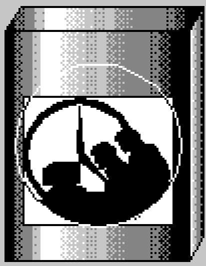
Chapter 4
SHIFTWORK AND SCHEDULING

4 Shiftwork and Scheduling



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Quote: " Working during nighttime hours lead to a number of physical and psychological problems that can compromise an individual worker's well being. "

INTRODUCTION

Shift is a common term used to delineate a specific work period or watch, as in, "I work the day shift." *Shiftwork* often implies rotating or changing work hours. However, this is not a common characteristic of shiftwork in the aviation maintenance industry. Rather, the common aviation industry practice is to permanently assign a worker to one shift. Despite the lack of shift rotation, there are a number of aspects of shiftwork that are both problematic and relevant in the aviation maintenance domain.

Working during the night shift, i.e., work that is done during the midnight-to-dawn work period, is associated with a number of physical and psychological problems that can compromise a worker's well being.[1] These shift-related problems also can lead to lapses in safety.

Even though maintenance workers tend to be permanently assigned to a single shift, aviation maintenance is typically a 24-hour operation, implying the need for manning multiple shifts. While different people man different shifts, some work tasks, especially during heavy maintenance checks, span more than one shift. Thus, more than one person on more than one shift will be working on different parts of the same task. The transfer of task responsibility from one shift to another is known as "shift turnover". Shift turnover is notorious as the locus of many problems and errors -- in aviation maintenance and in other industries.

Physical and psychological problems associated with shiftwork are related to the disruption of biological cycles keyed to daily periods of light and darkness. The wake-sleep cycle is the most apparent of these rhythms.[2] Other recurrent body cycles -- temperature, urination, endocrine secretions, and a host of others -- are synchronized with the wake-sleep cycle. This cycle can be disrupted in different ways. For example, when a person changes work periods by more than about three hours these cycling internal functions become desynchronized with the new wake-sleep period. A traveler flying across multiple time zones experiences the same sort of internal disorganization; this is called *jet lag*.

In the aviation maintenance industry, the most common cause of wake-sleep cycle disruption is work at night, i.e., working when it is dark and one would normally sleep. Depending on the individual, the physiological and psychological disturbances caused by disrupting the wake-sleep cycle range from moderate to severe. Because alertness is related to body temperature, it is affected by interruptions in the wake-sleep cycle. A decrease in alertness often leads to an increase in error rate. For occupations with a low tolerance for errors such as medicine, piloting, air traffic control, and aircraft maintenance, alertness-related performance decrements can be critical.

From a human factors perspective, shiftwork, sleep deprivation, etc., are interesting phenomena because they affect human performance through at least two mechanisms. First, as we noted above, disrupting the normal wake-sleep cycle causes various physical and psychological problems. Second, working long shifts during odd hours can also take a toll on workers' personal lives. The emotional stress caused by family tensions can degrade job performance every bit as much as the physical effects of shiftwork.

This chapter examines several aspects of shiftwork and scheduling, including the nature and causes of circadian disruptions and fatigue. In the GUIDELINES section, we present strategies for dealing with shift-related problems. Chapter 12 addresses, among other topics, some of the emotional and other stress-related factors that can result from shiftwork (and other causes).

BACKGROUND

All living things, except for certain bacteria and viruses, possess some form of a biological clock controlling the activity level of most, if not all, bodily functions. Eating, sleeping, waking, and other regular daily activities that occur more-or-less on schedule are so familiar to all of us that they need no description. When a person's daily functions are destabilized, he or she is said to be "off schedule." Until recently, these familiar bodily functions were thought to be entirely controlled by external factors. However, it is now known that in vertebrates (those animals with backbones) groups of cells in the brain comprise this biological clock.

Even people placed in experimental situations with all environmental factors held constant continue to conform to daily schedules. This persistence of regular activity in the absence of external clues was first shown almost 300 years ago by Jean de Mairan, a French astronomer. He placed a heliotrope plant in a dark closet and observed that it continued its daily schedule of opening its leaves at dawn and closing them at dusk. The plant kept time by some internal mechanism.[3]

When people are placed in constant light or constant darkness for extended periods, their intrinsic biological rhythms conform to a 25 to 27 hour day, instead of the 24 hour solar day. For this reason, the biological clock must be reset or corrected every day of normal life. The cells deep within the brain that make up the biological clock are not under conscious control and are reset primarily by the individual's exposure to light.[4,5] When the human body is exposed to bright light with appropriate spectral content, such as in sunlight, then it essentially resets its internal clock to the beginning of another daily cycle.

