the chemical industries. At issue in the area of shiftworkers' health is how to harmonise the necessities of the chemical industries and workers' demands for maintaining their health and improving their quality of life. Shiftworkers often suffer from sleep deficits and sleep disorders. Stress and accumulated fatigue are major causes of risk to their health and are linked to occupational injuries. More shiftworkers than day workers are diagnosed with diseases.
ILO *Best practices in work - flexibility schemes and their impact on the quality of working life in the chemical industries.*
Courtesy of International Labour Organization

The effects of fatigue can be verified and are so widespread that they should not be ignored. It is clear also that individuals do feel the effects of fatigue before it leads to more severe outcomes.

A recent questionnaire survey of 41 offshore installations disclosed that the workforce:

...identified fatigue due to shift work and stress about work as the factors most affecting their health in the offshore environment
HSE *Health and well-being in the offshore environment: The management of personal health*

The report includes some direct quotes from the workforce and their perceptions are interesting, for example:

"We do far too much time offshore to be in good condition (mind and body)...I'm coming to the end of my trip and I'm very tired. I've lost lots of sleep due to shiftwork...there is still pressure to get things done fast on drilling rigs thereby causing stress and probably accidents"

Research groups recognise that poorly-managed shiftwork is associated with long-term health effects in the workforce including:

— cardiovascular disorders;
— gastrointestinal disorders; and
— childbirth problems - miscarriage, low birth weight and premature delivery.

It should be noted that research in this area is not always conclusive or in agreement. Furthermore, some of the links between poorly-managed shiftwork and health issues, for example childbirth problems, are not as strong as others; however some organisations are taking the right steps to reducing the problem. Continuing the earlier example:

Several models for designing less onerous shift cycles exist. Where employers' and workers' representatives have collaborated in developing a shift-work system, success has been more likely, particularly when health and other experts are also involved.

Successful shift reform needs to take into account age, safeguarding jobs, stress reduction, maintaining productivity and improving quality of life.
ILO *Best practices in work - flexibility schemes and their impact on the quality of working life in the chemical industries.*
Courtesy of International Labour Organization

[1] Certain biological processes in the human body take place at certain set times of day. This includes production of the sleep-inducing hormone melatonin. Fighting against these natural rhythms, for example, attempting to sleep during the day or stay awake at night, is difficult and the end result is a less than fully alert worker.

This 'shift reform' is in direct response to problems found in the industry and, importantly, the solution was based on management and workforce collaboration.

1.3 FATIGUE DEFINITIONS

It is difficult to find an all-embracing and universally accepted definition of fatigue, but generally, fatigue is:

...a combination of symptoms including: impaired performance (loss of attentiveness, slower reaction times, impaired judgment, poorer performance on skilled control tasks and increased probability of falling asleep) and subjective feelings of drowsiness or tiredness.
ASTB *Options for regulatory approach to fatigue in drivers of heavy vehicles in Australia and New Zealand*

According to HSE *Terms and conditions of employment*, fatigue is:

...a result of prolonged mental or physical exertion; it can affect people's performance and impair their mental alertness, which leads to dangerous errors.

Other definitions exist, but those above usefully include the idea that fatigue is not simply 'tiredness' and that it has a direct effect on attentiveness/alertness.

1.4 CAUSES OF FATIGUE

Fatigue is the primary reason for lack of alertness in a work situation, but it is not the only reason. Alertness levels may be reduced if the working environment is not sufficiently stimulating; this may mean the work itself is tedious or routine or that the working environment is 'too comfortable' and has a tendency to induce sleep in a person who may only be moderately tired.

Fatigue may also arise in tasks that demand intense concentration and mental effort; although such work is not physically demanding it may be difficult to sustain attention on the task for even a short period of time.

Fatigue is made worse when coupled with other factors, in particular, alcohol:

On 20th December 2000:
...the tank barge Bruce Stone collided with the cargo vessel Loverval...

Loverval was secure alongside and in the process of discharging cargo.

Bruce Stone was in ballast; her normal cargo was gas oil...the cause of the accident was Bruce Stone deviating from her intended track because her mate had fallen asleep while on watch...
Contributory causes were:

- *the mate suffering from the effects of fatigue caused by long hours of duty;*
- *lack of quality rest and the alcohol he had recently consumed...*

MAIB *Report 5. Grounding caused by sleeping watchkeeper*

The International Maritime Organization (IMO) believes that fatigue is an inherently difficult factor to investigate and analyse. This is because there is little clear scientific guidance on what fatigue is and how it affects people:

At one time, fatigue was discounted as a potential cause of human error; indeed, a common myth existed that fatigue could be prevented by characteristics of personality, intelligence, education, training, skill, compensation, motivation, physical size, strength, attractiveness, or professionalism. Also, the lack of scientifically accepted information on how fatigue affects not only mood and feelings, but individual and team performance as well, constrained investigators and analysts. Further, guidance on how to investigate for fatigue and build the links between a person's recent history and potential impairment has been lacking. Unlike alcohol and drugs which can be measured by, for example, blood tests, there is no unequivocal physical or chemical test which can tell us that a person was impaired to a certain extent by fatigue.
IMO *Maritime Safety Committee - 70th session*
Courtesy of IMO

But, even in the absence of 'unequivocal tests', the likelihood of a particular shift schedule or overtime/ extra shift leading to fatigue can be assessed and an individual's state of alertness can be determined and appropriate remedies put in place.

1.5 FATIGUE MANAGEMENT

Few organisations are actively addressing the problem of fatigue even to the extent that it is an issue that is largely overlooked in industrial accident and near-miss reports, tending to be overshadowed by more obvious 'primary' causes such as the all-embracing, 'human error'.

Fatigue has been recognised around the world as a contributor to many accidents involving means of

transport. There have been many incidences where fatigue has been suspected of contributing to or causing transportation and industrial accidents; however, that connection was difficult to justify.
IMO *Guidance on fatigue and mitigation and management*
Courtesy of IMO

IMO is an example of an organisation that has taken considerable steps in tackling fatigue and improving incident investigations to consider the effects of fatigue on safety. It has also published guidance on fatigue (IMO *Guidance on fatigue mitigation and management*).

1.6 PROBLEMS IN MANAGING FATIGUE

A major problem with fatigue management is that, those suffering from fatigue are reluctant to admit to it; in particular in an incident investigation.

Fatigue then is a problem that cannot be easily measured and controlled. It is possible, however, to identify and manage fatigue and its causes, but indeed, part of the problem in dealing with fatigue is that there is a bewildering range of material available on the subject: books and articles, guides on legislation, methods for 'measuring' fatigue, and more. Some of this material is inconclusive; some studies seem to contradict each other. A key objective of this publication is to bring together the most accurate and industry-relevant materials in one place so that employers and employees can:

— Identify factors in their own workplace that could lead to fatigue/reduced alertness.
— Identify means of avoiding fatigue or reducing its likelihood.
— Where fatigue is unavoidable, consider a number of 'coping' strategies that they could use.
— Perform risk assessments and accident investigations that take into account possible fatigue-induced problems.

The publication also provides references to additional sources of advice and information on fatigue and on tools and techniques that could be used.

However, some people adopt healthy strategies for reducing fatigue:

"You must sleep somewhere between lunch and dinner, and no halfway measures. Take off your clothes and get into bed. That's what I always do. Don't think you will be doing less work because you sleep during the day. That's a foolish notion held by people who have no imagination. You will be able to accomplish more. You get two days in one – well, at least one and a half, I'm sure."
Sir Winston Churchill

2

FACTORS AFFECTING ALERTNESS

This section describes the key factors that need to be controlled in order to increase alertness/decrease fatigue; these include: hours of work, rest periods within and between shifts, shift patterns, working conditions and work content, with particular reference to factors that might affect those working in the petroleum industry. Specific sub-sections describe issues relevant to the offshore petroleum industry and also driving.

2.1 INTRODUCTION

The following information has been gathered from the best available research and case study sources. It should be noted, however, that the causes of fatigue, their effect on alertness and the most appropriate solutions to the problem of fatigue are not clear cut. What is clear, though, is that employees in any role will find it difficult to remain alert if they work:

— long hours;
— at night;
— without adequate breaks;
— without adequate rest between shifts;
— to an unfavourable shift pattern and if:
  – the work is repetitive/boring and
  – the workplace is warm, dark and comfortable.

The crux of the problem is that to remain alert, human beings need to have had adequate sleep and they need stimulation from their environment and from the activities they are doing provided those activities are not too taxing either physically or mentally.

2.2 LONG HOURS

Working long hours is potentially more fatiguing than working a 'normal' 8-hour shift. 12-hour shifts and 8-hour shifts plus overtime are fairly common in the petroleum and allied industries, and 12-hour shifts, sometimes with overtime, are the norm offshore.

Studies carried out on 8-hour versus 12-hour shifts, particularly where health and safety is concerned, are not entirely conclusive.

In some industries the advantage of moving from 8- to 12-hour shifts is evident from reduced accident rates, fewer shift handovers[2] and workforce preferences for increased breaks. However, long shifts are associated with an increase in on-the-job injuries and may lead to less flexibility for covering sickness, absence and training unless, for example, an extra shift is designed for these specific needs.

Shifts of more than 12 hours should be avoided as accident rates beyond the 12th hour begin to increase significantly, and this is a consistent pattern across different industries.

[2] The greater the number of shift handovers, the greater the risk of miscommunication and lack of continuity in lengthy tasks.

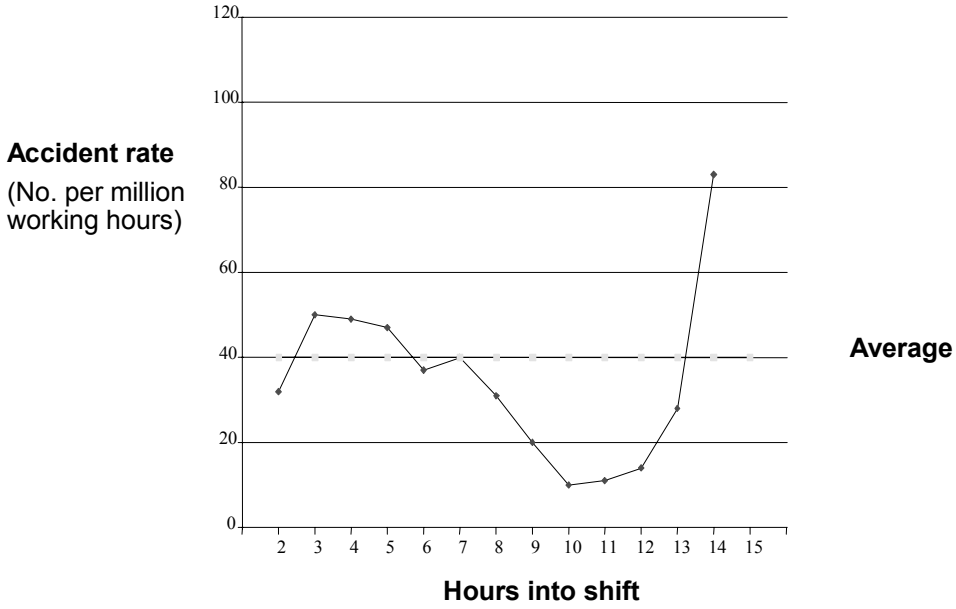

Figure 2.1: Effect of shift duration on accident rate

Figure 2.1 Gall (1996) shows the effects of working long shifts. The example is taken from the coal mining industry and shows two things: first, that there is an increase in accident rates between two and four hours from the start of working; secondly, there is a rapid increase in accident rates towards the end of shifts longer than 12 hours. The first effect has not been adequately explained; the second is almost certainly a result of fatigue.

2.3 SHIFT WORK/NIGHT WORK

Working in shifts is "a method of organisation of working time in which workers succeed one another at the workplace so that the establishment can operate longer than the hours of work of individual workers". There is a virtually unlimited number of potential shift work patterns.
ILO *What is shift work?*

HSE *Managing shift work* indicates that the number of people working shifts in the UK has generally increased over the last 20 years. Across a range of industries, the proportion of the workforce working shifts varies, but, in general, around 15% of the total UK workforce is engaged in some form of shiftwork most of the time; this work requires them to work at night. In the energy and water industries, it is around 19% and in the transport industry, nearer 30%. See Office for National Statistics *Changes in working trends over the last decade*.

2.4 TYPES OF SHIFT PATTERN

Some workers are on permanent night shift or work a 'rotating' pattern where they work, for example, in a three-shift system, on the day shift (6 a.m. till 2 p.m., say) for a week, then an afternoon shift (2 p.m. till 10 p.m.) then a night shift (10 p.m. till 6 a.m.). 'Continental' shifts, which rotate rapidly for example, working three mornings then two afternoon followed by two nights and then a break may also be worked.

In industries where there is an advantage in running the operation 24 hours per day (such as petroleum refineries, chemical plant, processing plant etc.) or where there is an advantage in part of the operation taking place during quiet hours (e.g. road haulage and distribution), a proportion of the workforce will work at night and therefore will need to sleep during the day time.

…night time shall mean any period of not less than seven hours….and which must include in any case the period between midnight and 5 a.m.

…night worker shall mean…any worker, who, during night time, works at least three hours of his daily working time as a normal course
The Working Time Regulations 1998

The main problem with this relates to the disruption such patterns of work cause to our natural bodily rhythms and as a consequence errors can arise which may lead to accidents. Night shift workers may find that their pattern of activity is out of phase with normal circadian rhythms. The effect of this can be to reduce mental and physical performance which may lead to errors and accidents.

