CIRCADIAN® Report

REDUCING THE COSTS, RISKS, AND LIABILITIES OF SHIFTWORK

Design specs of the human machine

CIRCADIAN®
24/7 WORKFORCE SOLUTIONS

Introduction

There are inherent necessities and considerable advantages to running our operations non-stop, 24 hours a day. There are also significant downsides because of increased fatigue, higher performance risks and the negative social impact on our people. Many round-the-clock companies aren't fully aware of their subsequent losses in operating efficiency, profitability, and employee relations. Even more troublesome is the reduced performance, poor morale and high absenteeism that often results from antiquated or inappropriate shift schedules.

Antiquated schedules and inappropriate shiftwork practices cost 24-hour businesses enormous sums of money from reduced productivity, excessive turnover and absenteeism, high overtime levels, preventable accidents, injuries and fatalities, increased liability and litigation, higher worker compensation and medical costs, poor customer service, and wasted management time. It is no longer necessary to absorb these costs, nor do we have to continue financing them as a part of doing business.

Determining the optimal staffing and shift schedules, and improving shiftwork practices can result in dramatic reductions of fatigue and human error while improving your operating efficiency. New research shows that both fatigue and human error are primarily the consequence of counter productive policies and practices that are out of sync with human biology, creating conditions which render employees as dangerously impaired as if they were legally drunk (Reid and Dawson, 1997). Implementing physically and socially compatible schedules and training employees and spouses on shiftwork coping techniques can significantly reduce the debilitating effects of stress and fatigue in the 24-hour workplace.

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Biological Basis of the Shiftwork Problem

On the surface of things, shiftwork, and its fatigue related problem, seem fairly straightforward. We all get tired, do what we need to do to get through it, and then catch up on sleep when we can. We still harbor a cultural mentality of mind over matter, and of human failing if one allows themself to get tired to the point of being unfit for duty. After all "if our people spent more time in bed getting their proper rest (and less time watching TV, sitting in a bar, or allowing themselves to be compromised by family life and personal activities), then they wouldn't be tired on the job!" In other words, from a management perspective, fatigue is often perceived to be a behavioral problem, caused more by personal irresponsibility and lack of discipline than by other factors beyond their control (and certainly not by our operating policies and procedures). Well, those of us who have lived and worked shiftwork know better. Just try sleeping in the daytime or rotating back and forth from days to nights for an extended period and see how much "proper rest" YOU get!

Similarly, we have this notion that, like our machinery and equipment, employee work capacity is a lineal function, that 80 hours of work will yield 80 hours of productive output (actually, it nets 50-55 hours depending on the level of employee interaction with the process; Figure 1; Nevison, 2001, Dembe, et al. 2005). In other words, one should be able to work as many days or nights in a row as management (or employees themselves) would like without any significant problem or loss of performance, and we're happy to let them do it! Overtime saves having to hire more people and paying all those costly benefits (actually the National Average is only 32%, as opposed to the 50% premium we pay for overtime), and it sure makes a supervisor's job a whole lot easier to fill absences, vacations and other benefit days off by "dishing out" the overtime to those who want it.

Thus, we rationalize, people are happy to have the extra money. But we take on more work at our own peril as fatigue and the ensuing sleep depreviation may place ourselves and others at risk. Indeed, our equipment and machinery units are lineal and actually designed to operate non-stop at peak-performance for extended periods of time. We humans are not.

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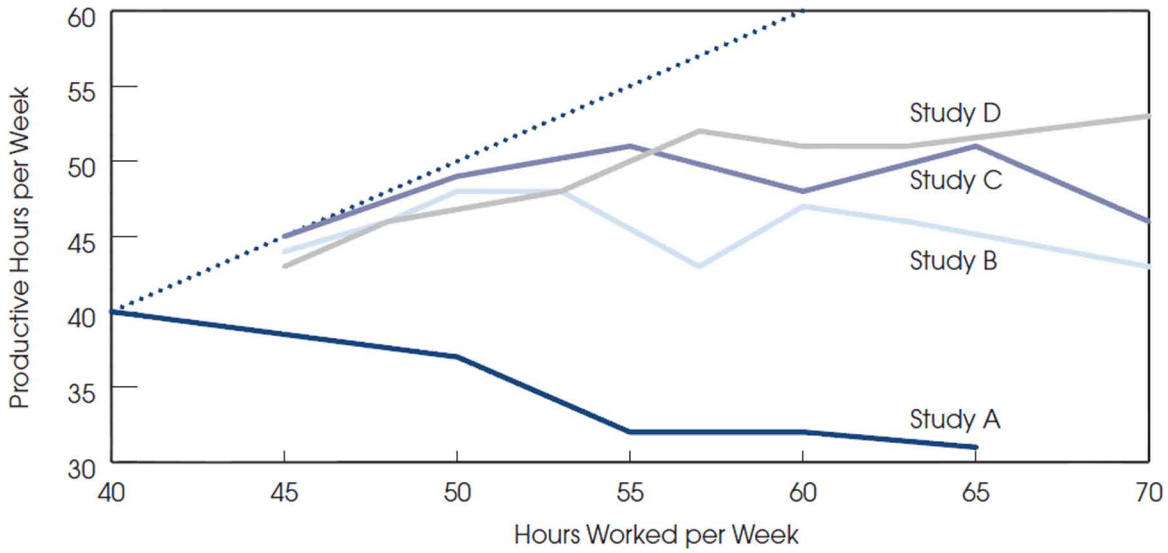
FIGURE 1: Overtime vs. Productivity