An example of a cyclic bodily function is maintaining one's body temperature. Daily human body temperature normally varies by about one and one-half degrees Fahrenheit. For those who are normally awake during the day and sleeping at night, body temperature is lowest in the predawn hours and highest in the afternoon. In such people of regular habit, the body temperature cycle and the wake-sleep cycle are synchronized or "in phase."

Alertness is related to body temperature; it is poorest when the body temperature is at its low point. When body temperature is its lowest, people are most prone to error-caused accidents. Single-vehicle truck accidents are five times as likely in the early morning hours when the driver's body temperature, and alertness, is lowest as about twelve hours later when the body temperature is highest.[6] A number of well-known accidents, including Three Mile Island, Chernobyl, and Bhopal either occurred or were initiated in the pre-dawn hours.

Shiftwork is certainly not the only, or even the major, reason for sleep deprivation and fatigue. Chronic fatigue is so much a fact of life in the United States that reports describing its magnitude and effects have begun to appear in the popular literature.[7] One recent article (cited above) quotes a number of surveys and studies indicating that one-third of American adults claim that "…being sleepy gets in the way of their day-to-day activities – even though they say they got enough sleep the night before."

Considering that most of the people in these surveys work during daylight hours, it is no surprise that the effects of sleep deprivation are aggravated by working during the night.

While we know of no published reports dealing specifically with the effects of shiftwork on aircraft maintenance workers, there have been many studies of the effects of shiftwork on workers in other industries. Shiftwork, i.e., daily, inconstant periods of work, has been identified as the principal stressor for emergency room physicians. It causes job dissatisfaction and a high attrition rate of about 12 percent per year.8 The average duration of practice in emergency medicine is about 9 years, much lower than that of other medical specialties.

ER physicians' complaints associated with rotating shiftwork include the following:

- chronic fatigue syndrome
- sleep disruption and deprivation (ER physicians average 4.5 hours of sleep per day when they are on the night shift)
- depression
- moodiness
- high divorce rate
- gastrointestinal problems
- immune system dysfunction
- alcohol and drug abuse
- infertility
- high blood pressure
- increased cardiovascular mortality
- increase in work-related accidents and errors
- increased traffic accidents commuting to and from work.

In Japan, night shift work has been held to be a legally compensable cause of premature death.9

Despite the overwhelming body of statistical evidence tying shiftwork to various physical and psychological maladies, recent work has called into question the direct cause-and-effect link.10 While not disputing the statistical linkage between shiftwork and the commonly-cited effects, the authors of this study question our basic understanding of the mechanisms that connect the two.

It should be emphasized that "shiftwork syndrome" refers almost exclusively to body cycle disruptions arising from or connected with the night shift. Night shift problems boil down to on-duty sleepiness and off-duty insomnia, meaning poor quality and inadequate amounts of daytime sleep. This is not a new problem; in 1584 an Englishman, Thomas Cogan, admonished his students as follows, "In sleeping and waking, we must follow the course of nature, that is, to wake in the day and sleep in the night."11

In fact, until recently (in historical terms), we were able to follow a more "natural" schedule -- working during daylight hours and sleeping or resting during nighttime hours. Martin Moore-Ede eloquently describes in his 1993 book on this topic how and why we have come to live in what he calls "the twenty four hour society".12 Various technological advances, such as the electric light, made us less dependent on daylight for our activities. More than anything else, however, the crush of global competition has forced businesses to operate their assets as efficiently as possible. It is much more efficient to operate one maintenance hangar twenty four hours per day, than to operate two or three hangars only during daytime hours.

In a 1991 report, the Office of Technology Assessment estimated that one of every five workers in the United States works according to some type of non-standard schedule.13 For those working during the night shift (midshift), the issue of fatigue is quite serious. A recent study estimated that 75% of those working at night experience sleepiness *every night*. Some 20% of these workers actually fall asleep on their work shift.[14]

When a worker changes from day to night work, the body's internal clock is not immediately reset. It continues on its old wake-sleep cycle, even though it is no longer possible for the person to sleep when the body thinks it is appropriate. All other body cycles also continue the old periods.