Risk of injury is 30% higher on night shift compared with morning shift and is highest in the first two to three hours; the risk then increases over successive night shifts so that the fourth night shift carries 36% more risk than the first. With extended working hours, risk increases more or less exponentially and in the 12th hour of work it is twice what it was during the first eight hours. The risk of injury is also increased by not taking breaks and rises linearly and substantially with time from the last break; there is twice the risk of injury 90 minutes after the last break compared with immediately after a break.
Hobson (2004)

These problems arise because of our lack of alertness. Perhaps the most extreme symptom of fatigue is that people can also simply fall asleep at work:

Overall, 60 to 70% of shift workers will report difficulty with sleep, sleepiness on the job or actually falling asleep unintentionally while at work.
Rosekind (2005)

And just to reiterate the problem with all of this:

Shift workers are used to living with fatigue, and most of the time no serious accidents occur, in spite of such fatigue. These positive experiences reinforce the notion that fatigue is not a serious risk at work. Fatigue has, however, been estimated to be the key factor in as many as 41% of accidental injuries and deaths caused by human error.
Sallinen (1997)

2.5 CIRCADIAN RHYTHMS

It is well known that a number of processes in the human body follow a regular cyclic pattern over each 24-hour period. For example, body temperature, hormone production, heart rate, digestion, blood pressure, pulse rate and sleeping and waking.

We are, in effect, 'programmed' to sleep during hours of darkness and to be awake and active during the hours of daylight. We produce the hormone melatonin at night and levels normally reach their peak in the early hours of the morning. It is this hormone that induces sleep and it becomes increasingly difficult to maintain alertness if we try to work during those periods when this hormone is at its peak level in our bloodstream. Working a night shift imposes exactly that situation.

In the same way, shiftworkers typically have problems trying to sleep soundly during the daytime not just because the bedroom is likely to be brighter, noisier and hotter than at night, but simply because it is a struggle to fight against the body's natural processes.

Melatonin production does adapt to our pattern of working over a number of night shifts, but it is a slow process (see Annex B) and the end result, even in a fully adapted person, is a 'sleep deficit' (the accumulation of several lost hours of sleep during the working week). Exposure to daylight before or after the body's melatonin peak can affect the rate of adaptation. It is usually difficult to control an individual shiftworker's exposure to light, although some attempts have been made, for example, issuing sunglasses for journeys home in daylight or moving nightshift end times forward to avoid exposure to daylight.

Some shift patterns are worse than others in disrupting the natural sleeping/waking cycle (see HSE *Managing shift work* for some useful tables describing different shift types). If an operator works more than three consecutive night shifts, their melatonin cycle will begin to adapt. Management should consider if they want their workforce to adapt to night work and arrange long periods of consecutive nights. The alternative is rapid forward rotating shifts where no attempt is made to adapt but the amount of 'out of phase' working is limited to just a couple of shifts.

2.6 BREAKS AND NAPPING

Scheduled and ad hoc breaks during work time are usually determined through collective agreements between employers and employees or by legislation. In terms of alleviating fatigue, there are no clear cut rules concerning the length of breaks or where in the working day they may be taken. Breaks are effective in alleviating boredom and in providing some relief from fatigue. Recent research suggests that napping within breaks is better than a break on its own (see section 4.3 for further information on napping).

There are social pressures against napping, although 'siesta time' is perfectly acceptable in many southern European countries; but, even in those countries, fewer people now use their siesta time to sleep.

If napping in the workplace is supported,

management should ensure that naps are properly scheduled and that adequate facilities for napping are provided (a quiet, darkened area with suitable furniture). Supervisors and co-workers should be made aware that the person waking from a nap will need some time to recover from their 'groggy' state after a nap and should not immediately start hazardous activities. There is some debate, also, as to the length of nap required and length of recovery period (see section 4.3).

Napping, of course, does not have to be in the workplace. Benefits have been found if nightshift workers take a nap in the afternoon or early evening before starting a nightshift.

2.7 SLEEP DISTURBANCE

In order to be alert during the working day, we need the right quality as well as quantity of sleep. Various sleep disturbances can affect both of these aspects of sleep. Other reasons why we lose sleep during daylight hours are because, often, the bedroom is too bright, or sleep is disturbed by noise from normal daytime activities inside and outside the home.

Night work is characterised by increased subjective and objective sleepiness, and studies frequently report full-blown sleep during night shift working, particularly in the early morning. After a night shift there are between two and four hours loss of rapid eye movement sleep and it usually takes two nights of sleep after the last night shift before normal sleepiness is restored. Importantly, shift workers are more tired when driving to and from home than non-shift workers.
Hobson (2004)

The conclusion of this research then, is that night shift work forces us to fight against our natural body rhythms and, although the body responds by moving this rhythm to match the sleep-wake cycle we are following, it never quite catches up. The exception is working 14 nightshifts in a row: in this case, it is possible to fully adapt although it may take longer and workers will only fully adapt if they maintain the same time schedule on rest days. Employers should decide, however, whether they require a workforce that is fully adapted to nightwork. Some nightworkers maintain their adapted state by, for example, adopting a nocturnal lifestyle. This may be less desirable than having non-adapted workforce on a rapidly-rotating shift pattern. Further advice on permanent night shift working can be obtained by contacting HSE.

Human beings sometimes respond to extreme tiredness by having 'microsleeps'. These are short duration, genuine sleep periods which can occur even with the eyes open.

In [a] NASA study of long haul pilots, there were 154 occurrences of physiological microevents[3] *(i.e., alpha or theta EEG or slow eye movements) recorded during the last 90 minutes of a 9-hour flight. A study of air traffic controllers conducted by the Federal Aviation Administration (FAA) found that 48% report "they often fell asleep unintentionally."*

Police officers report falling asleep on duty, for example, 80% report dozing off at a stop light once a week, 26% nod off during daytime activities and 41% during a night shift
HSE *Health and wellbeing in the offshore environment*

2.7.1 Sleep apnoea

This condition – known as 'Obstructive Sleep Apnoea Syndrome (OSAS)' affects approximately 4 % of adult males and 2 % of adult females in the UK population. Men over the age of 40 and obese men are particularly prone to it. It is a breathing difficulty experienced during sleep – the sufferer actually stops breathing for a short period – this causes them to wake momentarily hundreds of times per night causing a disruption of sleep quantity and quality.

2.7.2 Sleep deficit

The number of hours sleep we need each night to remain alert differs from person to person. Accumulated sleep loss, or sleep deficit (or 'sleep debt'), arises simply from having less than the required amount of sleep. Sleep deficit can occur for any of the reasons set out above.

NASA adopts the simple rule that losing one hour's sleep one night, will require an extra hour's sleep to compensate for this.

2.7.3 Chemical substances

Certain chemical substances can have a direct effect on our levels of alertness. Alcohol is an obvious example of a substance that can cause drowsiness. Many over-the-counter medicines can also cause drowsiness and usually carry a warning about this. For a list of common medicines that can induce sleepiness, see DFT *Over-the-counter medicines and the potential for unwanted sleepiness.*

[3] These are direct measures of alertness from eye movement and electro encephalogram readings.

Employees taking medicines of any kind should consult their occupational health advisor for advice. Note that some of these substances taken when 'off duty' may still be in the person's system when they next report for duty.

The sleep-inducing hormone melatonin has been used as a medicine – especially as a 'jet lag' cure. Melatonin is not licensed for sale in the UK. Even in those countries where it is licensed, it is not well controlled; users may find it difficult to judge the correct dose, and, as with other sleep-inducing substances taken when 'off duty', may still have too much in their system when reporting for duty. Shiftworkers report more use of such substances than other groups of workers. Long-term use of melatonin also has undesirable side effects.

Caffeine is an obvious stimulant that can interfere with sleep if taken at the wrong time. As well as in tea and coffee, it is found in chocolate and cola drinks. Caffeine-loaded drinks are increasingly available and contain large amounts of caffeine and other substances to promote alertness. The effects can be useful as a short-term measure and may be effective if accompanied by a nap, but should not be used as a regular measure against sleepiness.

In general, employers should monitor and control the use by their employees of chemical substances affecting alertness.

2.8 OFFSHORE

Working arrangements offshore differ from those in the rest of the industry: working hours are longer; the workforce lives and works away from home for extended periods; and the tour is often split into shifts comprising consecutive days followed by consecutive nights. The sleeping and working environment offshore can be more carefully controlled than in onshore operations.

2.8.1 The offshore environment

Working arrangements in the offshore sector of the petroleum industry are very different from those worked in the rest of the industry because:

- Typical shifts are 12 hours long for a period of 14 to 21 days, sometimes with overtime.
- There are different methods of arranging the shift patterns on the 14 or 21 day tour, i.e. all days, all nights or split shifts (rollover or swing shifts) where the offshore tour is split into seven nights followed by seven days.
- The workforce lives at the workplace for the duration of their tour; thus the employer is responsible for employee/contractor working and sleeping arrangements.
- The offshore worker may have a difficult journey to and from the workplace at the start and end of the tour.

Thus, to properly address alertness issues that arise, it is necessary to consider all offshore working conditions and arrangements.

Regarding sleeping arrangements, there are some advantages in the offshore environment compared to onshore: the sleeping arrangements are generally designed for a good rest – normal household noise and interruptions (telephone, visitors to the home, light) are absent and all on board are sympathetic to their co-workers' need for sleep.

The Working Time Directive (WTD) applies equally to offshore installations (fixed and mobile) as to those onshore, but it is complex and may apply differently to support vessels. For further advice on marine operations and the WTD, consult the Maritime and Coastguard Agency - see:
http://www.mcga.gov.uk/c4mca/mcga-home.
For all other offshore applications, HSE is the enforcing agency and may be contacted for advice:
http://www.hse.gov.uk/index.htm.

2.8.2 Contingency planning

Offshore installations are in a remote environment and shift and staffing arrangements have to include contingency for unusual circumstances that might require additional working hours or additional personnel. Such circumstances include: injuries/ incapacitation of personnel; or tasks taking longer than anticipated owing, for example, to poor weather conditions. Contingency arrangements may include the need to rearrange tasks or re-schedule work; having available a multi-skilled workforce; or slightly increasing staffing levels with personnel able to deploy additional skills.

Guidelines on how to address declared or observed fatigue impairment during a shift should be developed to ensure that decisions relating to potential fatigue are dealt with in a consistent, agreed manner.

2.8.3 Fatigue and fatigue counter-measures

Fatigue issues offshore have much in common with those found onshore; for example, sleep loss, the effects of nightshifts etc., but the arrangement of working a long period of night shifts (more than four in a row)

means that the advice concerning fast shift rotation does not apply. The reason for this is that there is strong evidence to suggest that 'permanent' night workers are able to adjust their biological sleep-wake patterns to match this shift arrangement. The problem is that some adjust more than others and more rapidly.

One implication of this body clock adjustment is that one of the tools recommended for assessing fatigue, the HSE 'Fatigue and Risk Index Calculator' (see HSE *The development of a fatigue/risk index for shiftworkers*), may need to be carefully interpreted when applied to personnel whose circadian rhythms are adjusting (as a result of working long periods of consecutive night shifts). The calculator itself replaces the earlier, 'Fatigue Index' and combines a fatigue index and related risk index.

The most recent advice on shift scheduling may be obtained from HSE's website: http://www.hse.gov.uk/index.htm (type 'shiftwork' into the search box). The most up to date information on shift working offshore may be found in research reports HSE *Psychosocial aspects of work and health in the North Sea oil and gas industry* and HSE *Effect of shift schedule on offshore shiftworkers' circadian rhythms and health*.

General guidance in this publication concerning alertness monitoring can and should be applied offshore; in addition, toolbox talks or other pre-task discussions and risk assessment 'prompt cards', where these are used, should include fatigue as an issue to be aware of – in some tasks more than others. Giving emphasis to fatigue at this early stage in a job will allow the work crew to raise alertness issues and make appropriate arrangements, e.g. to reschedule tasks or to staff the tasks with the most alert personnel based on previous work. Operational staff should be allowed to schedule when particular tasks are carried out – provided suitable controls and checks are applied – in order to match crew alertness with task criticality.

Companies should make good use of safety initiatives such as 'behavioural safety programmes', near miss analysis etc. as a means of extracting information on fatigue issues and acting upon the findings. Behavioural signs of fatigue include:

— difficulty keeping eyes open;
— head nodding;
— irritability;
— poor response times;
— poor coordination;
— repeated yawning.

The issue of travel to and from offshore installations is a joint employee/management responsibility. Employers could update existing education programmes to include specific advice on this issue and its bearing on fatigue. Travel time could also form part of a 'sleep contract' if this method of controlling alertness is adopted (see Section 4 for information on sleep contracts and IP *Research Report: Viability of using sleep contracts as a control measure in fatigue management*).

2.9 DRIVING

Working arrangements for professional drivers in the petroleum industry are different from those worked in the rest of the petroleum industry – driving is regulated via different rules. This section provides guidance that should be useful to drivers and their managers and also to anyone who regularly drives to and from work.

2.9.1 Background

Working time limits for professional drivers (who fit into the category of 'mobile workers') are set out in The Road Transport (Working Time) Regulations 2005. Note that the Regulations and its guidance are subject to ongoing review in the light of practical experience. Drivers and their management can keep up-to-date via the Department for Transport (DfT) website where any updates will be published (see DfT *Road transport (working time) guidance*).

It should be noted that, whatever the working time limits stated in the Regulations, the actual effect of working time on driver alertness should be continually monitored as part of an ongoing fatigue risk assessment programme.

The basic rules applying to drivers according to the Regulations are that their working time must not exceed:

— an average of 48 hours per week;
— 60 hours in any single week;
— 10 hours in any 24-hour period, if working at night.

The 48-hour weekly limit is usually averaged over four months but can be extended to six months. In addition, more than 10 hours can be worked at night if this is formally agreed to via a workforce or collective agreement. Mobile workers cannot, however, opt out of the weekly working time limits.