Study A shows productive hours when a person is excessively fatigued through overwork (burnout). Study B is after working 4 weeks of long hours. Studies C and D are from just 1 week of long hours. The dotted line represents theoretical or expected productivity (i.e. hours of work=lineal work output), as achievable with equipment or machinery. Solid lines represent human productivity, which is not lineal.
Source: Nevison, J., Overtime Hours: The Rule of Fifty; 2003.

Over the past 25 years, extensive research and field experience has confirmed that fatigue, as related to shiftwork, is fundamentally a biological problem, not a behavioral one. Certainly, one's behavior can induce or compound fatigue, but with most employees this is the exception and not the rule. Rather, the debilitating effects of shiftwork and fatigue are caused primarily by four operationally driven factors:

1. Circadian (Body Clock) Factors

a. Working when you would normally be asleep
b. Sleeping when you would normally be awake
c. Frequently having to change your sleep/wake timing
d. Misalignment of daily alertness cycles with work requirements
e. Desynchronization of human biological timing

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2. Sleep Factors

a. Inability to get normal hours of sleep
b. Inability to get normal quality of sleep
c. Inability to maintain consistent bedtime routines
d. Lack of on-site alertness recovery programs and policies

3. Work and Environmental Factors

a. Having early shift start times (e.g. before 7:00am)
b. Having fast rotating schedules and/or long, irregular hours (i.e. overtime)
c. Having inadequate rest/recovery time between shifts and/or work blocks
d. Having to work too many consecutive shifts
e. Having boring/monotonous work environments
f. Having boring/monotonous jobs

4. Health Factors

a. Medical sleep disorder problems (often shiftwork related)
b. Underlying health issues (e.g. hypertension, diabetes, epilepsy, etc.)
c. Improper timing and content of food (i.e. building cardiac risk factors, digestive disorders, etc.)
d. Use/abuse of coping substances (e.g. caffeine, sleeping pills, alcohol, etc.)
e. General shiftwork lifestyle issues

The circadian (body clock) and sleep factors are inherent in shiftwork and long irregular hours (Moore-Ede, 1982, Akerstedt, 1995). Human biology has been "hardwired" for daytime activity since the beginning of humankind. This did not become an issue until the development of electricity in the 1880's which ushered in the modern era of shiftwork and compromised our biological "design specifications" in order to support 24-hour operations. As a result, our shiftworkers have had to endure a dysfunctional state of being for the past 120 years…a state of being unknown to our primitive ancestors; a state of being not unlike jet lag, and one which negatively impacts our performance and reliability. It's known today as Industrial shift lag!

Thus, **the circadian and sleep factors** are both impacted by the operational necessity to keep the equipment running 24-hours per day (e.g. automation, continuous processing, asset utilization, reduced unit costs, improved customer service, etc...). **Work and environmental factors, on the other hand,** are influenced by counter-productive **management** attitudes, perceptions, policies, practices and operating procedures that often detract from human performance, rather than support it (e.g. by lack of human factors knowledge/understanding), by confusing human physiology with human behavior, by managing for the convenience of day managers to the inadvertent detriment of the shiftworkers, etc.).

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Health factors are driven by all of the above, as well as by lack of employee knowledge and understanding on how to manage shiftwork, in general, and how to manage fatigue and alertness levels, in particular (i.e. lack of shiftwork lifestyle training and education). The net results have been chronic ill health, inherent safety issues, broken families (i.e. higher divorce rates), and reduced performance (U.S. Office of Technology Assessment, 1991).

