

## Synopsis

There have been several high-profile accidents in the South African mining industry where fatigue was identified as either causal or contributory. The risk of fatigue is inherent in any work-time arrangement involving shift work and work that is physically or mentally demanding, repetitive, or requires high vigilance.

The management of fatigue is not simply a matter of correct shift scheduling. A more comprehensive approach is needed. In order to be successful, a fatigue management programme should address the unique needs of the operation in which it will be implemented and should be integrated into normal operations. Fatigue management is a shared responsibility between the organization and its employees, and all stakeholders should participate in order to provide the safest and healthiest working environment possible.

## Introduction

Fatigue is a growing problem in modern society. The incidences of insufficient sleep and circadian disruptions have become all too common in today's fast-paced world and these problems are increasingly taking their toll both in the workplace and in everyday life (Caldwell *et al.*, 2008).

Employee fatigue is a critical safety issue that affects many mines in the South African mining industry (Schutte and Maldonado, 2003). Fatigue has become pervasive because many employees work non-standard schedules, and they often fail to obtain sufficient sleep. From a health and safety standpoint, employee fatigue is a significant concern. Over the last number of years, increasing attention has been paid to fatigue management in the industry because of the recognition that sleepiness and fatigue are becoming endemic in the mining population, contributing to human error, and consequently to many (sometimes catastrophic) accidents.

## Definition of fatigue

It is difficult to find an all-embracing and

universally accepted definition of fatigue. Fatigue can be defined as 'a state of impaired mental and/or physical performance and lowered alertness arising as a result of or a combination of hard physical and mental work, health and psychosocial factors or inadequate restorative sleep. Fatigue can be either work or non-work related or a combination of both' (BHP Billiton, 2005).

Fatigue can also be defined as 'increasing difficulty in performing physical or mental activities. Signs of fatigue include tiredness even after sleep, psychological disturbances, loss of energy and inability to concentrate. Fatigue can lead to incidents because workers are not alert and are less able to respond to changing circumstances. Apart from these immediate problems, fatigue can also lead to long-term health problems' (Shaw, 2003).

Another definition describes fatigue as 'the loss of alertness and performance that results from insufficient or poor quality sleep or engaging in mentally or physically demanding activities' (Simpson, 2008).

Other definitions exist, but the above usefully include the concept that fatigue is not simply 'tiredness' and that it has a direct effect on alertness and work performance.

## Causes of fatigue

Total worker fatigue is the sum total of fatigue related to work-time arrangements, fatigue related to work and environmental factors, and fatigue related to the operator's personal factors as depicted in the model below:

$$F_T = F_{SS} + F_{ew} + F_{pf}$$

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where  $F_T$  = Total operator fatigue

$F_{SS}$  = Fatigue related to shift system design (working arrangements, circadian rhythm disruption, sleep deprivation)

$F_{ew}$  = Fatigue related to work and environmental factors (task requirements, physical work loads, workstation design, physical factors) and

$F_{pf}$  = Fatigue related to the operator's personal factors (health status, nutritional status, social and domestic dictates).

While the above model is not claimed to be a complete representation of all the factors that contribute to fatigue, it points towards a need for a broad and holistic approach to manage this issue. One of the major factors contributing to fatigue or on-the-job sleepiness is the disruption of the circadian rhythm. The human biological system operates on an internal clock in which different functions run on different cycle lengths. The circadian rhythm, for example, is a rhythm that cycles approximately every 24 h, with various functions either rising or falling at various times throughout the 24-h period. For example, high body temperature and heart rate are associated with increased alertness and performance and occur during the daylight hours. Sleep, on the other hand, is associated with a lowering of body temperature, heart rate, and cortisol, which decrease in the evening, then rise in the morning before we awaken (Van Dongen and Dinges, 2005).

The physiological tendency to sleep at night and to be awake during the day is powerful; difficulties occur when work-time arrangements cause individuals to work against this tendency. Altering the normal sleep/wake cycle affects both the ability to remain alert and the ability to sleep. Non-traditional work hours (night or early morning hours) create a misalignment between the internal clock and the normal activity and sleep schedule (Caldwell *et al.*, 2008).

### Effects of fatigue

Fatigue has an adverse effect on every aspect of human performance. High levels of fatigue cause reduced performance and productivity in the workplace, and increase the risk of accidents and injuries occurring. Fatigue affects the ability to think clearly, which is vital when making safety-related decisions and judgements. People who are fatigued are unable to gauge their own level of impairment. As a result, fatigued people are unaware that they are not functioning as well or as safely as they would be if they were not fatigued (Folkard *et al.*, 2003).

Fatigue can also result in long-term health problems such as digestive problems, heart disease, anxiety and depression. Women's reproductive health can also be affected by fatigue. Fatigue and irregular sleep patterns have been associated with a number of negative effects on pregnant women. Negative effects include an increased risk of miscarriage, low birth weight and a higher occurrence of premature births (Harrington, 2001).

### Fatigue management

Managing fatigue requires an appreciation of the nature of fatigue, an understanding of individual differences in fatigue vulnerability, and a willingness and ability to implement scientifically valid fatigue countermeasures (Caldwell *et al.*, 2008). For these reasons, there is no 'one-size-fits-all' fatigue management approach. The management of fatigue is not simply a matter of correct shift scheduling; a more comprehensive approach is needed. Ideally, a fatigue management programme should address the unique needs of the operation in which it is to be implemented. It should be integrated into the normal operations, and it should encourage active participation from all stakeholders (Schutte, 2008).