In a number of petroleum companies, the largest single cause of employee and contractor fatalities in all of their operations is road traffic accidents. A substantial number of these road safety incidents and accidents can

be attributed to driver fatigue.
Confidential petroleum company alertness programme and driving policy

An estimated 300 people a year are killed where a driver has fallen asleep at the wheel. Research commissioned by the Government found that falling asleep at the wheel accounts for up to 20% of crashes on motorways or similar roads, and as many as one in ten of all crashes on Britain's roads.
DFT *The THINK! road safety website*

Unlike other road accidents where the driver often has the chance to take evasive action or apply the brakes, vehicle accidents in which the driver has fallen asleep at the wheel are often more severe than other types as they tend to occur at high speed and drivers are less likely to take evasive action.

2.9.2 Causes of driving accidents

The same primary causes of fatigue described earlier in this section of the publication apply to driving tasks. For drivers though, the key factors are:

— number of hours worked;
— time of day;
— shift start time;
— amount of sleep in the previous 24 hours;
— age of driver.

Added to these are the monotony of long-distance driving, working in 'too comfortable' an environment, possible heavy work done before driving (e.g. preparing and loading the vehicle) and the effects of exhaust fumes and whole-body vibration.

Accident statistics indicate that around 20% of serious accidents on motorways were due to sleepiness; in urban areas 16% were sleep-related. This seems to be because of the monotony of driving on motorways.

There is some evidence of age differences in road accident patterns whereby accidents involving younger male drivers (18-24) are more likely in the early morning but those involving older male drivers (over 50) are more likely in mid-afternoon. It is not clear if this is because the proportion of younger drivers on the road at this time of day is higher or whether it is because of the tendency towards 'morningness' in older people. There is also evidence that sleepiness has a tendency to increase confidence in driving ability (particularly in younger drivers).

People who prefer early starts are referred to as 'larks' and those who prefer late starts as 'owls'. The 'lark' or 'owl' tendency of drivers can be assessed and considered as one of the factors in consultations with the workforce in assigning particular shifts to individual drivers.

"A fatigue-related risk assessment we recently undertook at one of our client's sites identified six drivers – 10 % of the workforce – who were responsible for 60 % of the accidents. On closer analysis it became apparent that these drivers were on shifts that were not best suited to their natural disposition: some who would naturally prefer an early start were on permanent late shifts while others who were on morning shifts were more suited to later starts. With a bit of negotiation and reorganisation we were able to swap these drivers' shifts around."
LARSOA *Interview with Awake*

There is some evidence that the percentage of professional drivers suffering from sleep apnoea is higher than average. This is a condition causing loss of sleep (see 2.7.1) and this disorder can be diagnosed. (Useful information on this disorder may be found at the DfT website, and at:
http://www.osaonline.com/default.asp
The DfT website includes a report on a workshop held in March 2004 entitled *Driving and medical aspects of daytime sleepiness*.

2.9.3 Counter measures

2.9.3.1 Driving hours and breaks

There are legal conditions that must be observed in relation to driving and also many companies have strict driving policies that all staff (professional drivers and those who drive to and from their workplace) must follow. For example, Box 2.1 sets out some of one company's requirements.

Legislation applying to drivers can be complex; this is partly because drivers often undertake other duties before and after driving which extends their working day.

Box 2.1: Extract from BP driving safety standard

(Elements 1-4 relate to BP vehicles)
BP driver requirements

4. *They are appropriately assessed, licensed, trained, and medically fit to operate the vehicle.*
5. *They are appropriately rested and alert.*
6. *They do not use a mobile phone or other two-way communication device while operating the vehicle.*
7. *In specific high-risk countries risks of the journey have been assessed and journey risk management plans in place.*
8. *Seatbelts are worn by all occupants at all times whenever a vehicle is in motion.*
9. *They are not under the influence of alcohol or drugs, or any other substance or medication that could impair their ability to drive.*
10. *Safety helmets are worn by rider and passengers of motorcycles, quads, snowmobiles and similar types of vehicle.*

Elements 7, 8 and 10 apply to BP employees who are passengers when on BP business as well as to BP drivers.

Note that the above describes BP's approach to driving safety: it does not endorse a particular approach nor does it constitute guidance.

The Road Transport Directive (RTD) and the EU drivers' hours rules set out the main conditions for drivers regarding:

— Weekly working time – 48 hours per week on average. Maximum in any one week 60 hours provided the average of 48 hours is not exceeded.

— Night work – limited to ten hours in any 24-hour period. This may be exceeded by collective workforce agreements, i.e. by signing an opt-out or derogation from the directive.

— Breaks – EU drivers' hours rules take precedence. These require a 45-minute break to be taken after four and a half hours of continuous or cumulative driving. Drivers are generally not permitted to work more than six hours without a break. Breaks should be 30 minutes long in a six- to nine-hour working day, 45 minutes in a nine-hour or more working day. These break periods can be divided over the day but must each be at least 15 minutes long. The break must not involve doing other work.

The rules are subject to change from time to time. The latest guidance can be obtained from the DfT *Road transport (working time) guidance.*

2.9.3.2 Effective strategies

Journey planning is essential to ensure that the working day is not too long or strenuous and that sufficient contingency has been allowed for potential hold ups or other problems.

A short-term remedy for sleepiness at the wheel is to stop driving and take a nap. This works more effectively when coupled with caffeine. Drinking one or two cups of strong coffee or caffeine drinks can reduce fatigue for up to an hour (hence it is a short-term solution only). Ideally, the driver should stop, drink the coffee/caffeine drink and take a nap. The coffee will take a while to take effect – which is enough time to take a short nap.

2.9.3.3 Ineffective strategies

Drivers will often use the following strategies to alleviate fatigue; they do not solve the problem but may give the impression of doing so:

— Opening the window to allow cold air into the vehicle.
— Turning on the radio or raising the volume.
— Using various 'devices' for detecting sleepiness. These may be positively harmful in encouraging fatigued drivers to continue driving.
— Resting without sleeping.
— Exercising ('stretching your legs').

2.9.4 Conclusions

Management need to provide appropriate education, advice and policies on the issues set out in 2.9 and on others described in Section 2 that apply to all workers not just drivers, including:

— The effects of certain medicines on alertness (e.g. hay fever treatments, antihistamines and cough mixtures).
— Effects of meals on alertness (the dip in performance following meals, particularly heavy meals).
— That sleep does not occur without warning – drivers will know that they feel sleepy and will be aware enough of this to take action.

Management should also consider:

— Medical surveillance – for example, conducting regular checks on all personnel, or those considered

particularly at-risk – prone to sleep apnoea; use of stimulants or sleeping aids; permanent night-workers, etc.
- Fitness for duty monitoring (see Section 4).
- Sleep contracts (see Section 4); see IP *Research Report*: *Viability of using sleep contracts as a control measure in fatigue management.*
- Increasing the flexibility of scheduling to enable a response to possible fatigue issues.

Education should be provided to the families of night workers; for example, by issuing guidance leaflets on establishing a suitable sleeping environment and encouraging good sleeping habits for the night worker.

2.10 SUMMARY OF FACTORS AFFECTING ALERTNESS

Table 2.1 provides a summary of factors affecting alertness and further information on the problems.

Table 2.1: Summary of factors affecting alertness

Factor	Problem
General	
Long hours	Tiring even if the work is not physically demanding
Shift work/night working	Working at night and sleeping in the day goes against our natural circadian rhythms for sleeping and waking
Shift patterns	Some shift arrangements allow the worker to adapt; some do not. There are benefits in each arrangement
Poor quality of sleep	Disturbed sleep because of a poor sleeping environment
Sleep apnoea	A particular disorder where the sleeper stops breathing frequently during sleep leading to sleep disturbance
Sleep deficit	Lost hours of sleep accumulate over a period of time
Unstimulating (boring) work	Can affect the level of attention paid to a task
Warm, dark, comfortable environment	Can induce sleep in a person who is already tired
Chemical substances	Medicines or drugs can prevent sleep or induce sleep
Offshore	
Environment	Workforce lives and works offshore for the duration of their tour. Can be better controlled for sleeping
Shift patterns	Long shifts, often with a split mid-tour changing from nights to days (other patterns are possible). Contingency for absences/ illness may be problematic
Driving	
The law	Different working time arrangements apply compared to the rest of industry
Impacts	Sleepiness can account for a large number of accidents. Road accidents can be the biggest risk for the workforce
Effective countermeasures	Good planning of journeys. Taking a break preferably with a nap and taking caffeine
Ineffective countermeasures	Opening the window for 'fresh air'. Turning up the radio. Use of alertness detection devices. Resting without sleeping. Exercising (stretching your legs)

3

HAZARD IDENTIFICATION

Two essential elements of any safety management system are: identifying hazards (and controlling them); and investigating incidents (and learning from them/ controlling future activities). This section illustrates how factors influencing alertness can be incorporated into both of these elements.

3.1 INTRODUCTION

There are two methods for identifying hazards in the workplace: via risk assessment or via incident (or accident) investigation.

A risk assessment is nothing more than a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm.
HSE *Five steps to risk assessment*

An investigation will involve an analysis of all the information available, physical (the scene of the incident), verbal (the accounts of witnesses) and written (risk assessments, procedures, instructions, job guides, etc.) to identify what went wrong and determine what steps must be taken to prevent the adverse event from happening again.
HSE *Investigating accidents and incidents*

The four steps described in HSE *Investigating accidents and incidents* are:

— *gather information;*
— *analyse information;*
— *identify risk control measures;*
— *develop and implement an action plan.*

From the above definitions, it is clear that risk assessment and accident investigation are actually two sides of the same coin. Both seek to control risk: the first by determining in advance how the workforce could be exposed to a hazard; the second, by examining 'after the fact' how the workforce was exposed to a hazard, and in both cases, establishing what controls and precautions need to be taken to prevent (further) incidents. Both are tools used in a safety management system for reducing risks, one pro-active, the other reactive.

3.2 RISK ASSESSMENT/RISK MANAGEMENT

Risk assessment is about recognising workplace hazards and taking effective steps to bring them, so far as is reasonably practicable, under control. This could mean either eliminating the hazard entirely or reducing the risk of exposure to the hazard.

It is possible to treat fatigue in itself as a hazard (see 3.4): to determine who could be harmed, what controls are required, etc. However, it is likely to prove more useful to conduct conventional risk assessments and to use them as a means for exploring the possible role of fatigue as a route to exposing people to other types of hazard. This is described later in 3.4 which also illustrates the link between risk assessment and accident investigation.

3.3 ACCIDENT INVESTIGATION

Note that accident investigation also includes the investigation of 'incidents', that is, 'near-misses'.

An example from the marine industry is provided in 3.4. It will be used to illustrate how fatigue issues can be identified via accident investigation. The same example is used as a risk assessment case study.

3.4 MARINE INDUSTRY EXAMPLE

A tug left port at 0200 hrs. and proceeded on a coastal passage in fine weather with good visibility. The wheelhouse was manned by the Mate and a helmsman, with the tug on hand steering. During the watch, the Mate periodically sat on a seat provided in the vicinity of the chart table, which was situated in an aft corner of the wheelhouse.

At approximately 0400 hrs, the Mate instructed the helmsman to alter course 10° to port with the intention of passing three cables (about 550 metres) off a shore light, which was then fine on the starboard bow at a range of four miles. He then sat down in the seat and soon fell asleep.

About 20 minutes later, the helmsman suddenly became aware of the close proximity of the shore light, instinctively shouted to the Mate and applied full port helm. The Mate awoke and saw the light dead ahead at close range. Although he immediately pulled the engine control lever back to full astern, the vessel grounded on rocks a few seconds later.

MAIB *Report 5. Grounding caused by sleeping watchkeeper*

The hazard, in this case, was the rock formation on the tug's route. The crew was aware of this hazard and had planned to avoid it by plotting a course around the rocks. Fatigue, however, prevented this plan from being carried out.

In effect, accident investigators seek to establish where the risk management system failed, to identify shortcomings in the system and to make necessary improvements. It should not be a process for assigning blame to individuals, unless those individuals have been clearly negligent, but one of developing an objective view of the underlying causes of accidents.

The key to understanding risk assessment and incident investigation is illustrated in the questions in Table 3.1. In all cases, the objective is to identify possible failures in protection systems, whether those systems are physical barriers or procedures to be followed to control hazards.

In Table 3.1, if fatigue itself is treated as a hazard ('something than can cause harm'), then the questions above can still be applied. For example, 'what went wrong and exposed personnel to fatigue? What was the immediate cause of fatigue?' etc. The questions and checklists in Section 4 will help to answer some of those questions and ensure that the key factors affecting alertness and fatigue are considered.

Further information from the Marine Accident Investigation Branch (MAIB) report will help in understanding the case study.

A major contributory factor to the Mate falling asleep was fatigue due to lack of adequate rest. However, any tendency for him to feel drowsy would have been exacerbated by him sitting down in the warm, dark and quiet atmosphere of the wheelhouse.

2. [T]he Master allowed insufficient time to ensure that [the crew] were adequately rested for the passage. In this regard, each crew member also had an individual responsibility under The Merchant Shipping (Health and Safety: General Duties) Regulations 1984 to ensure his own fitness for duty.

3. The helmsman was under no obligation to maintain a lookout while steering the vessel. However, it is probable that had he been less fatigued, he would have realised the close proximity of the shore light at an earlier stage, in time for avoiding action to be taken.

MAIB *Report 5. Grounding caused by sleeping watchkeeper*

Table 3.1: Comparative questions etc. for accident investigation and risk assessment

Accident investigation	Risk assessment
What went wrong and exposed people to the hazard?	What could go wrong that could expose people to the hazard?
What were the immediate causes?	What would be the immediate causes?
What were the underlying causes?	What would be the underlying causes?
What in the protection systems failed and led to exposure to this hazard?	What deficiencies in the systems could fail and lead to exposure to this hazard?