Having said all that, let's define what we mean by fatigue, how its related to shiftwork, and what are some of its consequences and costs in the shiftworking industries.

The Legal and Medical Definitions of Fatigue (Moore-Ede, 2006)

Fatigue is an impairment of mental and physical function manifested by a cluster of debilitating symptoms, usually including excessive sleepiness, reduced physical and mental performance ability, depressed mood and loss of motivation, which may result from a variety of causes including:

1. Sleep deprivation: Fatigue develops as the result of an extended time awake and/or reduced time asleep (acute sleep deprivation), from disrupted or poor quality sleep (partial sleep deprivation), or from the cumulative effect of multiple days with shortened or disrupted sleep, such as may occur in jobs with extended work hours or with night shift work (chronic sleep deprivation).

2. Sleep disorders: Fatigue manifested as excessive daytime sleepiness is the most common presenting complaint in sleep disorders, such as obstructive sleep apnea, restless legs syndrome, narcolepsy or most of the other 85 different sleep disorders currently listed in the International Classification of Sleep Disorders (1997).

3. Illness or disease: Fatigue is common in many diseases and illnesses (ranging from flu to cancer) which may occur as a direct result of the metabolic or other systemic pathophysiological disturbances of that disease, as a secondary consequence of sleep disturbances caused by other symptoms such as pain, nausea etc., or as the primary presenting complaint (e.g. chronic fatigue syndrome).

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4. Therapeutic Side-Effect: Fatigue is a commonly listed side-effect of prescription or over-the-counter pharmacological drugs, or may occur as the result of other therapeutic interventions (e.g. surgical procedure).

5. Heavy Stressful Physical or Mental Exertion: Fatigue occurs as the result of extended hours of work with heavy muscular activity (e.g. lumberjack, or marathon runner), continued stress or danger (e.g. combat fatigue) or intense mental exertion (student taking LSAT examinations) which occurs either during the task or as a rebound effect after the task, in proportion to the relative fitness (and/or prior training) of the individual.

6. Stimulant Drug Usage: Fatigue often occurs as a person rebounds after the initial euphoria or "high" induced by illegal or prescripted stimulant pharmacological substances.

Unlike the engineering use of the word "fatigue," which is utilized to describe irreversible failure of a material as a result of stresses over an extended period of time, the **medical definition of "fatigue"** usually refers to a loss of physiological and psychological function as a result of extended wakefulness, heavy work, excessive stimulation, illness or stress. The good news is that medical fatigue can be reversed in whole or in part by rest, sleep, treatment or recovery from the condition that caused it.

Thus, shiftwork, and its major symptom, fatigue (or excessive sleepiness), is now well recognized in law and regulation as a significant human impairment, malfunction and source of ill-health, as well as accident and injury risk. It is not just a feeling of being physically tired, it's also a state of impaired alertness, attentiveness, mental and physical performance. Being fatigued also includes having reduced motor coordination, and slower reaction time. When we are fatigued, there is a loss of environmental awareness, impairment of cognitive/logical reasoning skills, poor judgment and diminished ability to communicate and/or process communications and information.

In fact, there is now scientific evidence (as well as legislation and case law) that suggests when we're tired (or mentally fatigued) our ability to perform the simplest of tasks is impaired to the same level as if we were legally intoxicated! (Dawson and Reid, 1997). Such is the frequent state of being that today's shiftworkers have to endure.

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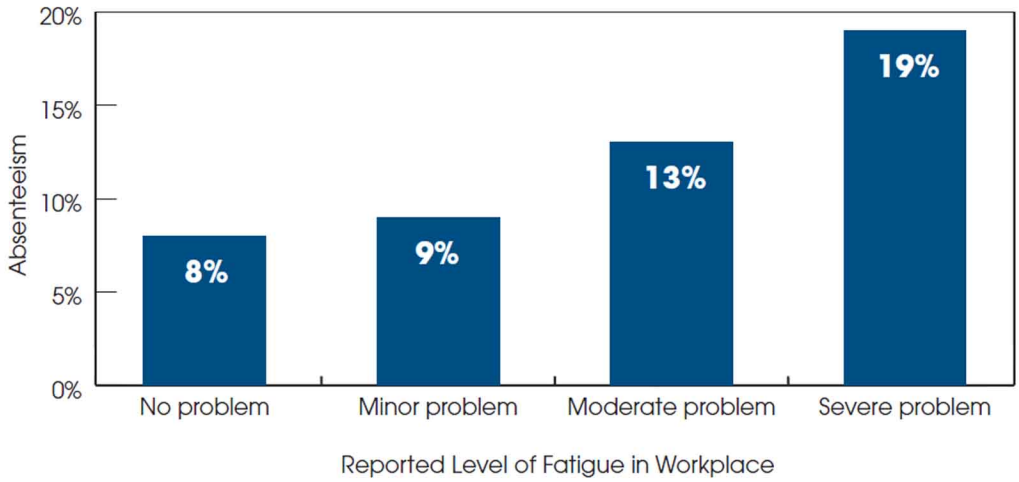
Consequences of Fatigue