It is possible for a worker to become acclimated to working at night, if he or she can establish a new wake-sleep cycle. However, this is difficult. Bright light resets the body's internal clock. When a person gets off the night shift and drives home, the bright morning sunlight resets the internal clock. After the internal clock is reset, it is difficult for the person simply to go home and sleep. Some commercial companies have developed various products to help shift workers arrange their off-work hours to help them get the rest and nutrition they need to remain alert and healthy while at work.[15] We discuss some of these coping mechanisms later in the chapter.

The disparity between biological and solar days has led to the recommendation that rotating shifts move towards the longer biological day, instead of away from it. Thus, shift rotation should be to later shifts instead of earlier ones. A common example of the benefit of doing so is that jet lag is less severe westbound, when the day is lengthened, than it is eastbound, when the day is shortened.

Shift rotation in aviation maintenance is not a primary source of shift-related problems. Most maintenance technicians work on shifts that do not change for weeks or months, or ever. The central problem in aviation maintenance is that many, perhaps most, routine tasks are performed during nighttime hours so that the aircraft can fly and produce revenue during the daytime. In addition, maintenance tasks often span more than one shift, requiring information to be passed from one shift to the next. Shift turnover is the source of many errors.

The length of each work period also affects the error-producing effects of fatigue. In some industries, work periods are longer than in others. For example, workers in nuclear power plants are commonly scheduled to work 12-hour shifts.[16,17] In the interests of safety, airline pilots' work periods are limited by regulation to 30 hours of flight time in seven consecutive days, with no more than 8 hours of flying between prescribed rest periods.[18] Air traffic controllers work a basic 8-hour day, 40-hour week, but overtime may considerably lengthen their work periods.

The bumper sticker that says, "A bad day at the beach is better than a good day at the office" pretty well sums up many workers' attitude toward their work. Improvements in the workplace environment are widely thought to improve workers' morale and boost production. However, research has found that the connections among shiftwork, morale, and productivity are not simple.

Employees at the Miami International Flight Service Station were given the opportunity to choose non-rotating work periods, limited by certain requirements for the presence of full crews.[19] It was evident from interviews that the workers selected a preferred time off to pursue personal or business activities and were willing to work whatever schedule would provide that time off. Some workers chose to work the midshift continuously because they wanted their daylight hours off every day. Given the opportunity, many workers will choose to work four ten-hour days, instead of five eight-hour days, to have three consecutive days off.

The choice of the Miami employees points out a fairly common occurrence that underscores the need to use objective human factors methods when evaluating shiftwork and scheduling changes. When given a choice of working conditions, products, procedures, etc., workers' preferences are sometimes at odds with the effects of their choices on performance. That is, the most popular choice does not always produce the best job performance. By choosing a work schedule that maximizes their free time, workers might work longer hours than are conducive to good (i.e., safe, effective, and error-free) work.

ISSUES AND PROBLEMS

From a human factors perspective, we are especially interested in shift- and schedule-related problems that are reflected in degraded maintenance performance. In this section, we will list and describe some of the most common issues and problems that you can anticipate. You should understand that these issues and problems are neither necessarily nor entirely caused by shiftwork or scheduling. Many work-related and personal factors can contribute to most of the items we describe below.

Higher Absentee Rate

Particular shifts and schedules can cause workers to be away from work more often than people who work on more "normal" schedules. There are several factors that contribute to higher absenteeism. Shift workers tend to have more health problems than non-shift workers. A fairly innocuous cold, when coupled with the increased fatigue due to night work, can cause increased use of sick leave. Family-related issues, such as childcare and companionship, can cause workers to take short periods of time off. More serious incidents, such as an extended sickness in the family, can force shiftworkers to juggle their personal and work lives.

Higher Error Rate

Elevated error rates are directly associated with mental and physical fatigue. Shiftwork and shift schedules can contribute to fatigue by disrupting normal wake-sleep cycles, forcing extended working hours, and increasing personal and family-related stress. The first abilities to be compromised by fatigue are those related to cognitive processing, decision making, and judgment. Unfortunately, these are the very abilities that come into play when making safety-related maintenance decisions.