Figure 3.1 illustrates how risk assessment and accident investigation principles can be applied using the above case study as an example. It illustrates one way of setting out the facts of the incident in a logical manner. Other formats may be used, but the basic aim is to follow a logical sequence of events from 'system failures' to harmful outcome and to learn from this analysis.

The central column of Figure 3.1 describes the additional key facts to emerge from the accident investigation and lists them in terms of 'latent failures', 'human failures' etc. There are other ways of categorising the different contributory causes (they depend on which accident investigation method is used) but this seems a helpful way of examining the contributory causes of an accident or incident.

Other methods of accident investigation can be used to develop insights into fatigue problems simply by using 'fatigue' as a keyword in those investigations.

It is of interest to note that MAIB records contain many further examples of the problem of crews falling asleep on watch. In addition, these examples and others from a wide range of industries seem to indicate that people are generally willing to attempt to work even when it is obvious that they are not fit to do so. One reason for this is that we all tend to overestimate our level of alertness.

It is also of interest to note that fatigue is not the only problem in maintaining alertness – the MAIB report makes a crucial point about other factors that can affect us.

If a watchkeeper is allowed to sit in a chair during the hours of darkness, with few navigational duties to perform, there will always be a tendency for him to fall asleep. He does not necessarily have to be fatigued or otherwise impaired for this to happen.
MAIB *Report 5. Grounding caused by sleeping watchkeeper*

In other words, MAIB suggest that it is not necessary to be tired, as such, to fall asleep in a warm comfortable control room. These conclusions have emerged from a large number of examples of similar incidents but, in fact, there is no scientific evidence that people fall asleep simply because it is warm and comfortable: for this to happen, they also have to be tired.

Even in industries where the potential consequences of falling asleep could be catastrophic and far-reaching, sleeping on the job has also been observed:

On March 24, 1987, the Region I office of NRC [United States Nuclear Regulatory Commission] received information that certain control room operators at the Peach Bottom Atomic Power Station had been observed sleeping while on duty in the control room and other wise being inattentive to their license obligations.
NRC *Shutdown order issued because licensed operators asleep while on duty*.
Courtesy of NRC

It seemed that this was not the first occasion when the crew had fallen asleep on duty. The problem appeared to arise particularly in the night shift: 11 p.m. to 7 a.m. Furthermore, senior staff up to the level of shift supervisor have also slept on duty and management have either known this and turned a blind eye or were not aware of it and thus were failing in their supervisory duties.

3.5 FURTHER INFORMATION ON ACCIDENT INVESTIGATION AND RISK ASSESSMENT

This publication can be used as an aid to accident investigations in which fatigue appears to be a primary or secondary cause.

Subsequent sections provide information that will help the reader to identify possible latent failures, human failures and performance influencing factors relevant to fatigue. An overview/checklist is provided as a simple guide. These broad factors should be considered in risk assessments or accident investigations. More detailed factors may be found in the checklists in Section 4, particularly those relating to 'questionnaire surveys' and 'review of incident and accident reports'. The information provided under those sub-sections will help to ensure that a risk assessment addresses the key risk factors relating to fatigue.

3.6 RISK ASSESSMENT/ACCIDENT INVESTIGATION CHECKLIST

Factors to consider, as a minimum, in risk assessments and accident investigations are:

— shift length;
— shift schedules worked (direction of rotation, number of consecutive night shifts);
— breaks during the shift;
— rest periods between shifts;
— sleeping patterns of staff – ensuring sufficient good quality sleep;
— the nature and demands (both physical and mental) of the job (too demanding or too routine/repetitive);
— the working environment;
— travel time before and after shifts;
— substances likely to cause drowsiness or prevent sleep;
— age.

The processes are summarised in Table 3.2.

INCIDENT/ACCIDENT INVESTIGATION (What actually happened and how?) Start here and work down ⇩	**INCIDENT OR ACCIDENT SEQUENCE (Example)**	**RISK ASSESSMENT (What could happen and how?)** Start at the bottom of the column and work up
Gather facts about the accident or incident For potential fatigue-related incidents, note time of day, shift patterns worked by personnel involved that day and for a week prior to the accident Note relevant events leading up to the harmful outcome. Note the sequence of events	**HARMFUL OUTCOME** Vessel runs aground on rocks **KEY EVENT(S)** 1. 0:00 Crew reported for duty 2. 01:20 Helmsman reported for duty 3. 02:00 Vessel departed. Course known to pass within about 550 m of a lighthouse 4. 04:00 Altered course by 10° to port. Some time later, the Mate fell asleep 5. 04:20 helmsman became aware of proximity of shore light; alerted Mate and began evasive action but too late	Consider the worst case in terms of consequences of the events identified below Consider the latent failures, credible human failures, performance influencing factors and issues with barriers that could lead to exposure to the hazard. What are the likely consequences of those failures?
Identify barriers that were impaired or removed that could have prevented the harmful outcome Think of barriers in terms of physical barriers and also 'procedural' barriers e.g. rules, best practices	**BARRIERS BETWEEN PEOPLE AND HAZARD** 1. No physical barriers possible, but crew following normal procedures should reduce the risk of an accident	Consider the barriers in place to keep the hazard under control. Are they adequate, are any further barriers needed?
Identify any 'job', 'person' or 'organisational' factors that contributed to the event. Were there any specific factors that particularly impaired the barriers against the hazard?	**PERFORMANCE INFLUENCING FACTORS** 1. Tired crewmembers 2. Time of day (4 a.m.) 3. Environment – quiet, dark, comfortable wheelhouse – encourages sleep	Identify factors that could trigger a human failure. These may be general or apply to particular 'special' circumstances
Identify anything the personnel involved in the accident did (or failed to do) that reduced their control over the hazard Identify anything that others did that reduced their control over the hazard	**HUMAN FAILURES** Master failed to check fitness for duty of crew; also failed to take adequate rest himself – assumed Mate fit to take charge Mate failed to ensure he had adequate sleep before the shift	Identify opportunities for a 'slip', 'lapse', 'mistake' or 'violation' that could lead to a major accident (See HSE *Reducing error, influencing behaviour* for definitions)

Consider whether this was an 'accident waiting to happen'. Were procedures and systems for preventing it in some way inadequate, e.g. was there a culture of working when fatigued? Was the hardware provided to do the job or to prevent accidents ineffective?	**LATENT FAILURES** Absence of a watchkeeping alarm (a reminder device) Common practice to work whilst tired (assumed from evidence)	Identify any possible 'latent failures', that is, inadequacies in the systems, procedures and practices required to control the hazard. Again, it may be useful to consider 'job', 'person' and 'organisation' factors. Latent failures could lead to a human failure or contribute to performance influencing factors – see above
Consider the aim of the task and identify the critical aspects of the task (those things which the operator had to do to keep the hazard under control)	**CRITICAL TASK** To move the vessel in darkness through channels where known hazards were present. Critical aspect of the task: to maintain 'situational awareness' and to be alert to hazards	Identify the 'critical tasks': those required to manage the hazard (and where failure to perform adequately could result in a harmful outcome)
Describe the hazard that should have been kept under control. Could anything have been done to remove the hazard or physically guard against its effects? If not, were suitable systems of work or safety equipment available and used to reduce risk?	**HAZARD** Obstacles on route (rocks, other vessels)	Identify the hazards present in the work environment Make a list. Take each hazard in turn and move up

Figure 3.1: Risk assessment/accident investigation applied to a marine industry case study

Table 3.2: Summary of hazard identification/risk assessment processes

Method	Objective
Hazard identification	Finding out what can cause harm in the workplace
Risk assessment	Systematically working through the hazards identified to determine ways of bringing them under control. Controls include physical barriers and systems designed to ensure that constant attention is given to risk
Accident investigation	Systematically gathering evidence from an accident (or near miss) to determine the immediate causes of the accident then working back through the chain of events to determine the root causes (these are usually inadequacies leading to failures in one or more organisational systems)

4

ASSESSING THE PROBLEM: IDENTIFYING SOLUTIONS

The purpose of this section is to summarise the preceding sections and to set out a number of practical solutions to the problem of fatigue. It contains several useful checklists and possible strategies for investigating fatigue issues and developing solutions that have been used and shown to be of value to industry.

4.1 AIMS OF SECTION

Previous sections of this publication described the key factors that can reduce operator alertness/increase fatigue. This section describes a number of possible solutions.

To identify the correct solutions, duty holders first should identify more clearly which of the key factors are present. This publication cannot prescribe specific solutions to specific problems but it should enable the identification, from duty holder knowledge of their own organisation, of a range of practical and acceptable solutions.

In general, solutions aim to:

— Eliminate fatigue or its causes.
— Reduce the likelihood of fatigue occurring in the workplace.
— Counteract the effects of fatigue when it occurs.

Of the above types of solution, the first may often prove to be impossible as every worker at some time will feel the effects of fatigue. However, with knowledge of the underlying causes of fatigue, it should be possible to remove some of the causes and thus reduce the incidence of fatigue. On those occasions where an employee or contractor is suffering the effects of fatigue, steps can be taken to reduce the impact on their health and safety.

4.2 INITIAL INVESTIGATION

It is unlikely that an organisation with a significant fatigue problem will be unaware that it has a problem, if only from 'tea room discussions' but more likely from the number of incidents it is experiencing, and it should already be taking steps to address this.

There are a number of problems to be aware of when investigating fatigue. Some of the most common are:

— Lack of in-depth analysis that would identify fatigue as the underlying cause.
— Lack of accepted criteria or structured approaches for evaluating the role of fatigue in accidents.
— When conducting a root cause analysis of events that involve human error, lack of objective proof that the individual was impaired by fatigue.
— Difficulty of establishing the cause of an event: whilst an individual's abilities may be impaired by fatigue, fatigue may not be recognised as having caused the event.
— Accuracy of post-event observations; following involvement in an incident, an individual may be 'keyed up' by the event itself, i.e. they can appear alert because of having to respond to the

Table 4.1: Checklist for evaluating whether there is a fatigue problem

Are any of these statements true in the workplace?	**YES**	**NO**
Many employees work shifts that include nightshifts		
Working overtime/long shifts is common		
Back-to-back shift working is common		
Breaks during shifts are short and do not provide a good rest		
Some people have to drive a long way to work, work long hours, then drive home		
Some shifts start very early (before 7 a.m.)		
Many employees work a split or 'swing' shift		
Shifts rotate 'backwards' (nights, evenings, day shifts)		
Shifts rotate forwards on a slow pattern		
Safety critical work is often done at: — a 'circadian low point' — two to four hours into a shift — at the end of a shift — following mealtimes — just before or just after a break (crew member may be tired just before the break, not fully alert after the break)		
Work is mainly very boring and uneventful		
Work is done: — in a warm environment — where the lighting is low — and it's fairly comfortable		
Shiftworkers don't have any say in the design of shift patterns		
Shiftworkers' family and friends don't provide much support for their unusual working hours		
There is no realistic support from employers on how to handle problems caused by shiftworking (e.g. 'education', briefings, counselling)		
Fitness for duty is not checked – especially the amount of sleep someone has had before starting a shift		
Some employees 'moonlight' during scheduled rest periods between shifts		
There is an ageing workforce working nights or long hours		
Some employees who are clearly not suited to it are working at night		
People rely on tea, coffee or other stimulants to stay alert		
The shift system has been designed entirely by the workforce		
Some people need to take unofficial 'naps' to keep working		

Scoring: Add the number of ticks in the 'YES' column, this gives broad indication only of whether there is an alertness/ fatigue problem.

3 or fewer ticks – probably no need for action

4 to 10 – it would be wise to investigate further and consider solutions

>10 there is definitely a problem; there should be further investigation and immediate action

incident or through realising its potential consequences. Clearly, in such circumstances, impairment from fatigue would be difficult to detect.
— Accuracy and validity of self-assessment – subjective assessment of fatigue is notoriously unreliable. Studies have shown that individuals may believe that they are relatively more alert than indicated by physiological indices.

Some organisations may regard fatigue as insignificant or low priority in relation to other health and safety issues; however, most organisations may not need to commit much more effort than they do at present in their required routine safety management activities in order to address fatigue issues. This publication provides information to help ensure that those management activities do at least take account of fatigue as a risk factor.

4.2.1 A fatigue checklist

The checklist in Table 4.1 has two functions:

— To recap the information contained in the previous sections of the guidance.
— To provide a starting point only for establishing if there is a potential fatigue/alertness problem in a workplace.[4]

Those wishing to determine whether there is an alertness/fatigue problem in a workplace should consider the statements in Table 4.1; the more YES boxes ticked, the more likely it is that there is a problem in a workplace.

4.3 FURTHER INVESTIGATION

If the checklist in Table 4.1 indicates there is a problem, the suggested next steps should be to gauge its extent – for example, whom it affects, how it impacts performance, the primary causes of fatigue in the workplace – and from this more detailed information, determine the most appropriate solutions.

Further investigation, then, may involve one or more of the methods presented in Table 4.2, which are provided in order of easiest/least formal to most complex/formal, together with their pros and cons.

4.4 FATIGUE AND SAFETY MANAGEMENT

It should be clear that some of the methods in Table 4.2 are part of good safety management practice – risk assessment and incident/accident investigation in particular (see Section 3).

It should also be clear that a good safety culture will be required to ensure that all levels in the organisation cooperate in sharing information and developing/implementing solutions.

4.4.1 Brief informal survey

This is likely to be an unstructured initial attempt to find out if the workforce is experiencing alertness/fatigue problems. It could be a 'show of hands' at a safety meeting, one-to-one or group conversations with members of the workforce, part of a toolbox talk or a multiple email message sent to staff soliciting information, message boards, the intra-net or handing out booklets or other information such as the FTA *Driver fatigue*; HSE *Briefing note on fatigue*; DTI *Guidance on the Working Time Regulations*. Such information sources can also be used to prompt a response from anyone who feels there is a fatigue problem in their workplace.