Due to the reduced mental or physical impairment caused by shiftwork related fatigue, the inevitable results are increased human error, and reduced ability to work safely and productively. Numerous scientific studies, and extensive field experience, confirm that shiftworkers with higher relative fatigue index are more likely to experience sleepiness, nodding-off, and making mistakes while working, as well as nodding-off or fighting sleep while commuting to and from work. (Aguirre 2003).

Fatigue also affects mood. The U.S. National Sleep Foundation (2002) found that people who do not get enough sleep are more likely to become impatient or aggravated, and they have difficulty getting along with others. Increased irritability and stress negatively influences personal, work, and family relationships, resulting in inadequate/ineffective communications. They also correlate with increased absenteeism and turnover, as well as reduced morale and poorer labor relations. Moreover, industrial surveys reveal that absenteeism rates are nearly double in facilities with significant fatigue problems, as compared to facilities where fatigue is not a problem (Aguirre and Moore-Ede, 2008).

FIGURE 2: Fatigue Levels and Absenteeism in 24/7 Operations



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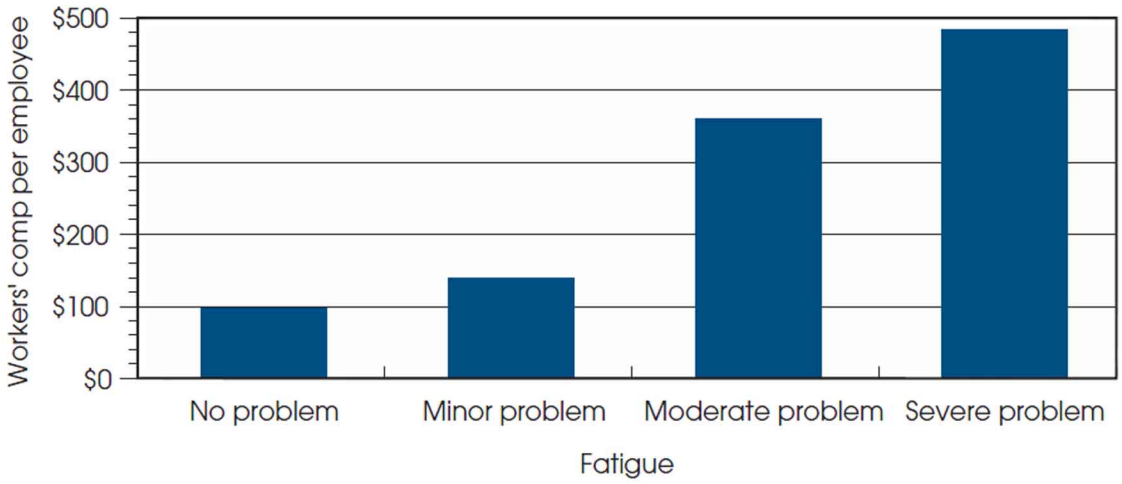
The consequences of fatigue also impact a company's operating efficiency and costs. Fatigue results in reduced productivity and customer service quality, reduced operating reliability and decreased operating profit, increased health and wellness costs, and higher overall costs, risks, and liabilities. Industrial survey data further indicates that Workers' Compensation costs per employee per year are almost five times higher in facilities with severe fatigue problems, compared to facilities where fatigue was not a problem (Aguirre and Moore-Ede, 2008).

FIGURE 3: Fatigue and Annual Workers' Compensation Costs in 24/7 Operations



Costs of Fatigue

Virtually every industry suggests that 80-90% of all their accidents and incidents are human error related, and this statistic is confirmed by insurance claims adjusters. Modern engineering and technology has fixed most of the equipment problems, so what we have left are people problems…and more of them due to the long, irregular hours of work and the stripping away of most of the mental and physical stimulation in today's jobs by that same high technology designed to make our jobs easier. Concurrently, the value of the property, plant and equipment at risk today (per tired employee) is unprecedented, such that a simple human error, or a 10 second microsleep, can be extremely costly, if not catastrophic.