In addition, the fact that aviation maintenance organizations tend to be 24-hour operations means that some tasks are distributed across multiple shifts. Poor shift turnover procedures, especially the communication aspect of shift turnover, has been implicated in a number of serious aviation accidents. The fatigue that accompanies working on the night shift causes shift turnover procedures to assume added importance.

The unavoidable fact is that most aviation maintenance occurs during nighttime hours, which we know to be especially conducive to human error. There is nothing we can do to fundamentally alter human physical and psychological responses to night work, at least in the long term. We should expect, therefore, to experience many human errors and must tailor our procedures to provide ample opportunities to catch and fix these errors before they affect our workers or the flying public.

Physical and Psychological Problems

There are many studies linking shiftwork, especially rotating shiftwork and especially working at night, to a variety of physical, emotional, and psychological problems.[10] Because aviation maintenance workers tend to be permanently assigned to a specific shift, it is reasonable to be concerned about the long-term effects of night work. Unfortunately, we have very few answers in this regard. We can't even say with certainty that working on the night shift causes the problems with which it is statistically associated.

About the best we can do to address this issue is to provide coping processes that allow nighttime workers to maintain a semblance of normal sleeping patterns and then closely monitor their physical and psychological conditions.

Increased Injuries

Most athletes understand that their risk of injury increases when they are tired or not paying attention. This is also true for industrial workers. Just as cognitive (thinking) errors increase with increased fatigue, so do physical errors, which result in personal injuries. All of the elements that we described above, such as loss of judgment, contribute to the increased likelihood that a worker will be injured.

Dissatisfaction and Poor Morale

The combination of long hours, disrupted wake-sleep cycles, increased instances of domestic conflict, and higher workloads is an obvious source of poor morale and dissatisfaction among shift workers. As a performance shaping factor (see Chapter 1), emotional issues are potent causes of poor job performance.

Lower Productivity

One of the primary reasons for working on shifts and longer hours on each shift is to utilize human and capital resources more efficiently. For example, an expensive test and fabrication equipment isn't earning a return if it is idle. Also, working slightly longer shifts reduces the amount of non-productive time at the beginning and end of each shift. It is somewhat ironic that engaging in a practice that can increase productivity when used sparingly can actually decrease productivity when used excessively. To use an extreme example, people cannot produce twice as much output if they work 24 instead of 12 hours.

Higher Attrition Rate

Humans can only take so much physical and mental stress. Eventually, many workers will opt to simply go elsewhere rather than endure a shift schedule that causes constant fatigue and family stress. While there is presently a surplus of aviation maintenance workers, projections show a looming shortage (see Chapter 7). It is costly and wasteful to lose skilled aviation maintenance workers.

REGULATORY REQUIREMENTS

For clarity, we have addressed regulatory requirements in two categories -- scheduling and shift turnover. As you can easily see from this discussion, there seems to be some type of regulation affecting both these issues for all regulated groups *except* aviation maintainers.

Scheduling

For largely unknown reasons, the eight-hour day is now clearly the benchmark for a day's work. Work beyond eight hours on any given day is customarily compensated as overtime, either with money or time off. The Fair Labor Standards Act mandates that work done beyond 40 hours per week be compensated as overtime; this effectively established the 40-hour work week. However, there seems to be no umbrella regulation or law setting limits on daily consecutive hours of work, at least not by the U. S. Office of Personnel Management or by the Department of Labor.

Federal agencies seem individually to set daily hours of work according to mission needs and safety, after considering input from workers and the public. In private industry, daily hours of work, overtime compensation, night differential pay, shift rotation patterns, and any other matters related to working conditions are usually settled in a union contract or in other negotiations.

There appears to be only one FAR that related directly to work schedules for AMTs and other aircraft maintenance workers. Part 121.377 states that "…each certificate holder shall relieve each person performing maintenance … from duty for a period of at least 24 consecutive hours during any seven consecutive days, or the equivalent thereof within any one calendar month." In essence, this rule requires that maintainers be given at least one day off per week or four days off per month.

There are no restrictions (at least in the FARs) regarding how many hours a maintainer can work in a given day. If the letter of the cited rule is observed, an AMT could work continuously for six days, if they are given the seventh day off.