4.4.2 Questionnaire surveys

4.4.2.1 Purpose of questionnaire surveys

A brief questionnaire is a useful means of gathering information from a wide range of people who might be affected by fatigue; it has the added advantage that it can be confidential. Before embarking on a questionnaire survey, however, it should be clear on what the survey aims to achieve from it and what will be done with the information generated. A questionnaire can generate a large amount of information; it can also suffer from missing or incomplete information so, unless the surveyors are skilled and experienced in administering questionnaires and interpreting the information derived from them, it can be difficult to know what to do with the results, in which case expert help may be needed.

4.4.2.2 Suggested questions

The questions set out in Box 4.1 can form the starting point for a questionnaire that will enable a surveyor to establish whether there is a fatigue problem in an organisation and broadly where the problem lies. Once

[4] The checklist is not a scientifically rigorous method for gauging fatigue but sets out to provide a broad indication of fatigue-inducing factors.

Table 4.2: Methods to further investigate fatigue

Method	Pros	Cons	Section
A brief survey of employees and contractors – carried out on a 'straw poll' basis by supervisors or managers – within a safety briefing meeting or similar session or in the workplace	Rapid method; information gathered directly from the workforce; low cost if conducted within routine safety meeting	Not a rigorous process; results may be dominated by a minority view	4.4.1
A questionnaire survey based on questions in Table 4.1 and supplemented by other sources such as IP *Human factors briefing notes No.5: Fatigue*	Confidential questionnaire can yield unbiased and more honest responses; can distribute to a large number of personnel rapidly (may be possible to administer on line)	Low response rates could produce biased results	4.4.2
A review of accident or incident reports for evidence that fatigue was a causal factor	Makes use of existing information; reports likely to have been developed via a formal data-gathering process	Can be a lengthy process; information on specific causes may be absent from reports; fatigue issues may be under-reported with more obvious or immediate causes dominating reports	4.4.3
A review of risk assessments to gauge whether existing management arrangements adequately cover alertness and fatigue issues	Proactive method; can identify and correct weaknesses in fatigue management procedures	Likely to involve significant effort; specialist help may be required	4.4.4
A review of other data sources e.g. sickness absence reports, behavioural observations	Objective reports; makes use of information gathered by existing systems	The systems may lack specific information on fatigue – information may require expert analysis to identify potential fatigue issues	4.4.5
A scoring method such as the 'Fatigue and Risk Index Calculator' available in HSE *The development of a fatigue/risk index for shift workers*	An objective scientific method for assessing working arrangements	Be careful to note any exceptions or warnings provided with such techniques. The calculator, for example, is designed for rotating shifts and not suitable for assessing prolonged or permanent night shift working	4.4.6
A survey using a specific toolkit such as that used by HSE field inspectors; routine safety inspections; behavioural safety audits etc.	Simple to obtain and use. Based on a familiar safety management model. Easy to include fatigue/alertness issues in other methods (e.g. behavioural safety surveys) already in use at company sites	May require expertise and knowledge to use this effectively as a survey method	4.4.7

Method	Pros	Cons	Section
Research or investigations using methods such as fatigue measuring devices or scales/scoring techniques that 'measure' sleepiness or sort people into 'morning' or 'evening' types	Some methods may have an objective scientific basis	Some techniques may be unproven; some devices may not be accurate measures; will require expert assistance to administer	4.4.8

Note: A number of other tools and methodologies are listed in HSE *Managing shift work.*

there are results, the analyst should be careful about interpreting the answers. The results should be discussed with a selection of individuals or groups who have responded to the questionnaires to ensure that the findings have been interpreted correctly and appropriate steps towards a solution have been identified.

4.4.2.3 Types of questions

Questions will mostly consist of two types:

— Those seeking objective information from individuals concerning their experiences of fatigue. For example, 'Have you ever reported for a night shift in a sleepy or less than fully rested state?' or relating to their co-workers – 'Have you ever noticed a fellow-worker showing signs of drowsiness (e.g. nodding off) at work?'.

— Those seeking subjective information relating mainly to underlying causes of fatigue, for example, 'Do you think management do enough to make sure that safety critical work is done only by fully alert operators?' 'What, in your opinion, are the three things that make you feel tired at work?'.

These may be followed up by supplementary questions or prompts, ('if so why?', 'list these') or multiple-choice lists (lack of sleep before starting work; breaks are too short; work is generally dull and routine, etc.).

Purely factual information about shift patterns worked by different groups of employees – start and end times, durations, direction of rotation, etc. – can be found from other sources, for example, Human Resources department.

4.4.2.4 Sample questions

Questions from IP *Human factors briefing note No.5: Fatigue* are reproduced in Box 4.1 as a starting point for a questionnaire. Some additional lines of questioning are given in Box 4.2.

Box 4.1: Initial questions for a fatigue questionnaire

Is it common to find that people in your company:

— *Doze off suddenly during a shift?*
— *Feel generally drowsy a lot of the time?*
— *Regularly work a lot of overtime?*
— *When changing from night shifts to day shifts – feel 'rough' for the first few days?*
— *Are noticeably absent-minded or forgetful at work or find it hard to concentrate?*
— *Sometimes feel that they just can't move; or don't want to?*
— *Suffer from a lot of heartburn, indigestion or generally upset stomach?*
— *Find it difficult to get a good undisturbed sleep between shifts?*
— *Drink more coffee or smoke more and eat badly on the nightshift?*
— *Regularly find they are so busy that they can't take a proper break?*

Some of these are normal and unavoidable effects of shiftwork, this doesn't mean that answering 'yes' to any of the above is acceptable. If anyone is showing severe or long-term symptoms of fatigue, action should be taken.

Box 4.2: Supplementary questions for a fatigue questionnaire

— Do you regularly lose one or two hours' sleep when working shifts?
— Is the quality of sleep you get generally poor – e.g. frequently interrupted (by noise or bright light)?
— Do you sometimes have to work on safety critical tasks at a 'low point' in the day e.g. early hours of the morning; mid to late afternoon or after a meal?
— Can you negotiate with your manager about the type of work you do at these 'low points'?
— Do you regularly work long shifts – e.g. over 12 hours?
— Do you have enough breaks during the shift?
— Are the breaks long enough?
— Are rest periods between shifts long enough to recover from the previous shift (at least 12 hours)?
— Can you rest properly (or even nap) during breaks?

At work, do you:
— Often find it hard to concentrate, make clear decisions or take in and act on information?
— Have more than occasional lapses of attention or memory?
— Find your reaction times are slow (for example, responding to an alarm or a threat that builds up in your workplace)?
— Make lots of errors?
— Occasionally fall asleep at work – momentarily or for several minutes?
— Have little motivation or interest in your work?
— Find that you are often irritable?

Do your managers:
— Seek to avoid long shifts and too much overtime: aim for less than 50 hours' work per week?
— Arrange for breaks away from the job during the working day?
— Allow 'napping' at work to restore performance but beware of persons working immediately after a nap – they will be less effective for up to 30 minutes, perhaps an hour?
— Have contingency plans for dealing with sudden demands on employees e.g. to cover for unexpected absences?
— Realise that shorter shifts may not solve the problem – errors are higher a few hours into a shift than later on?
— Ensure that employees have the opportunity to sleep for at least eight hours between shifts?
— Restrict night shifts to four in a row or to two in a row if they are 12 hour shifts?
— Allow at least two days off after nights?
— Ensure that shifts 'rotate forwards' mornings, followed by afternoons followed by nights?
— Encourage employees to develop good sleeping habits?
— Arrange for more interesting and varied work to be done at night and other low points but make sure these are not too demanding or too monotonous/repetitive?
— Consider personal preferences – some people are 'morning people' some are 'night people' (larks or owls)?
— Take into account employee preferences for different shift patterns but note that preferred shift patterns are not always the safest or best for human performance?
— Provide the means for employees to report problems confidentially and without fear of sanctions?
— Investigate accidents or near misses where fatigue may have been an issue and take lessons from this?
— Act on information provided on alertness and fatigue to improve matters?
— Actively seek information on fatigue issues, including liaising with other organisations with experience and different insights into these matters?
— Appreciate that none of us are good at assessing how fatigued we are?
— Understand that, although employees are often skilled at coping with fatigue, the downside is that this can increase stress or the risk of gastric disorders or other health problems?

Questionnaires should seek to gather information on:

— Working hours and breaks.
— Scheduling (shift patterns, arrangement of work, job design).
— Suitability of staff for particular working arrangements.
— Support and education in relation to fatigue provided by management.
— Coping strategies/countermeasures and their effectiveness or harmfulness.
— Companies' checking/monitoring and data gathering arrangements.

A section should be included on the questionnaire for respondents to add additional comments or observations.

4.4.3 Review of accident or incident reports

Section 3 describes one method of conducting an accident or incident investigation. HSE *Investigating accidents and incidents* provides a template for conducting such an investigation and also a glossary of useful terms and concepts. As noted in 3.1, the investigation method comprises four steps:

— gathering the information;
— analysing the information;
— identifying suitable risk control measures;
— the action plan and its implementation.

Of course, this is a general method and is not devised simply for investigating any possible fatigue issues that impacted on the incident. However, one reason for developing this publication on fatigue is because there is evidence that fatigue is under-reported in incident investigations. This is thought to be because those involved in such incidents do not wish to admit that they were suffering the effects of fatigue, or the fatigue effects were 'masked' by other underlying causes; or, in many cases, the investigators simply did not think to explore the fatigue element in detail.

When conducting an investigation or reviewing existing reports, the users should find the following helpful in identifying whether fatigue was an issue in the data gathering and analysing phases of the investigation.

4.4.3.1 Gathering and analysing the information

Consider the time of day the incident occurred. Was it:

— At a 'circadian low point'?
— Close to the end of a shift?
— Within the period two to four hours from the start of a shift?

Consider the point within the shift cycle when the incident occurred. Was it:

— At a change of shift, for example, during the first day shift following a cycle of night shifts?
— At the end of a period of night shifts?
— At the changeover point in a swing shift cycle?

Consider sleeping patterns of those involved in the incident, in particular, those who seem to have 'caused' the incident? Were they:

— Sufficiently rested during the off-shift period before coming on shift? (had they had the opportunity for an eight hour sleep and had they had that amount of sleep?)
— Suffering from disrupted sleep?
— Accumulating a sleep deficit or loss of several hours? (Look back as far as possible for signs of accumulated fatigue noting that objective information may be difficult to obtain).
— Moonlighting during an extended period of rest days between shifts?

Consider the working environment. Was it:

— Dark?
— Warm?
— Quiet?
— Generally conducive to sleep?

Consider the type of work being carried out? Was it:

— Routine/uneventful (boring)?
— Work that required sustained attention or extended concentration? (This can be fatiguing.)
— Work requiring significant physical effort (either because of nature of the work itself, the need to access the work area (up ladders, in a tiring posture e.g. bent or stretching for a long period, or the need to walk a long distance to the worksite or the need to wear cumbersome personal protective equipment (PPE))?
— Safety critical work that could have been scheduled at another time?

Consider those involved in the incident. Were they:

— Taking any medicines that could have caused drowsiness or lack of attention?
— Taking stimulants (such as caffeine) to maintain

their alertness?
— Using ineffective measures to reduce fatigue (brisk walk in the fresh air; playing background music)?
— Assessed for fitness for duty before starting work or monitored during the shift for signs of fatigue?
— Tired on arrival after a long journey to work?

4.4.4 Review of risk assessments

Risk assessment is described in Section 3 and is the process of identifying hazards and ensuring that suitable precautions are in place against those hazards. A review of a company's existing risk assessment records can be useful:

— Whether fatigue has been identified as a risk factor and what measures have been taken to reduce the risk; this information can be applied to other parts of the organisation or to other tasks.
— That fatigue has not been properly accounted for as a risk factor; this information can be used to reduce the risk and to revise the risk assessments.

4.4.5 Other data sources

An analysis of sickness absence data, absence records, production and quality records, and confidential reporting schemes may reveal a problem at certain times of day, e.g. 3 a.m. to 5 a.m. Ill health records may also indicate whether shift workers are more prone to absences than other workers.

Safety observations, walkrounds and ad hoc discussions may also disclose information that indicates a fatigue problem.

4.4.6 The Fatigue and Risk Index Calculator

HSE's Fatigue and Risk Index Calculator replaces the Fatigue Index and may be used as part of an organisation's risk assessments to determine the risk of fatigue or an untoward incident occurring as a result of particular shift arrangements. It provides a focus for making changes to reduce risk. Details may be found in HSE *The development of a fatigue/risk index for shiftworkers*.

The calculator considers the key factors that affect fatigue and alertness including:

— The nature of the task, including workload.
— Time of day, shift start time.
— Length of shift.
— Number of consecutive shifts.
— Rest breaks within and between shifts.
— Direction and speed of rotational duties.

The calculator is in spreadsheet format and gives highly graphical and easy to understand output. There are two elements to the output:

— A fatigue index – indicating the probability of high levels of sleepiness resulting from the working conditions (as per the bullet points above).
— A risk index – indicating the relative risk of an incident occurring (as a result of sleepiness).

Note that the calculator can be used for split shifts and on-call working but it should not be applied to work involving very long series of night shifts such as those worked offshore.

4.4.7 Specific toolkit survey

A survey using a specific toolkit such as that used by HSE for managing fatigue risks (see HSE *Managing fatigue risks*). This is one example of a 'ready made' survey checklist supported by underlying information used by HSE inspectors to assess fatigue control provisions at major hazard sites. In addition, other regular surveys already conducted by companies – safety inspection walkrounds, behavioural safety audits, etc. – that could be adjusted slightly to include fatigue issues.