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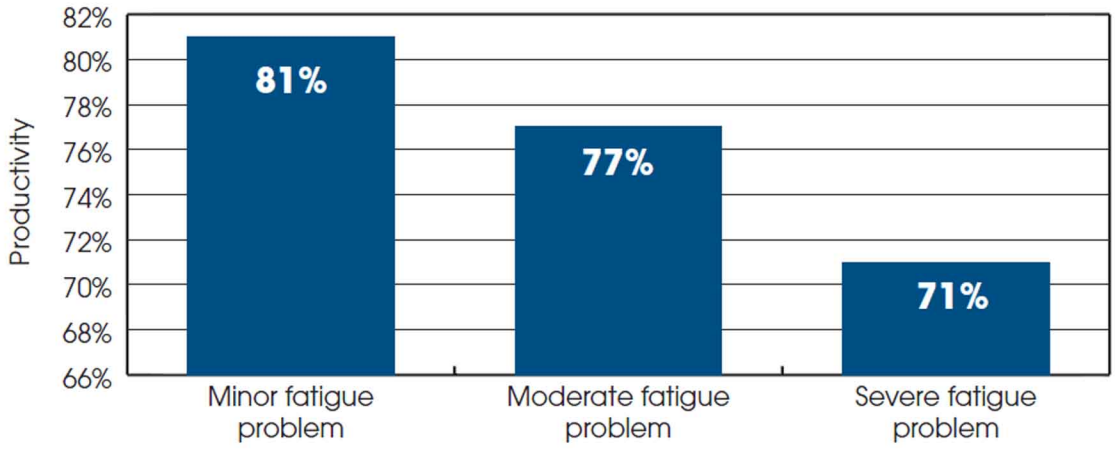
While many incidents and productivity losses related to human error can certainly be attributable to inexperience or behavior, the growing majority are more typically physiological in nature. **Adjustment to night work, shift rotations, and/or overtime create health, safety, and performance problems for operators.** By every measure, performance decreases at the beginning of early morning shifts, during the post lunch hours, and during overnight shifts…particularly during the predawn hours.

In fact, the number of fatigue-related accidents and fatalities are considerably higher at night than during daytime (Mitler 1988). Other studies have found that motor vehicle drivers are 50 times more likely to fall asleep at 2 am than at 10 am (Horne and Reyner, 1995). No matter how well trained, skilled, motivated, or experienced, our employees are frequently being compromised by fatigue. Behavior becomes erratic and deviant…not willfully, but because of our biological make-up. As a result, incidents are frequently misdiagnosed as being due to behavioral problems, when they are actually physiological in nature.

Thus, understanding of human physiology, and human design factors if you will, is key to successfully identifying, and managing, the inherent problems of shiftwork and fatigue-related human error.

The resultant costs of fatigue are far greater than just those of safety, although the Billions already spent on cleaning up the Texas City Refinery incident should be enough justification to proactively address this issue. While there were certainly technical and equipment failures involved in this unfortunate incident, the US Chemical Safety Board (2007) also cited fatigue as a causal factor due to understaffing and excessive overtime. Fatigue also correlates with higher maintenance costs, lost productivity, increased turnover, absenteeism, and presenteeism, higher health and wellness costs, reduced customer service quality, higher operating risks and liabilities, and, ultimately, reduction in overall operating profit.

FIGURE 4: Reported Level of Fatigue in Workplace



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We can certainly argue and debate over the inherent costs of shiftwork, but there is no denying the enormity of their magnitude. The good news is that it clearly represents recoverable opportunity, and a whole new avenue for improving operator safety and performance that has been largely unaddressed for the better part of the last century. Moreover, with today's ability to measure and quantify the costs of fatigue, it is now possible to build a compelling business case and ROI proposition to justify a proactive **Fatigue Risk Management System (FRMS).**

Developing and Installing an Effective Fatigue Risk Management System (FRMS)

So how as a company, or as operating mangers, can we objectively, systematically, and measurably eliminate fatigue from our operations, thereby reducing our costs, risks and liabilities? And is it really possible to increase operational efficiency....while at the same time improving employee health, safety and quality of life to create a win-win proposition?