FAA rules frequently are withdrawn if public comment indicates general disapproval. This was the case with the FAA's attempts to establish flight and duty time for airline pilots when it became evident that all contingencies could not be anticipated. However, Part 121 of the Federal Aviation Regulations establishes the maximum allowable flight time and required rest periods for airline flight crews.18 Flight crewmembers may not be scheduled for flight assignments that exceed the following limitations:

- 1000 hours in any calendar year
- 100 hours in any calendar month
- 30 hours in any 7 consecutive days
- 8 hours between required rest periods.

Flight crewmembers must also have the following rest period during the 24 hours preceding these flight assignments:

- 9 consecutive rest hours for flight time of less than 8 hours
- 10 consecutive rest hours for more than 8 but less than 9 hours of flight time
- 11 hours of rest time for 9 or more hours of flight time.

Only under special circumstances spelled out in the rule may these restrictions on work periods be altered.

Since March 1995, similar rules have applied to flight attendants.20 This is the first time that non-cockpit crew members have been covered by such regulations. Under these new rules, flight attendants must have at least 9 hours of scheduled rest if they have been on duty 14 hours in any 24-hour period. Flight attendants must also have a 24-hour rest period every 7 calendar days. Attendants on international flights are allowed to work 18-20 hours, but their workload must be reduced by more attendants on duty.

The National Highway Traffic Safety Administration has promulgated regulations limiting truck drivers to 10 hours of driving in any 24 hour period and to 60 hours in any 7-day period. The Federal Railroad Administration limits railroad engineers to 12 hours of work in a 24 hour period, to 30 hours in 7 days, to 100 hours in 30 days, and to 1000 hours per year.

The Nuclear Regulatory Commission makes recommendations to licensees who operate nuclear power plants, but does not set daily hours of work. The government recommends that the 8 hour day, 40 hour week, be the goal of licensees, but recognizes that considerable overtime is inevitable. The recommended limits are 16 hours of duty in 24 hours, exclusive of shift change time, with a minimum break of 8 hours between 16-hour stints; 24 hours in any 48 hour period; and 72 hours in a 7-day period. Based on these figures, a nuclear power plant operator is allowed to work 100 hours in 10 days; an airline pilot is allowed to fly only 100 hours in 30 days.21

As these examples show, the length of work periods varies considerably, as do ideas about fatigue and human error. In fact, both fatigue and human error are difficult, if not impossible, to measure objectively. When one considers that there could conceivably be 50 different state regulations about standard lengths of work periods and a much greater number of local regulations, it is easy to see that generalizations are impossible.

Shift Turnover

There are no FAA regulations that directly address specific shift turnover practices in aviation maintenance organizations. Part 121.369 (b)(9) requires an organization's maintenance manual to contain "Procedures to ensure that required inspections, other maintenance, preventative maintenance, and alterations that are not completed as a result of shift changes or similar work interruptions are properly completed before the aircraft is released to service." However, no guidance is given regarding what those procedures should (or might) be.

The most specific regulatory guidance related to shift turnover is given in Orders and Standards from the U.S. Department of Energy (DOE). Obviously, aviation maintenance facilities are not bound by DOE regulations. However, there is a lot of good information in these requirements that can be easily adapted to the aviation maintenance environment. The DOE has a long history of operating facilities, many of which process potentially dangerous substances. A complicating factor is that many, if not most, of these facilities are operated by contractors.

Recognizing that many incidents and accidents in these facilities were caused by poor communication during shift turnover, the DOE promulgated Order 5480.19, which details the conduct of operations at DOE facilities.22 Chapter 12 of this Order is titled "Operations Turnover" and lists a series of guidelines related to shift turnover procedures and checklists.

Order 5489.19 invokes or references several standards. Two that directly address shift turnover are DOE-STD-1038-93, "Guide to Good Practices for Operations Turnover",23 and DOE-STD-1041-93, "Guide to Good Practices for Shift Routines and Operating Practices".24

In the GUIDELINES section, we use material from these DOE sources, as well as from work sponsored by the FAA/AAM in the aviation maintenance environment to develop reasonable and effective shift turnover practices.

CONCEPTS

Although the reality of fatigue-induced performance problems associated with shiftwork has been evident for many years, the underlying mechanisms causing these effects have only recently been identified and explained. The key concepts associated with shiftwork-related performance problems are described below.