4.4.8 Fatigue measuring devices

The following are some of the methods that can be used to find out whether an individual is suffering the effects of fatigue. They are typically used in research studies to 'measure' fatigue and relate this to work schedules, working conditions, etc. There may be some limited value in using them as part of an assessment of fatigue, but they are more likely to be used by research institutes conducting academic research or by specialised consultants in fatigue.

4.4.8.1 Sleepiness scales

Sleepiness scales are self-rating methods to find out either how sleepy a person generally is (and therefore how prone to fall asleep during the working day) or for use in studies where a score is needed at the time of the person's state of sleepiness.

The Epworth sleepiness score asks how likely it is that the person will doze off in different situations (e.g. at the cinema, talking to someone, immediately after lunch). The scores range from zero – would never doze; to three – high chance of dozing; this provides an overall sleepiness/tendency to sleep rating. People with a high rating should seek advice from their doctor. The scale should be administered by a medically qualified

person.

The Stanford sleepiness scale asks the person to rate their present state of sleepiness from one – feeling active and vital; alert; wide awake; to seven – almost completely preoccupied, sleep onset soon; lost struggle to remain awake (the stage after that is actually asleep).

The Karolinska sleepiness scale is similar to the Stanford scale but with nine levels from one – extremely alert to nine – very sleepy; great effort to keep awake. Both are used in experimental studies to see what causes sleepiness.

4.4.8.2 Morningness/eveningness scale

The Horne-Ostberg scale is a questionnaire method for identifying whether an individual is more suited to daytime or nighttime activity. It scores the individual as either a 'lark' (morning person) or an 'owl' (evening person) or as 'indifferent' (having no preference for either morning or evening activity). 'Approximately 15% of the population are 'larks', 20% 'owls' and the rest are in the 'indifferent' category.

The scale could be used to help in assigning shifts to individuals or to 'measure' those already on shifts to ensure that they are suitable in this respect (noting that morningness and eveningness is just one element to consider among many others in shift design).

4.5 SOLUTIONS

Once the fatigue problem has been identified by carrying out the initial or further investigations described in sections 4.2-4.4, solutions should be explored. There are only a limited number of factors that can be adjusted to influence on alertness/fatigue: these are listed in Table 4.3; some may be obvious, but the list is intended to be reasonably comprehensive. In addition, it is clear that some possible solutions will be impractical to implement for operational reasons. Those who are unable to make a particular change should consider some alternatives; for example, if particularly fatiguing shift patterns cannot be avoided, the safest option should be implemented and safety critical work should be done on days when the pertinent staff are likely to be at their peak of alertness.

4.6 IMPLEMENTATION PLANS

Most solutions adopted will represent a change to the way things are currently done, in this case, with the express purpose of improving alertness. Management of change procedures should therefore be adopted as per the organisation's existing safety management system. For guidance see IP *Human factors briefing notes No.3: Organisational change* or HSE *Organisational change and major accident hazards*.

Broadly, the steps required for major changes to systems are:

- Inform all those likely to be affected by the change that this is being considered, explain the rationale behind the decision and that a change management team has been established to drive the process forward.
- Establish a management of change team – identify a leader and key members which should include, for example, specialists in the job area, members of the workforce and safety representatives.
- Agree the problems identified (are they concerned with, for example, shift schedules, design of work and work environment?).
- Agree appropriate solutions – consult guidance, experts in the field and workforce (the latter for acceptability issues in particular: keep those affected fully informed).
- Plan the change using risk assessment principles to determine the implications of the change, especially on major hazard risks but also on occupational safety and health and wellbeing in the short and long term. The risk assessment should help to identify:
  - key performance indicators (indicators of the success or failure of the change);
  - suitable subjective and objective measures of those indicators;
  - remedial actions required in the event of problems.
- Manage the transition from the existing to the new procedures/practices; ensure that contingencies have been identified in the risk assessment process and that resources and fall-back plans are available to manage any that arise.
- Monitor the new arrangements against the key performance indicators noting that some short-term temporary problems are likely to arise. The length of the monitoring period cannot be fixed in advance but is related to the extent of the changes made. Monitoring may need to continue for several months in order to ensure that results are valid.
- In the event of failure of the new arrangements, ensure that the previous arrangements can be easily reintroduced; consider in the first instance whether the new arrangements need to be modified rather than abandoned.

Table 4.3: Solutions to fatigue/alertness issues

Factor	Problem	Suggested solution	Comments
Scheduling			
Length of work period	Shifts are too long. Several long shifts are worked on consecutive days	Reduce hours as necessary/possible. Where not possible, continue to monitor for adverse effects and schedule safety critical work for safest period of shifts	Some organisations cannot avoid working 12-hour shifts. Long shifts are popular with many people as they result in compressed week/longer periods off. The WTR limits working to 48 hours on average per week averaged over 17 weeks (there are exceptions e.g. averaged over 26 or 52 weeks for offshore installations). In some workplaces, the workforce can opt out and work longer hours
Rest breaks within shifts	Rest breaks are too short or do not allow the opportunity for resting	Arrangements are usually determined by collective agreement. Workforce breaks should be monitored	Adequate rest and meal breaks should be taken away from the work station and in an appropriate place conducive to proper rest/relaxation. Consider allowing 'napping' during long or particularly fatiguing shifts. A quiet comfortable rest area will be required and napping supported by co-workers and management. Beware of period immediately following napping – the operator will need time to recover – deploy on non safety critical tasks for that period
Shift patterns	Operators work a backward-rotating shift or shifts are forward rotating but on a slow rotation	Change shift patterns to rapid forward rotating shifts; avoid backward rotation and slow rotations; also, avoid swing shifts if possible; avoid permanent night shifts if possible	Forward-rotating shifts are: a period of morning shifts followed by afternoons followed by nights followed by a break then the cycle begins again. A typical fast rotating or continental shift would be: three mornings, two afternoons and two nights. Slower rotating shifts may consist of a week each of mornings, afternoons and evenings
Rest period between shifts	Period between shifts is too short	Ensure adequate rest opportunity. Consider 'sleep contracts'[5] or other means of monitoring behaviour between shifts	Breaks between shifts should allow the opportunity for an eight-hour sleep period. Where the workforce sleeps at work (e.g. offshore, truck drivers) provide suitable sleeping accommodation (quiet, dark, comfortable), encourage those sharing accommodation to be considerate to others. Typically, shared cabins will be arranged to accommodate one night and one day worker offshore. The cabin is occupied by only one person at a time
Shift breaks/ holidays	Operators failing to recover from shift by 'moonlighting' or otherwise taking inadequate rest	Adopt policies for ensuring adequate rest is taken; include 'sleep contracts' or other contractual obligations with appropriate sanctions	Workforce returning after a between-shift break, sickness absence or a holiday need time to return to full efficiency and alertness. Consider scheduling duties to avoid safety critical work or increase supervision during this period

Factor	Problem	Suggested solution	Comments
Standby support/call out	Staffing levels and shift rostering is inadequate for providing cover in unusual circumstances	Develop contingency plans to postpone safety critical tasks; review staffing arrangements; ensure that 'standby' personnel are on-call and fit for duty to step in as required	Resources that make up the IP *Staffing arrangements toolbox* can be used to assess whether staffing arrangements are adequate; this includes a specific element on alertness and fatigue. It may be possible to roster an additional shift into the working arrangements to cover for training needs, sickness absence, peak demands, etc. and also to allow time out for training. This arrangement can also improve company communications as time is then available for discussion, briefings, etc.
Scheduling of safety critical tasks (circadian)	Safety critical tasks are performed at circadian (or other) 'low points' during the shift	Either reschedule the tasks or provide support to the task performer (supervision or a co-worker to assist/check). Identify workers who are more suited to night working (owls) day working (larks) and assign duties if possible based on type. Otherwise, be aware that a 'lark' may be working as an 'owl' and provide support/ supervision and education	Accident rates are generally higher within two to four hours of the start of a shift. Research has failed to establish a conclusive reason for this, but it should be noted that this is also a less suitable time for scheduling safety critical tasks. Alertness is low around the hours of 2 p.m. and 4 a.m.
Job environment			
Working conditions	The working environment encourages sleep rather than alertness (warm, dark, comfortable, silent)	Control lighting, noise levels, temperature and comfort of the workplace. Educate workforce to stretch, walk around and alert others to the fact that they are feeling drowsy	Ensure that staff have the opportunity for a break that takes them out of such a working environment if they feel drowsy. Caffeine is a short-term solution but more effective if accompanied by a nap. Bright light will reduce the level of the sleep hormone melatonin in the body; bright light in the workplace (controlled to a level that will not cause glare/discomfort) or in break areas (if napping is not used) may be effective in reducing sleepiness in the short term
Work content	Work is unstimulating and uneventful	Rotate work to ensure that staff have a mix of interesting stimulating work interspersed with more routine tasks Consider staff preferences and aptitudes for different types of work	Consider multi-skilling of staff, flexible working and self-directed team initiatives to stimulate interest in and control over work content

Factor	Problem	Suggested solution	Comments
Staff support			
Consultation with and involvement of staff	Staff not involved in decisions that directly affect them can feel left out and fail to support solutions offered	Consult and actively involve staff on fatigue and alertness matters; for example, collaborate on shift schedule and working arrangement design (work content) and on incident investigations and their follow up. HSE *Simple assessment tool for reviewing workforce involvement*. Appoint person to act as champion (train them – as part of general health and safety training)	Staff consultation is good for determining solutions that are practical and acceptable; for example, to eliminate the causes of certain fatigue-related incidents. It should be noted that shift patterns preferable from a social or economic viewpoint may not necessarily be the safest. Negotiation on such matters should be based on the best evidence available on the relative risks involved in different staff arrangements compared to the benefits for staff and employers. An external consultant may be required to advise
Involvement of family, friends and others	Shift worker is not supported by family – shift worker requirements for a home environment conducive to their needs is not understood	Involve family (and friends) in supporting shift workers. Provide educational leaflets and advice to family concerning sleeping arrangements and habits and also maintaining a social life outside of work. Expert advice or counselling may be required and may be coupled with general training and education on shiftwork	Spouses/partners and other family members can help by maintaining a quiet home to ensure that the shift worker there is able to sleep when required. This will involve them eliminating noise that they make and also any noise made by neighbours or visitors to the house (friends, meter readers, delivery staff, etc). Family members should also help ensure that the shiftworker adopts good sleeping habits and also good habits relating to diet, exercise and socialising, all of which can be affected by working evenings or nights
Social interaction	Working shifts can disrupt social contact with friends and family – breaks may coincide with normal weekends only occasionally	Shift arrangements should be as flexible as possible to allow time off and socialising; rapidly rotating shifts tend to allow more frequent time off to coincide with weekends. Allow shiftworkers to contact family and be contactable when working shifts or if working away from home	There is little research on the issue of the social effects of shiftwork but much anecdotal evidence of problems with family and friends as a result of working shifts
Management procedures			
Monitoring following changes	Not knowing if the remedies are working	Monitor impact of changes	Need to decide on a 'measurement'. Self-reports from staff are useful but rely on staff being truthful about their state of fatigue

Factor	Problem	Suggested solution	Comments
Fitness for duty testing	Staff report for duty without having sufficient rest beforehand or with medical/social problems that may affect alertness	Where staff are involved in hazardous work, conduct routine assessment of their fitness for duty. Educate workforce on the key issues including travel arrangements to and from work (early start if commuting long distance; driving to and from work). Consider sleep contracts with workforce members. Establish contingency plans to deal with unexpected/short-term problems (e.g. cover for family sickness, etc.)	Methods for assessing fitness for duty include self-reporting and 'sign on' discussions with supervisors. More formal methods may require the operator to sign a declaration of fitness including statements confirming that they are fit, well, rested, in a good state of mind and not taking any substances that may adversely affect alertness (e.g. alcohol, hay fever preparations, decongestants, travel sickness preparations, etc.). More intrusive medical surveillance measures may include blood or urine sampling although this would not be a routine practice
Incident analysis	Fatigue as a contributor to or cause of incidents is overlooked or not investigated	Raise awareness of fatigue as a possible factor in incident investigations See incident analysis guidance (section 3.3)	Ensure that accident/incident investigation systems include some line of questioning relating to fatigue. Monitor time on job/sleep before accident or incident
Risk assessment	Current risk assessments may not feature alert-ness as an issue	See risk assessment guidance (section 3.2)	The guidance in this publication should support the risk assessment process by providing an overview and some detail concerning the factors that affect alertness
Information input	Under-reporting of incidents	Establish a confidential reporting scheme to identify fatigue and alertness issues in the workplace	Fatigue is an under-reported problem due to the stigma attached to being seen to be working whilst fatigued. Confidential reporting would be a means of gathering more information on the extent of the problem
Sickness absence monitoring	Employee(s) take time off to recover from fatigue	Patterns of sickness following long shifts or extended night work may indicate a fatigue problem	Further monitoring, discussion and counselling of employees may be necessary
Education/information			
Develop-ments in fatigue research	Low awareness of developments in alertness, fatigue and sleep issues	Maintain awareness of developments in these issues by, for example: – Subscribing to web-sites specialising in this field. – Establishing contact with academic institu-tions specialising in studies of alertness, fatigue or sleep – Sharing information across industry fora	New information is constantly being developed on fatigue, alertness and sleep; industry is generally seeking new solutions and approaches and legal requirements change or become more refined. Company health and safety departments or safety representatives might take on responsibility for this among other duties