Perhaps this sounds far fetched, but it's already being done. With the current knowledge, technology and experience base that exists today, dramatic improvements are being achieved in the way people live and work, to the betterment of both the employees and their companies.

The first, and most important step, is to recognize the cause shiftwork risks and opportunities, and to make a **corporate commitment** to eliminate them. Too many companies are absorbing unnecessary costs and risks by not recognizing the importance and the urgency of fatigue management problem. This is evident by the fact that over 90% of shiftworkers receive no training on how to manage their schedules or their shiftwork lifestyles (Aguirre and Moore-Ede, 2008). We see many shiftworkers who are well trained and skilled at their jobs, but who have never been taught how to deal with fatigue, how to better manage their sleep, or how to adapt to the inherent physical and social challenges of shiftwork. As a consequence, they develop debilitating habits and/or become victims of common shiftwork pitfalls that further compromise their ability to perform to their fullest capabilities. This is just one of the many reasons that shiftworking employees conservatively cost companies over **$10,000 per person per year** in excess costs over and above their daytime counter-parts (Kerin and Carbone, 2003, adjusted for inflation).

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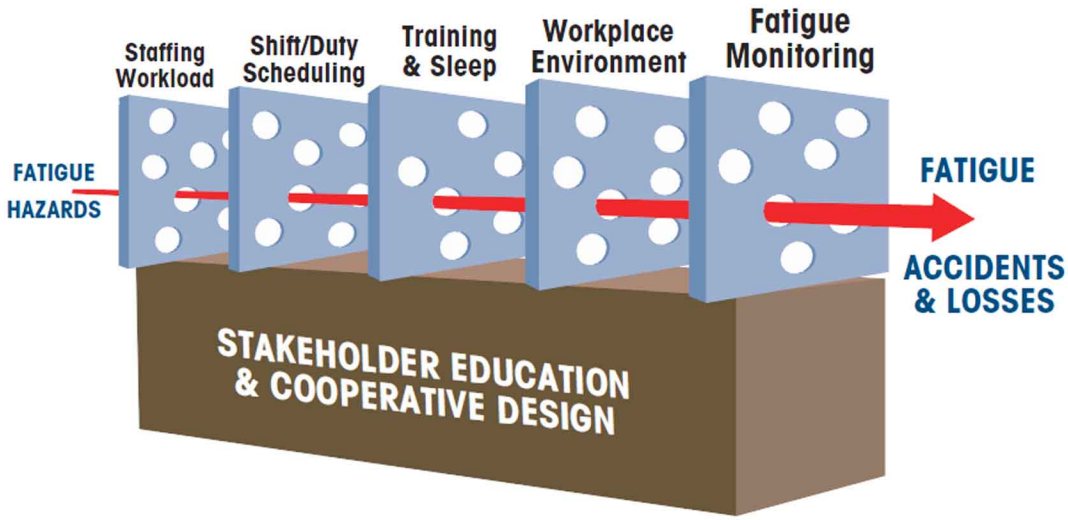
To recover these costs, and to mitigate risk, company executives must make the reduction of shiftwork and fatigue related issues a core corporate value. Just as safety has become a key focus on the corporate mission statement, so must fatigue (which dovetails nicely into existing safety management systems) become part of that mission. Adapting Professor James Reason's "swiss cheese" concept of Safety Management Systems (SMS), and utilizing each slice of cheese as a defense mechanism against fatigue, the risk of accidents and losses can be reduced by "plugging" and "mis-aligning" the holes in the cheese to prevent the hazards from getting through (figure 5). To further "shore-up" the defenses and to provide a platform from which to launch and support the campaign against fatigue, however, requires a "cheeseboard." In other words, it is imperative to first educate the corporate infrastructure and build consensus and support of all the "stakeholders"…management, union, and regulators (if applicable)…if the mission is to succeed on a sustainable basis.

FIGURE 5: Fatigue Risk Management Relies Upon Five Key Defenses in Depth



From this "platform" we can now build our defenses. This will require a developing and implementing of a comprehensive set of science-based, data driven Fatigue Risk Management System (FRMS) that must include the following tasks and activities that make-up an in-depth and sustainable FRMS "system."