Circadian Rhythms

The term *circadian* refers to the fact that the types of cycles we described in previous sections have a period nearly, but not exactly, a 24-hour day. The word *circa* is Latin for "about" or "approximately." Physiological and psychological variables that follow our internal clock are said to be "circadian." Body temperature is an example of a circadian cycle. Figure 4-1 shows the approximate body temperature cycle for an individual following a normal wake-sleep cycle.

Compressed Schedules

Certain types of schedules are said to be "compressed" because they compress a full work-week into fewer days than a normal 8-hour day requires. The most common compressed schedule requires four consecutive 10-hour workdays, followed by 3 full days off.

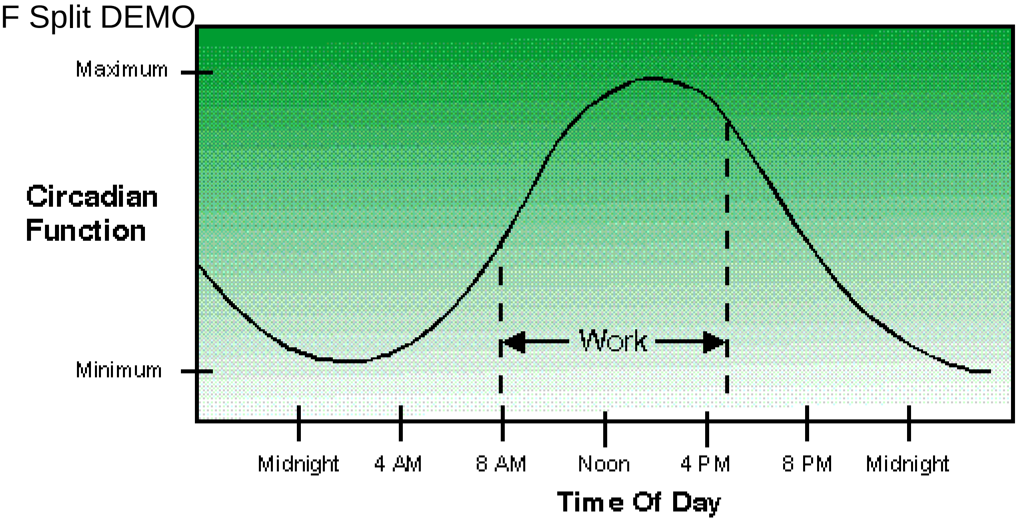

Figure 4-1. Approximate daily (circadian) cycle for body temperature

Another compressed schedule is known as the 2-2-1, or the "rattler." It consists of a 5-day work week made up of two evening watches, followed with two day watches, and finished with one midwatch. In this way, a forty-hour work week is compressed into 88 consecutive hours. This leaves 80 hours (48 percent of the 168-hour, 7-day, week) for the weekend. The FAA uses this schedule in many air traffic control (ATC) locations. However, as Table 4-1 shows, such a schedule does not provide 16 hours off duty between any two consecutive watches. Consequently, there may be inadequate time for rest between work periods.

Table 4-1. Compressed, phased-advanced 2-2-1 schedule.

Day #	Work Hours	Hours between Watches	
1	1600-2400		
		14	
2	1400-2200		
		10	
3	0800-1600		
		14	
4	0600-1400		
		10	
5	0000-0800	_____	
Total Week	40 +	48	= 88 hours
Weekend			= 80 hours

7-day Week			**=168 hours**

Coping Mechanisms

If we can't eliminate a particular stressor from our lives, then we must somehow learn to live with it. The alternative is to allow the resulting stress to eventually manifest itself in physical, emotional, or psychological damage. The ways in which we reduce the effects of a stressor are called a coping mechanisms. Coping mechanisms can be as simple as choosing to ignore the situation, although we are typically not able to ignore the fact that we can't sleep during the daytime. More often, we cope with nighttime work by some combination of planning off-duty activities with our family, sleep schedules, nutrition, exercise, physical modifications to our home, and even wearing sunglasses when we drive home from work.