Factor	Problem	Suggested solution	Comments
Knowledge of fatigue causes	Management and workforce are not familiar with fatigue issues	Educate/advise/counsel all staff to ensure that they are aware of the primary causes and effects of fatigue	HSE *Managing shift work* and this publication include references to many information sources on the subject
Additional factors			
Exercise	Employees may be generally unfit and feel lethargic	Educate in healthy lifestyle Provide facilities for exercise	Fitter personnel are better able to cope with the strains of shiftworking and tend to sleep more soundly
Age differences	Older workforce less able to cope with shift work. Younger drivers more likely to have an accident	Monitor older members of workforce; use self-reporting methods	The circadian rhythms of people in their late 40s/early 50s change and they tend to become more 'lark' than 'owl'; this makes them less able to tolerate nightworking
Diet/ stimulants/ depressants	Employees have a poor diet which may be either: – Conducive to sleep when at work. – Disruptive to sleep when at home	Provide guidance on: – Suitable diets. e.g. avoiding heavy lunches which can encourage sleepiness shortly after. – Effects of drugs to promote sleep or alertness. – Side effects of drugs used for other purposes that can affect alertness	Caffeine may be used as a short term solution; it can be used very effectively if coupled with a nap. It is recommended that the coffee is drunk before the nap (that is, before the caffeine takes effect). Certain medicines can cause drowsiness – raise awareness of the effects of prescription and non-prescription preparations; ensure that members of the workforce who are taking any medicines – prescribed or otherwise – consult the company occupational health department, medic or a pharmacist for advice; consult up to date list of possible sleep-inducing medicines (See DfT *Over-the-counter medicines and the potential for unwanted sleepiness*); raise awareness of combinations of factors, for example, older people are more affected by alcohol. Some workers have obtained supplies of melatonin to encourage sleep but this is not a licensed medicinal product in the UK and there are a number of untoward side-effects. Even in the US where it can be obtained, it is not well-controlled and dosages can vary widely

[5] A sleep contract is a means of managing fatigue within a company's safety management system. Employers and employees formally document how they will: 1) identify and report fatigue risk; 2) respond to reports of fatigue problems; 3) record, review and address reports of fatigue risk. Sleep contracts make it clear that employees and management are jointly responsible for fatigue risk management and state the responsibilities/accountabilities of each party. See IP *Research Report*: *Viability of using sleep contracts as a control measure in fatigue management.*

4.7 MONITORING THE EFFECTS OF THE CHANGE

Monitoring for signs that the new arrangements are acceptable to the workforce and are having the desired effect on fatigue management requires a combination of subjective and objective measures including:

- Discussion/review with staff – within formal and informal sessions.
- Survey of staff – confidential questionnaires may be needed to gather information that cannot be obtained from direct discussion.
- Diaries – kept by individual employees to log shift hours worked, feelings of sleepiness/lack of alertness and the circumstances where they occurred; near misses thought to be a result of fatigue and other issues arising such as effect on social and family life.
- Measures of sleepiness – sleepiness scales may be administered to determine whether any particular aspects of the new arrangements are raising levels of sleepiness (these should be benchmarked against overall sleepiness ratings under the previous working arrangements).
- Review of incidents – reported incidents may not be an effective measure of the success of the change; short-term reactions of staff may be positive with a strong will to succeed, or fatigue-related incidents may not be reported if personnel wish to retain the new arrangements. Confidential reporting may help in obtaining a more realistic view of incidents. It may take several weeks or months for effects to be noticeable; hence the need for a long monitoring period.

4.8 SUMMARY OF SOLUTIONS

Table 4.4 provides a summary of solutions to fatigue/alertness.

Table 4.4: Summary of solutions to fatigue/alertness

Basics	Objective
General aim	Eliminate fatigue or its causes or reduce the likelihood that employees will suffer from fatigue. Develop ways of coping when fatigue is unavoidable
Initial investigation	Determining whether the organisation has a problem. Being aware of pitfalls in gathering evidence. Using a systematic checklist method to determine whether there is a problem
Further investigation	Using many of the methods available. Some are basic; others are advanced and require expert help
Key elements	**Objective**
Shift scheduling	Arranging appropriate shift patterns with appropriate breaks to ensure that work is covered but fatigue and alertness are controlled
Job environment	Providing a stimulating environment in terms of work content and working conditions
Staff support	Providing support from management, colleagues, family and friends. Ensuring that management and workforce cooperate in determining problems and solutions
Management procedures	Ensuring that existing procedures, for example, for risk assessment, incident investigation, fitness for duty testing, sickness absence monitoring etc. take into account fatigue
Education	Management ensuring that the most up to date information on the issue of fatigue is obtained and communicated to all who may be affected
Additional factors	Being aware that age, diet, use of stimulants or sleeping aids, exercise and other issues can affect alertness
Implementation plans	Using a management of change process to implement changes
Monitoring effects	When changes are made, ensuring that the effects are carefully considered and any necessary adjustments made

ANNEX A

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ANNEX B

DETAILS OF BACKGROUND STUDIES ON FATIGUE

The information contained in this publication has been derived from a number of sources across a range of industries and reflecting alertness and fatigue problems and practices from a number of different countries. The key learning points from some of the research and case studies consulted are of particular interest and have been summarised in this Annex for reference.

B.1 LENGTH OF SHIFT

B.1.1 Long (>12 hours) shifts

Figure B.1 which shows a marked increase in accident rates beyond the 12th hour of long shifts, is taken from research on working hours across a number of industries and was reproduced in the IP *Human factors briefing note No.5: Fatigue*. The original work was in support of the driver restructuring initiative (Wharf (1994) and Gall (1996)) and showed that this pattern of increased error rates is consistent across different industries and is an indication of the general fatigue inducing character of very long shifts.

B.1.2 Eight-hour versus twelve-hour shifts

Much of the research on 8-hour versus 12-hour shifts has been usefully summarised in HSE *Psychosocial aspects of work and health in the North Sea oil and gas industry* prepared by Oxford University and quoted below:

Laundry and Lees found that a change from 8-hour to 12-hour shifts was associated with reduced accident rates, but with increased rates of on-the-job injuries.

Furthermore, at least one study (Rosa) has demonstrated that personnel do not show long-term adaptation to 12-hour shifts; in this study, performance decrements associated with a change from 8-hour to 12-hour shifts were still apparent when examined in a follow-up assessment carried out three and a half years after the initial study.

Results have been equivocal but the balance of evidence suggests that adverse effects on mood and performance occur towards the end of 12-hour shifts, and that these adverse effects may be cumulative over a sequence of 12-hour shifts (e.g. Rosa et al. (1985); Rosa and Colligan (1988)).

However, in spite of these disadvantages, the employees concerned welcomed the move to longer shifts because of the increased leisure opportunities afforded by more rest days, and plant management personnel considered the performance of the plant to be unchanged. The favourable response to 12-hour shifts was reflected in the large majority of personnel concerned (80%) who voted to continue the new schedules.

Tucker et al. (1996) reported similar findings from a survey of two groups of chemical industry employees, one group working 8-hour shifts and the other working 12-hour shifts. Although the two groups did not differ on most of the outcome measures, the differences that did exist suggested advantages for the longer shift duration, with the important exception of lower reported alertness towards the end of 12-hour shifts (especially night shifts) as compared with 8-hour shifts.

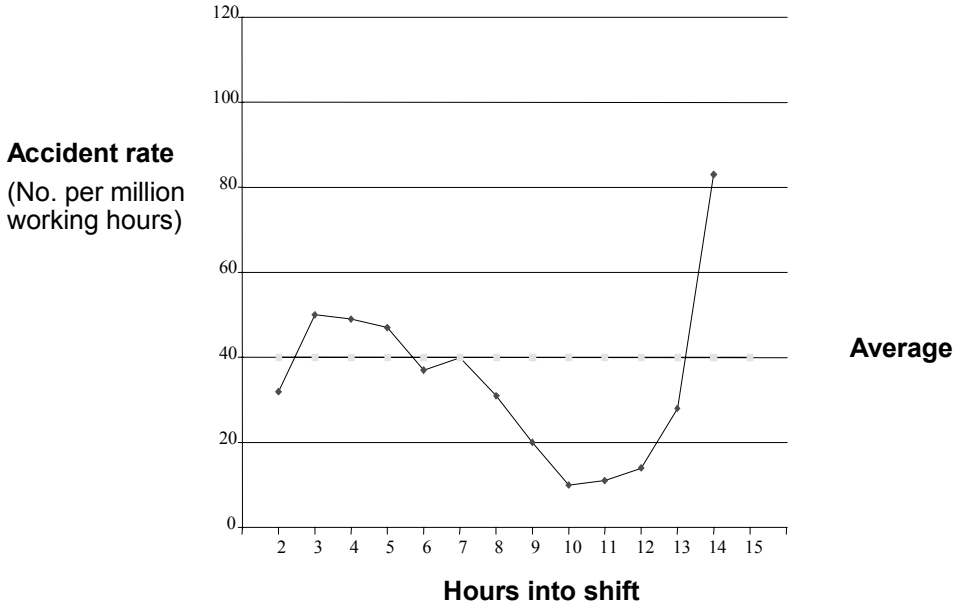

Figure B.1: Effect of shift duration on accident rate

B.2 SHIFT PATTERNS

B.2.1 Swing shifts/rollover shifts

Much of the research on the issue of 'swing shifts/split shifts' has been summarised in Miles (2004). Extracts are paraphrased below.

The study for HSE by Josephine Arendt considered 'swing shifts' (also known as rollover shifts). These are shifts whereby the offshore tour is split into seven night (7N) shifts followed by seven day (7D) shifts – with a rapid change around on day eight (finish at 6 a.m., rest, re-start at 6 p.m. the same day). It was found that the circadian rhythms (melatonin production) of those working this system were 'out of phase' for five out of the seven night shifts. It had adapted and stabilised by the end of the first seven workshifts, but, by then moving immediately on to a day shift, they were out of phase again for four to five days of the day shift. Thus in all, to quote the research:

…optimal working conditions may only be achieved for around six days of a 14-day period on the rigs.

Another study for HSE by Katharine Parkes of Oxford University examined the performance of those working the same shift patterns as in the work of Arendt: 7N+7D; 7D+7N and fixed shifts comprising 14 consecutive days (14D) or 14 nights (14N) alternating between each tour of duty.

It was found that:

…rollover patterns gave rise to significant impairments as compared with the corresponding fixed-shift schedules. For the 7N+7D group, the initial adjustment to shifts was followed by a further 12-hour circadian change at the start of the second week; consequently, the operators concerned showed impaired alertness and performance from the start of the night shift to the end of the second week. The disruptive effects of rollover were also evident in the 7D+7N group as compared with the 14D condition.

Measures of performance used were: reaction time, memory and logical reasoning. It was found that, compared with the 14D shift pattern, performance was worse in the rollover patterns on these measures. There were some slight differences between performance on the 7D+7N and 7N+7D conditions and in some respects the 7D+7N condition was worse than the 7N+7D. It would be expected that the 7N+7D would be the worst; however, on the particular platforms studied, the 7N+7D workers had three days of short day shifts rotating backwards to prepare them for the night shift proper, and this may have had a beneficial stabilising effect. The overall finding however was impaired performance in the rollover patterns.

The researchers estimated the decrease in performance in the two shifts immediately after the rollover compared with the shift immediately before rollover as between 5-10%. This is the same level of

reduction in performance that someone would have with a blood alcohol content (BAC) of around 0,10. This BAC level is the equivalent to five or six units of alcohol (two and a half to three pints of beer) and is 'over the limit' in UK law for driving.

This level of performance reduction, also equivalent to a BAC of 0,10, is found in people who have stayed awake for 24 hours.

B.2.2 Sleep deficit

In addition to the performance problems, all 12-hour shifts result in a sleep deficit over the 14-day tour. The 14D patterns resulted in 12,6 hours of lost sleep by the end of the tour; the 14D pattern 16,4 hours; 7N+7D was the worst at 20,3 hours.

In case there was any doubt that swing shifts are a problem:

…the most usual system of day/night rotation offshore (in which a mid-cycle shift change takes place at the end of the first week) violates all five recommendations put forward by Knauth for the design of better shift systems.. (see Section 2).

The sleep deficit in these cases seemed to be accumulated as a result of noise problems from continuous production offshore and also cabin sharing.

B.3 CIRCADIAN RHYTHMS

It has long been established that performance measures vary with stages in the biological cycle; in particular, performance shows gradually increasing efficiency when the body core temperature is in a rising phase and decreasing efficiency as temperature falls. This is not usually interpreted as a causal relationship, but simply a case of temperature acting as a convenient marker for more general biological rhythms. A large number of other physiological variables show similar rhythmicity, notably the production of hormones which can be measured. Data on long hours and safety are very limited. Analysis of accident data in two countries indicates a rise in accident rates after nine hours of work. Experimental data from cognitive psychology predict an increase in errors after eight hours' work. Most data from studies of 12-hour shifts show an equally good, or in some cases better, safety record following a change from 8-hour to 12-hour shifts; but these data should be viewed with caution and not viewed as unequivocal evidence that long shifts are safe. There are a number of possible explanations for the data which have not been properly investigated.