- Educate the organizational infrastructure to achieve consensus and stakeholder support (e.g. managers and supervisors at all levels, union leaders, regulatory agencies, etc.)
- Develop, document and communicate a written FRMS plan
- Provide training for employees to empower them to take more control over reducing their personal levels of fatigue, as well as better coping with shiftwork, (especially with new hires)

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- Reinforce the training and personal commitment to behavioral lifestyle change by providing educational support publications and practical shiftwork information to operators on a regular basis
- Educate/train supervisors on how to identify and intervene with tired shiftworkers
- Re-evaluate work schedules and overtime policies and practices to ensure they are not causing excessive fatigue
- Optimize staffing and crewing levels to maintain safe and manageable overtime levels
- Optimize work schedules to provide adequate rest, to minimize fatigue, and to maximize quality of life
- Evaluate the indoor and outdoor work environment for potential modifications that could reduce fatigue (e.g. more mentally stimulating control rooms, etc.)
- Evaluate work tasks and activities for opportunities to make them less boring and monotonous
- Re-evaluate operating policies and procedures that may no longer be valid, in light of new understanding of human physiology, and that may actually be counterproductive to improving health, safety and performance
- On an annual basis, screen and treat sleep disorders that are prevalent among shiftworkers, and provide education on managing sleep
- Incorporate fatigue analytics/human error analysis into reporting systems to monitor and track results by collecting and reporting fatigue-related data
- Incorporate fitness-for-duty impairment screening programs
- Keep abreast of new R&D initiatives to continually advance state-of-the-art
- Establish a continuous improvement process that is not merely today's priority, but rather a permanent core operating value of the company

Figure 6 encapsulates the key elements of the FRMS defenses, and it illustrates the continuous improvement mechanism. As the defenses are installed, key metrics are established to monitor their effectiveness, and predetermined "actions" are initiated to intervene with deviations. As these actions systematically begin to reduce risk and prevent incidents, accidents and other adverse events will still occur, albeit with decreasing frequency and severity as the FRMS plan takes root. When such an incident does occur the first action is to confirm that fatigue was indeed the root cause. This can now be readily achieved with 90% probability through the use of new fatigue analytics (Fatigue Accident/Incident Causation Testing Systems). Secondly, you can now go back and determine which of the fatigue defenses broke-down and enabled that incident, and what appropriate actions should be taken to prevent future failures. Thus, a sustainable, continuous improvement process is established to mitigate the costs, risks, and liabilities of shiftwork and fatigue-related issues.

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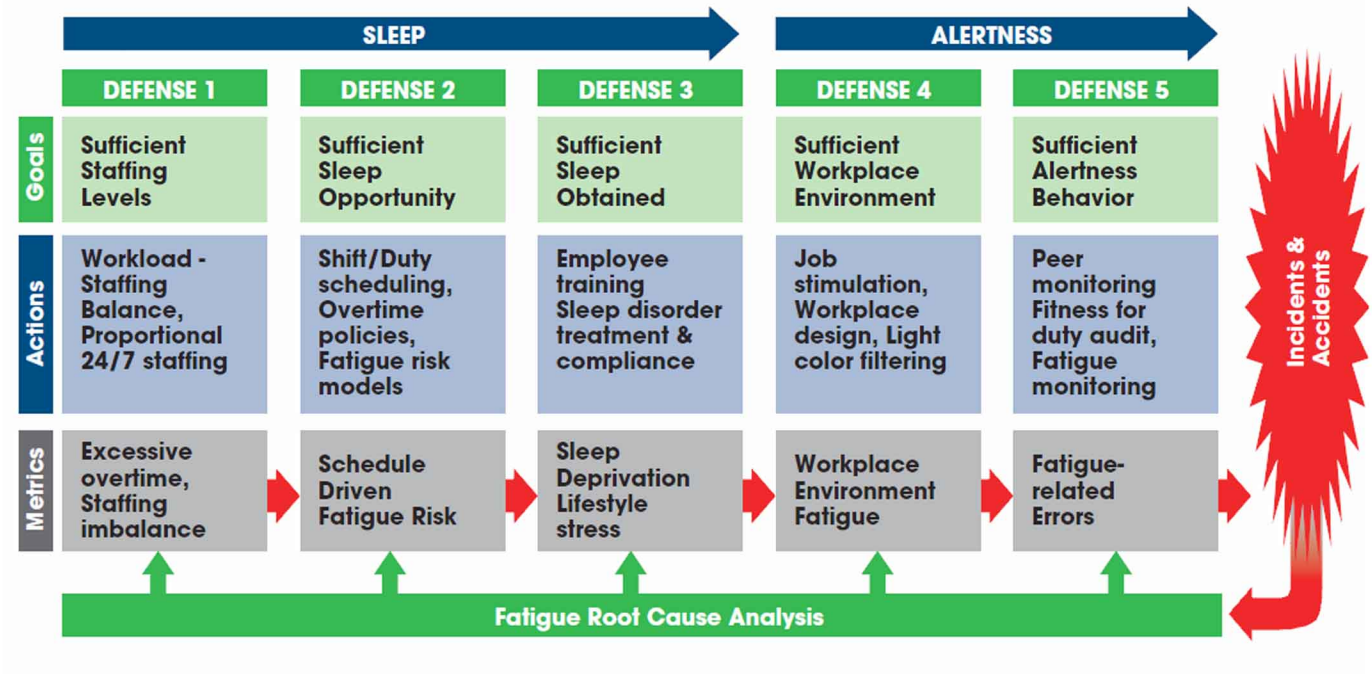
FIGURE 6: Key Elements of the FRMS Defenses