Countermeasures

Because of the universal existence of and performance decrements related to schedule-induced fatigue, there has been quite a bit of research directed at finding effective countermeasures. NASA has sponsored a Fatigue Countermeasures Program for many years. It is aimed at reducing the dangerous effects of fatigue among flight crew members.25 In studying the effects of planned naps for crew members during long, over-water flights, the NASA program found that short naps drastically reduce the negative performance effects of fatigue.

Other countermeasures that have been studied include various types of chemical stimulants such as caffeine and amphetamines, increased physical activity, and planned rest. Chemicals such as melatonin are thought (but not yet proven) to allow people to fall asleep easily, allowing them to synchronize their wake-sleep cycle to a new shift or time zone.26,27 Recent studies of carefully controlled exposure to bright lights has shown it to resynchronize circadian rhythms rapidly.28

Desynchronization

As with other types of oscillations, circadian rhythms can be either in or out of phase with our physical surroundings. They are said to be "in phase" when the effects they produce, such as sleepiness or alertness, are appropriate for the time of the work day they occur. Being tremendously sleepy at 4 a.m. is not a problem if you are in bed and do not begin working for several more hours. Drifting off to sleep at 4 a.m. while you are in control of an airplane or a nuclear power plant, obviously, can cause major problems.

Workers on rotating shifts routinely become desynchronized when they change shifts. Airline pilots who regularly cross time and date boundaries also live in a fairly constant state of desynchronization. Even workers who consistently work on the night shift can remain desynchronized indefinitely. While it is possible to become resynchronized, the time required to do so depends on many factors, including the dark-light environment in which one works. Figure 4-2 depicts a desynchronized circadian rhythm.

Fatigue

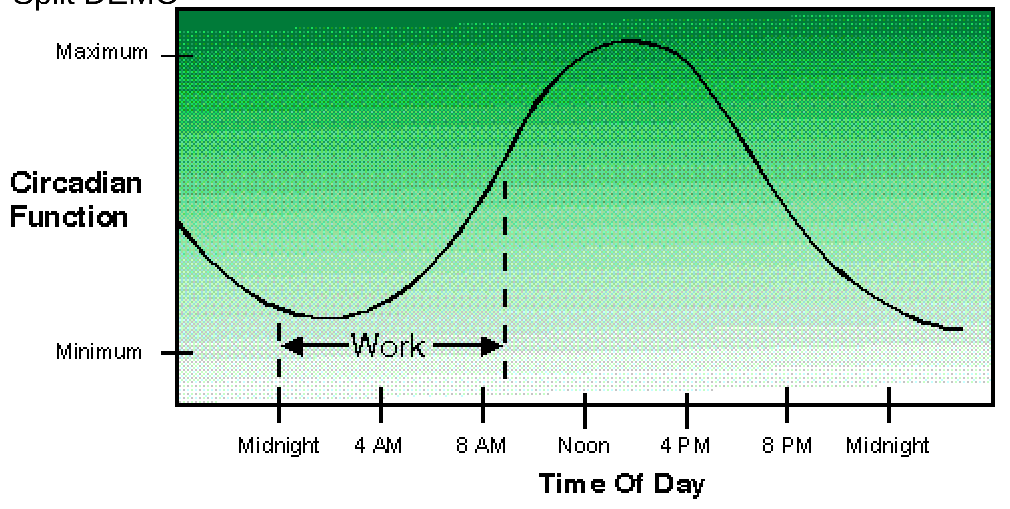

Figure 4-2. Example of a desynchronized circadian rhythm.

The concept of fatigue is more easily understood through common experiences than through quantitative research. It is not possible to measure fatigue directly, as one might measure blood pressure or the length of a person's hand. Fatigue is indirectly measurable through its effects. For example, you can measure the number of errors committed per unit time on a particular task. If the person doing that task continues without rest long enough, the number of errors he or she commits increases. At some point, you would conclude that the person is fatigued. Working long hours, working during normal sleep hours, and working on rotating shift schedules all produce fatigue-like effects, although the mechanisms are different for each situation.

Shift Turnover

Shift turnover is the process of handing off tasks and responsibilities from one shift to the next. This term is probably too general to convey what actually happens when shifts change. In fact, entire shifts do not hand over tasks and responsibilities. Instead, they are handed from one individual to another. The essence of good shift turnover practice is to ensure that every individual gets the appropriate information to understand where things stand as his shift begins and what he is expected to do during the work shift.

