California Training Institute

Science based solutions to human factor issues

Fatigue Facts & An Effective Fatigue Risk Management System

Key Points

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1. We require 7-8 hours' sleep per night.
2. In order to acquire 7 hours physiological sleep time, an average healthy adult must spend approximately 8 hours in bed, as physiological sleep occurs for 85-95 percent of time in bed for healthy sleepers.
3. Although some people can function at normal levels for a night or two with 6 hours of physiological sleep, repeated days of 6 hours of sleep can result in cumulative fatigue and its attendant cognitive performance deficits in a significant portion of the population. (*Van Dongen et al., 2003a; Mollicone et al., 2007)*
4. Twenty-four hours of sleep deprivation has been shown to impair neurobehavioral performance comparable to a 0.10% blood alcohol level. (*Dawson D, Reid K. Fatigue, alcohol and performance impairment. Nature. 1997;388:235.)*
5. Small amounts of sleep loss can affect the ability to sustain vigilance on some tasks. Only 2 hours less sleep per night than optimal over a week can lead to performance decrements equal to 24 hours of consecutive wakefulness. (*Belenky G, Wesensten NJ, Thorne DR, et al. Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose response study. J Sleep Res. 2003;12:1–12.)*
6. Sustained wakefulness decreases performance.
    - Between 10 and 26 hours of wakefulness performance drops 0.74% per hour.
    - Between 10 and 26 hours of wakefulness each hour equates to a 0.004 equivalent blood alcohol concentration (EBAC) increase.
    - An increase of 0.01 EBAC decreases performance by 1.16%
    - Approximately 18 hours of wakefulness = 0.08 EBAC and 24 hours = 0.10 EBAC
7. Beyond the 'regular' eight-hour day, every extra hour at work has the potential to contribute to fatigue and fatigue-related risk. Scientific data showed that accident risk increased nearly exponentially with hours at work. Additionally, it was also found that at the twelfth hour of a shift the relative accident risk was double compared to the first eight hours of the shift, clearly demonstrating increased risk beyond a 'typical' eight- to nine-hour shift. *Folkard and Tucker (2003)*

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Investigation Procedure Checklist: Establishing Link between Fatigue and Unsafe Act/Decision

Performance Impairment	Indicators
Attention	• Overlooked sequential task element • Incorrectly ordered sequential task element • Preoccupied with single tasks or elements • Exhibited lack of awareness of poor performance – impaired subjective evaluation • Reverted to old habits • Focused on a minor problem despite risk of major one – channeled attention • Did not appreciate gravity of situation • Did not anticipate danger • Displayed decreased vigilance – detection of a stimulus or problem • Increase in false positives – Problem identified as not serious when it was • Did not observe warning signs
Memory	• Forgot a task or elements of a task • Forgot the sequence of tasks or task elements • Inaccurately recalled operational events
Alertness	• Succumbed to uncontrollable sleep in form of microsleeps, nap, or long sleep episode • Displayed automatic behavior syndrome
Reaction Time	• Responded slowly to normal, abnormal, or emergency stimuli • Failed to respond altogether to normal, abnormal, or emergency stimuli
Problem-solving Ability	• Displayed flawed logic • Displayed problems with arithmetic, geometric or other cognitive processing tasks • Applied inappropriate corrective action • Did not accurately interpret situation • Displayed poor judgment of distance, speed, and/or time
Mood	• Was less conversant than normal • Did not perform low-demand tasks • Was irritable
Attitude	• Distracted by discomfort • Displayed a willingness to take risks • Ignored normal checks or procedures • Displayed a “don’t care” attitude
Physiological effects	• Exhibited speech effects—slurred, rate, content • Exhibited reduced manual dexterity—key-punch entry errors, switch selection

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The Supporting Framework for a Fatigue Risk Management System (FRMS)

For an FRMS to be effective, each defense must in turn be integrated into the overall framework of FRMS.

Level 1 Controls: Requires the employee to be allowed an adequate opportunity for sleep.

A reduction of extended work shifts has the capacity to reduce fatigue, with evidence showing increases in fatigue/ accident risk beyond an eight to nine-hour day. Longer breaks from work will typically result in more sleep with some data showing that a 16-hour break is required to ensure seven to eight hours sleep. Recovery must also be thought of in terms of time following a shift-cycle (which may simply be the weekend following the five-day working week). Longer recovery may be required following night-shifts where a larger sleep debt is likely to have been accumulated.

Level 2 Controls: Need to ensure that the employee actually obtains adequate sleep.

Inadequate sleep and prolonged wakefulness can both result in increased fatigue levels and at Level 2, thresholds are based around these two factors; sleep and wake. The amount of sleep needed and duration of wakefulness that can be withstood varies between individuals. However there is good laboratory and field-based evidence showing there are thresholds for both these factors that, once reached, will diminish the safe-work capacity of any individual. The impact of moderate sleep restriction may be more profound when a sleep debt has accumulated, that is when sleep is restricted over two or more nights. Two weeks of restriction to six hours per night induced impairment equivalent to one night with no sleep and that at four hours per night, impairment was equivalent to two nights with no sleep.

Studies clearly demonstrate that over the course of a week or more, there is a cumulative effect in terms of performance deficit. Continued sleep restriction (less than six hours), even if only moderate, will result in significant impairment to waking functions. Importantly, these deficits may be comparable to that induced by total sleep deprivation. How long is too long to be awake? Research continues to illustrate that when wakefulness is extended beyond what is normally experienced (16 to 18 hours) impairment on various cognitive functions will result. Impairment can manifest as slowed response speed, increases in attention lapse frequency and decision making.

Significant fatigue may still be experienced late at night and in the early hours of the morning, regardless of prior sleep/ wake/work variables.

Research shows the subjective experience of fatigue may not necessarily align with objective indicators

Level 3 Controls: Need to ensure that employees who obtained adequate sleep are not experiencing fatigue-related behaviors because of, for instance, sleep disorders.

Level 4 Controls: Need to ensure that the fatigue-related errors do not lead to fatigue related incidents.

Level 5 Controls: Needs to ensure that in the event of a fatigue-related incident there needs to be an incident investigation process to identify how and why the control mechanisms failed.