Under normal conditions body temperature, and alongside this performance efficiency, begin to rise around 7 a.m., ending with peak performance in mid-evening around 9 p.m. Both are at their lowest in the

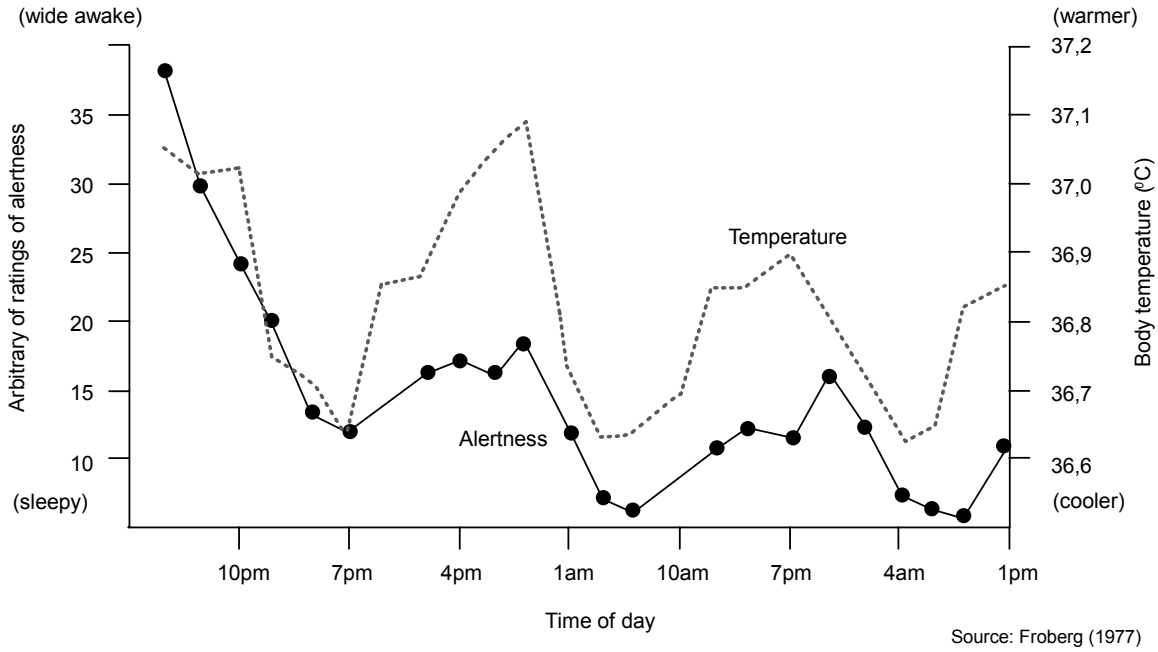

Figure B.1: Body temperature and alertness from a group of 15 young subjects experiencing 72 hours of constant wakefulness

early hours of the morning, approximately between the hours of 2 a.m. and 6 a.m. This is illustrated in a study by Froberg (1977) who measured body temperature and self-reported alertness in 15 young healthy volunteers who stayed awake over a 72-hour period. See Figure B.1.

The information above was found in ILO *Working time: Its impact on safety and health*.

B.4 BREAKS

Scheduled and ad hoc breaks during work time are usually determined through collective agreements between employers and employees or by legislation. In terms of alleviating fatigue, there are no clear cut rules concerning the length of breaks or where in the working day they should be taken. Recent research has also questioned whether breaks alone can reduce the effects of fatigue.

There is little evidence concerning the optimum length of rest breaks (other than for heavy physical work), or to support the contention that increased rest-breaks can off-set the negative impact of extending shift durations, or to suggest that rest breaks counteract the negative impacts of circadian variations in alertness, unless they involve taking a nap or caffeine. The scarcity of epidemiological evidence highlights the need for more research.

It should be noted that there are some differences of opinion on this subject as the following quote from Tucker (2003) illustrates:

Rest breaks every two hours are common in many industrial settings, and have been shown to act as an effective means of controlling the accumulation of risk as a function of time-on-duty. However, there is evidence from a range of settings that scheduling additional short rest breaks can be beneficial. Such arrangements will increase the likelihood of allowing the worker to rest at times of heightened fatigue that do not coincide with the conventional two hourly rest breaks.

B.5 EFFECT ON SAFETY

Risk of injury is 30% higher on night shift compared with morning shift and is highest in the first two to three hours; the risk then increases over successive night shifts so that the fourth night shift carries 36% more risk than the first. With extended working hours, risk increases more or less exponentially and in the 12th hour of work it is twice what it was during the first eight hours. The risk of injury is also increased by not taking breaks and rises linearly and substantially with time from the last break; there is twice the risk of injury 90 minutes after the last break compared with immediately after a break.

The above information was found in Hobson (2004).

These problems arise because of our lack of alertness, but we can also simply fall asleep at work:

Overall, 60 to 70% of shift workers will report difficulty with sleep, sleepiness on the job or actually falling asleep unintentionally while at work.

In [a] NASA study of long haul pilots, there were 154 occurrences of physiological microevents[6] i.e., alpha or theta EEG or slow eye movements) recorded during the last 90 minutes of a 9-hr flight. A study of air traffic controllers conducted by the FAA found that 48% report they often fell asleep unintentionally.

Police officers report falling asleep on duty, for example, 80% report dozing off at a stop light once a week, 26% nod off during daytime activities and 41% during a night shift.

Rosekind (in press)

The above information is courtesy of Rosekind.

Driver sleepiness is thought to cause at least 10 % of all road accidents and as many as one in four accidents on motorways and trunk roads. Over 39 000 serious injuries and nearly 3 500 deaths occurred on roads in the UK, according to DTLR statistics. Drowsiness is now considered to be a major cause; the killer claiming more lives than alcohol.

Falling asleep at the wheel is increasingly preceded by feelings of increasing sleepiness that drivers are aware of but often ignore. They will wind down the window, turn up the radio, stretch etc., but drive on. Neither these latter methods nor the willpower to stay awake have much effect in overcoming sleepiness.

The above information was taken from IAM *Driver fatigue*.

Shift workers are used to living with fatigue, and most of the time no serious accidents occur, in spite of such fatigue. These positive experiences reinforce the notion that fatigue is not a serious risk at work. Fatigue has, however, been estimated to be the key factor in as many

[6] These are direct measures of alertness from eye movement and electro encephalogram readings.

as 41% of accidental injuries and deaths caused by human error.
The above information was taken from Sallinen (1997).

B.6 HEALTH EFFECTS

Although the primary aim of this publication is to provide information on how to reduce fatigue, there is also evidence that shift work also has adverse effects on workforce health.

Gastrointestinal disorders are more common in shift workers, who complain of pain and alteration in bowel habit. There is strong evidence linking shift work to peptic ulcer disease, and rather strong evidence linking shift work to coronary heart disease (Hobson (2004)).

Potassium, uric acid, glucose, cholesterol, and total lipids are all increased during night work but return to normal during day work, although the evidence for a link to diabetes is inconclusive. There is rather strong evidence in support of an association between shift work and pregnancy outcome in terms of miscarriage, low birth weight, and preterm birth. There is no evidence that night work increases the risk of cancer or that shift work affects longevity (Hobson (2004)).

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ANNEX C

GLOSSARY OF TERMS AND ABBREVIATIONS

C.1 GLOSSARY OF TERMS

For the purpose of this publication, the interpretations below apply, irrespective of any meaning the words may have in any other connections.

accident/incident investigation: a formal method of examining evidence following an incident or accident to determine the immediate and underlying ('root') causes.

alertness: the state of readiness to respond to any stimulus.

antihistamine: a chemical substance found in common medicines, e.g. hay fever preparations. It can cause drowsiness.

backward rotating shifts: a shift system where the shift changes to an earlier shift period at each shift change, thus, from mornings to nights to afternoons.

Blood Alcohol Content (BAC): a measure of how much alcohol is present in the blood stream.

circadian rhythms: certain bodily processes such as digestion, hormone production and sleepiness that follow known regular patterns of rising and falling over a 24-hour period.

Continental shift: synonymous with rapidly rotating shift. A shift pattern in which short periods of shift work are worked on a rapidly rotating pattern such as two morning shifts followed by two afternoon shifts followed by two night shifts followed by a break. No attempt is made to 'acclimatise' the worker to night shifts, i.e. to allow their circadian rhythms to adapt. See *circadian rhythms*.

coping strategy: methods adopted in an attempt to cope with the effects of a problem (such as fatigue) rather than remove the problem.

Critical Flicker Fusion (CCF): a rapidly flickering light will, at high frequencies, appear as a steady 'continually on' light. The frequency of flicker before the light appears continuous to a person is a measure of the person's level of alertness.

eveningness: the tendency for some people to be more alert during the evening and night time than during the day. 'Evening' people are referred to as 'owls'. See *morningness*.

fatigue: the state of weariness following a period of exertion, mental or physical, characterised by a decreased capacity for work and reduced efficiency to respond to stimuli.

fatigue index: a method for estimating the likely effect of a shift pattern on fatigue by examining five factors: start time; duration; rest period between shifts; rest breaks during shifts; and cumulative fatigue. This method has been superseded by the fatigue/risk index calculator. See *Fatigue and Risk Index Calculator*.

Fatigue and Risk Index Calculator: a method for

determining the risk of fatigue or an untoward incident occurring as a result of particular shift arrangements.

fitness for duty: mental and physical ability and readiness to work. Not suffering any negative effects from: illness; fatigue; drugs; medicines; alcohol; or personal problems.

forward rotating shifts: a shift system where the shift changes to a later shift period at each shift change, thus, from mornings to afternoons to nights.

hazard: anything with the potential to cause harm. It could be an obvious feature of the workplace such as moving machinery, sharp tools, corrosive or toxic chemicals, or it could be less obvious such as gravity (when working at height).

human error: an error made by a human operator. See *slip, lapse* and *mistake.*

human factors: synonymous with 'ergonomics'. The study of people in their working environment.

human factors briefing note: a short two to four page pamphlet on human factors issues published by the Energy Institute as an IP branded publication.

lapse: a type of human error in which a person has a lapse of memory (forgets something) or a lapse of attention (is distracted or loses concentration). See *human error*.

management of change: a formal process of changing working conditions or the working environment in which the change is devised, implemented and monitored in a series of carefully planned stages.

melatonin: a hormone secreted from the pineal gland in the brain which causes sleep.

microevents or microsleeps: short duration sleeps ('nodding off') that are unnoticed by the sleeper; they happen without warning and the sleeper may still have their eyes open.

mistake: a type of human error in which a person fails to correctly interpret information, comes to the wrong conclusion and acts on that conclusion. 'Misdiagnosis' of a set of symptoms is a typical example. See *human error*.

morningness: the tendency for some people to be more alert during the morning and afternoon than during the evening and night. 'Morning' people are referred to as 'larks'. See *eveningness*.

naps: short sleeps usually taken during break periods within a shift as a strategy for improving alertness.

night work: work taking place at any time during the period between midnight and 5 a.m.

Personal Protective Equipment (PPE): clothing or equipment provided to protect against workplace hazards.

Rapid Eye Movement (REM): a period of sleep, when the eyes move rapidly; this is when a person is dreaming and is necessary for a fully refreshing sleep.

rapidly rotating shift: see *Continental shift.*

risk: the likelihood that a hazard will cause a specified harm to someone or something.

risk assessment: a formal and systematic method for examining the hazards in the workplace and assessing the risk of those hazards causing harm.

Road Transport Directive (RTD): EU directive leading to the Road Transport (Working Time) Regulations that came into force in April 2005. They affect mobile workers (mainly drivers, crew and other travelling staff) who are travelling in vehicles subject to the Community Drivers' Hours regulation (3820/85/EEC) or, in some cases, the AETR (relating to international driving).

rollover shift: see *split shift*.

shift work: any method of organising work in shifts whereby workers succeed each other at the same work stations according to a certain pattern, including a rotating pattern, and which may be continuous or discontinuous, entailing the need for workers to work at different times over a given period of days or weeks.

shift pattern: the particular arrangement of shifts for a workforce. See *continental shift; slowly rotating shift; split shift.*

slowly rotating shift: a shift pattern in which long periods of each shift are worked, for example, four morning shifts followed by four evenings followed by four nights with rest days in between. There is a wide variety and complexity of shift patterns – slowly rotating patterns make some attempt to allow adaptation

of circadian rhythms but also allow rest periods to compensate. Very long patterns may be worked (for example 21 days) to allow complete adaptation and some workers adopt permanent nights.

split shift: synonymous with swing shift and rollover shift. A shift pattern in which a long period of days is followed by a long period of nights (or vice versa). A typical offshore split shift is a 14-day tour starting with night shifts of 12 hours for the first half of the tour then changing to day shifts for the second half. The advantage is that the worker is adapted to normal day/night circadian rhythms when returning home.

swing shift: see *split shift*.

shiftworker: any worker who works shifts.

sleep apnea (or apnoea): a medical disorder in which sleep is disturbed at frequent intervals through breathing difficulties.

sleep contract: a means of managing fatigue within a company's safety management system. Employers and employees formally document how they will: 1) identify and report fatigue risk; 2) respond to reports of fatigue problems; 3) record, review and address reports of fatigue risk. Sleep contracts make it clear that employees and management are jointly responsible for fatigue risk management and state the responsibilities/ accountabilities of each party.

sleep deficit: synonymous with sleep debt. Loss of sleep which can accumulate over a number of days.

sleep debt: see *sleep deficit*.

sleepiness scales/scores: methods for rating a person's alertness/sleepiness using a rating scale (the person chooses the description that best describes their current state of sleepiness).

slip: a type of human error in which a person performing a physical act (operating a control, looking at a display) fails to perform the task correctly (operates the wrong control, operates the right control but in the wrong direction, looks at the wrong display or misreads the right display etc.). See *human error*.

violation: an action by a person in which they deliberately choose not to follow a known rule or work practice. Usually, there is a 'reward' for the violator – in terms of saving time cost or effort in performing a task.

walkrounds: regular workplace visits with the intention of observing and removing hazards or poor work practices.

C.2 ABBREVIATIONS

For the purpose of this publication, the interpretations below apply, irrespective of any meaning the abbreviations may have in any other connections.

AETR	European Agreement concerning the Work of Crews of Vehicles Engaged in International Road Transport
BAC	Blood Alcohol Content
CCF	Critical Flicker Fusion
PPE	Personal Protective Equipment
REM	Rapid Eye Movement
RTD	Road Transport Directive
WTR	Working Time Regulations 1998