Conclusion

As responsible managers and operators, we strive to keep our equipment well oiled and well maintained. We ensure that it is operated in full accordance with the manufacturers design specifications, in terms of temperatures, pressures, flow rates, etc.. To do otherwise would invite premature failure, costly downtime, high maintenance, and lost productivity and capacity. By the same reasoning, it would also seem to make good business sense to keep what we all tout as our "most important asset" – our people – equally well maintained and operated.

Yet, ironically, our people are being asked to operate outside their design specs every day to support our continuous production requirements. The net result, as you might surmise, has been pre-mature failure (in terms of sickness and injury), costly downtime (in terms of absenteeism and presenteeism), high maintenance (in terms of health and wellness costs), and lost productivity due to human error. Continuing to overlook the debilitating effects of shiftwork on our most important asset will perpetuate this cycle of high cost and potentially high catastrophic risk.

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It is time to understand that these costs, risks and liabilities no longer have to be accepted and financed as part of doing business. With today's knowledge base, technology, and available fatigue/shiftwork interventions, they can be converted into a new source of operating profit and reliability that we never knew or believed existed. Moreover, they can be systematically addressed through a collaborative, human involvement process between labor and management to achieve substantial win-win benefits.

REFERENCES

Aguirre A. Health in extended hours operations: understanding the challenges, implementing the solutions. Circadian Technologies. Stoneham. 2003.

Aguirre A, Moore-Ede A. Shiftwork Practices 2007. Circadian Technologies, Stoneham. 2008. Akerstedt T. Work hours, sleepiness and the underlying mechanisms. J Sleep Res 4, Suppl. 2:15-22.1995

Dawson D, Reid K. Fatigue, alcohol and performance impairment. Nature 388 (6639): 235. 1997.

Dembe AE, Erickson JB, Delbos RG, Banks SM. The impact of overtime and long work hours on occupational injuries and illnesses; new evidence from the United States. Occup. Environ Med. 62(9):585.2005.

Horne JA, Reyner LA. Driver sleepiness. J. Sleep Res. 4 Suppl. 2:23-29. 1995
Kerin A., Carbone J. Financial Opportunities in Extended Hours Operations. Circadian Technologies. Stoneham. 2003

Mitler MM, Carskadon MA, Czeisler CA et al. Catastrophes, sleep and public policy: consensus report. Sleep 11 (1):100-109. 1988.

Moore-Ede MC. The twenty-four hour society, Addison-Wesley, Reading. 1993.

Moore-Ede MC, Sulzman FM, Fuller CA. The clocks that time us. Harvard University Press, Cambridge, 1982.

Moore-Ede MC, Legal and Medical Definitions of Fatigue, www.circadian.com White Paper, 2008.

National Sleep Foundation. 2002 Sleep in America Poll. www.sleepfoundation.org.

Nevison JM. Overtime Hours: The Rule of Fifty. Project Solutions Report. 2001.

US Chemical Safety and Hazard Investigation Board. Final Investigation Report. Refinery Explosion and Fire. BP Texas City, TX. Report No 2005-04-I-TX. 2007.

U.S. Congress, Office of Technology Assessment, Biological Rhythms: Implications for the Worker, OTA-BA-463. Washington, DC: U.S. Government Printing Office. 1991.

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ABOUT CIRCADIAN™

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Working from offices in North America, Europe, Australia and Asia, CIRCADIAN experts ensure that over half the Fortune 500, and other leading international companies, improve their competitiveness in the global 24/7 economy. CIRCADIAN's core expertise is the staffing, scheduling, training and risk management of their most vital asset – the 24/7 workforce. For more information about **CIRCADIAN**, please visit our website at **www.circadian.com**.

THIRD EDITION
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