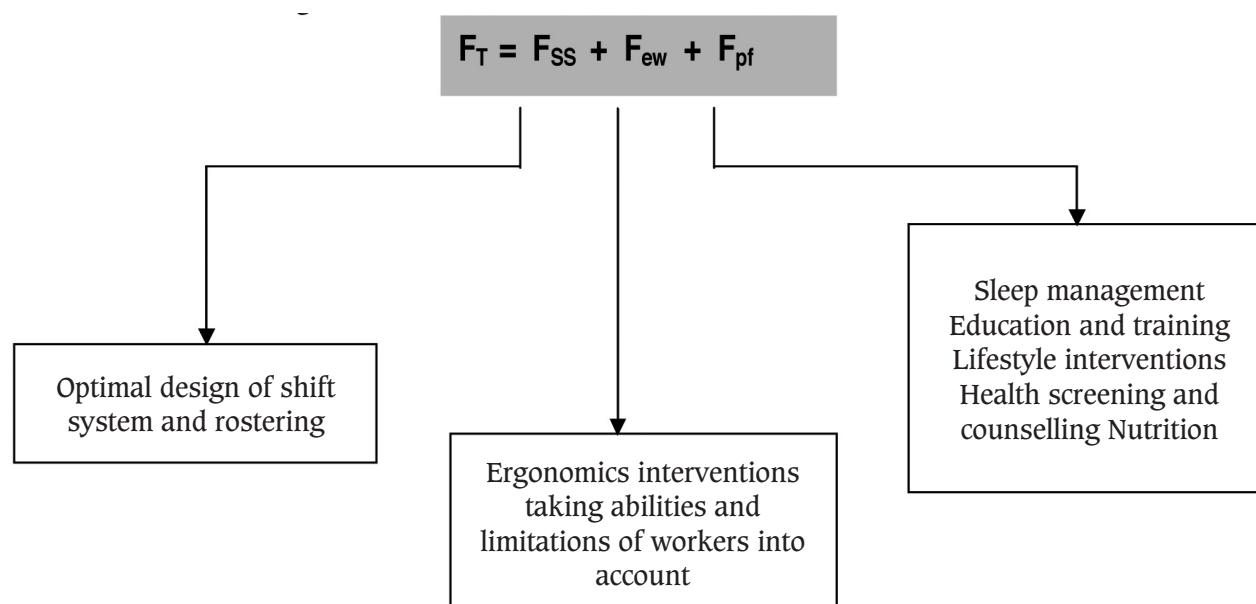
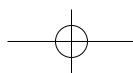


Figure 1 – Framework for managing fatigue



## Fatigue risk management: charting a path to a safer workplace

The management of fatigue is a shared responsibility between the organization and its employees. It is, therefore, necessary to develop a culture in the organization in which everyone accepts that fatigue is a barrier to excellence in safe production and wellness, and that everybody needs to work together to overcome this barrier. The effective management of fatigue depends on the management of the organization's culture and on the promotion of self-management rather than on technological solutions. In view of the above it is important that a comprehensive approach be taken to address the issue of fatigue at mine sites.

Figure 1 provides a framework for managing fatigue since it addresses the factors that cause fatigue.

In general, the goal of a fatigue management plan is to maintain and, where possible, enhance safety, performance and productivity in operational settings, and manage the risk of fatigue in the workplace.

The recommended process of developing and maintaining a successful fatigue management plan consists of five interrelated elements:

- Securing and maintaining senior management commitment
- Developing policy and programme
- Managing fatigue
- Communicating the policy and fatigue management plan and
- Monitoring, reviewing and modifying.

In order to make the fatigue management programme as practical and comprehensive as possible (BHP Billiton, 2005), emphasis needs to be placed on:

- Structure and design of work-time arrangements
- Ergonomics design of workplaces and tasks
- Employee fitness for work
- Management processes for monitoring and controlling a worker's potential for fatigue
- Fatigue-related education and information and
- Employee assistance programmes.

### Operator fatigue detection technologies

While operator fatigue is predominantly a people-management issue, technology is available that can be adapted to assist in the detection of the onset of fatigue and interface with the operator to prevent an incident, and subsequently allow remedial actions to be taken. The mining industry worldwide has looked to technology to provide supplementary solutions to the driver/operator fatigue issue. Numerous technologies have surfaced, but none has been clearly identified as the ideal solution in terms of accuracy or widespread operator acceptance.

### Measurement of effectiveness of fatigue management

Management is a process, not a goal. To manage any programme effectively, ongoing monitoring, evaluation and adjustment are required. The need to measure and maintain holds true for fatigue management. Ongoing evaluation is necessary to determine whether a programme is remaining effective and relevant.

Ideally, the measurement of the effectiveness of fatigue management should strike an appropriate balance between leading indicators and outcome measures. Examples of leading indicators are the number of individuals diagnosed with and treated for sleeping disorders, and the number of individuals who self-report fatigue when at work. Outcomes involve the usual measures such as incident and accident rates, equipment damage, and feedback from employees.

### Conclusions

Fatigue in modern society is both a personal and an occupational risk factor. It is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness. It is associated with spending long hours awake, an inadequate amount of sleep over an extended period or obtaining an insufficient quality of sleep, high physical and mental loads, and a number of non-work related factors.

From a practical viewpoint it is doubtful whether fatigue in the workplace can be eliminated altogether, but it can certainly be controlled; fatigue can be limited by proper management. The management of fatigue is a shared responsibility between the organization and its employees, and all stakeholders should participate in order to provide the safest and healthiest working environment possible. To achieve this objective a holistic approach, based on best practices, is required.

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