Sleep Inertia

When you awaken from sleep, you are not immediately capable of performing the same type of physical or mental tasks as after you have been awake for a while. This performance decrement, known as *sleep inertia*, has been documented for a variety of tasks. It is especially acute for tasks requiring complex mental processing.29,30,31 The effects of sleep inertia can take several minutes to dissipate and are more pronounced after experiencing sleep deprivation or when one awakens in a low circadian cycle.

METHODS

Various methods have been used to determine if shiftwork-related, i.e., fatigue-related, problems exist in a particular organization and, if so, to mitigate these effects. The GUIDELINES section describes several ways of reducing the effects of rotating and nighttime work shifts and of coping with the effects that remain. In this section, we look at methods that help supervisors determine the extent to which shift rotation or other scheduling characteristics decrease safety or productivity.

Critical Incident Technique

The critical incident technique asks workers to describe, in writing, accidents or near accidents they've observed, heard about, or been involved in while on the job. Although we're concerned about the effects of shiftwork and scheduling on job performance in this chapter, there are many other important aspects of job performance such as safety, productivity, efficiency, etc. The critical incident technique allows us to identify aspects of shiftwork that might directly affect the safety of workers or the flying public.

To be effective, critical incident reporting must be anonymous, or at least *allow* anonymity. A variation of the critical incident technique has been used for many years to allow cockpit crew members to report unsafe incidents or near-incidents.[32] Critical incident reporting need not be complicated to be effective. A few items on a questionnaire can provide an easy vehicle for such reports.

Direct Measurement

Direct measurement can be considered as a method for evaluating scheduling and shiftwork effects. The general idea of direct measurement is that some aspect of schedule-related fatigue causes a physical or psychological change that can be objectively measured. To some extent, probe tasks, as described in "Empirical Testing," below, are a type of direct measurement. However, all behavioral tasks are subject to the vagaries of human performance from a measurement perspective.

Certain physical variables are not directly affected by user perceptions or behavior. For example, it is possible to measure the levels of melatonin in the bloodstream. Melatonin levels are directly related to feelings of sleepiness. Thus, directly measuring melatonin levels is a way to assess sleepiness without asking people to describe how sleepy they feel. Likewise, core body temperature is directly related to alertness, and eye movements are associated with attentiveness. In fact, a number of these physical variables are directly tied to conditions that either enhance or degrade job performance.

The biggest drawback of direct measurement is that it is extremely intrusive; the act of making the measurement can affect the factor being measured. For example, drawing blood to analyze melatonin will definitely cause a certain increase in the worker's arousal level. Taking core body temperature measurements can be even more intrusive. Because of the intrusive nature of these measurements and the ethical considerations inherent in making them, this type of direct measurement is best left to professional and academic researchers.

Empirical Testing

In human factors, the preferred method of determining the effects of any condition, situation, substance, etc., is to have people under the influence of that condition perform a realistic task. Such empirical testing is the cornerstone of all objective science. In the case of fatigue, for example, a reasonable empirical approach would be to cause fatigue in a group of people, perhaps through lack of sleep, and then have them perform a work-related task.

Such testing must be subject to stringent safety precautions. It is not ethical to study the effects of alcohol on driving performance by giving people large amounts of alcohol and then letting them drive. Likewise, we cannot intentionally cause fatigue in a group of aircraft maintainers and then let them work on actual aircraft systems.

Most empirical testing for schedule-related fatigue effects has been done in one of two ways. The first is to place people in a laboratory setting, to have them undergo a particular wake-sleep cycle or simulated work schedule, and then to measure their performance on some set of tasks. Although these tasks can be made quite realistic, since they are not undertaken in the workplace no one is exposed to hazards.

The second empirical testing strategy is to keep individuals in an actual work situation and observe their behavior on an abstract task, sometimes called a *probe task*. Probe tasks are designed to test some aspect of a person's ability to perform work, such as the ability to perform numerical calculations. Errors on the probe task are then analyzed to determine whether the condition, in our case fatigue, is associated with an increase in particular types of errors.

Empirical testing is objective and can provide very precise measurements of fatigue-related effects. It is difficult to design a test that measures *only* the effects of the condition we want to evaluate. In fact, there is an entire science devoted to designing empirical studies. Since empirical testing is so difficult to use properly, we recommend that interested readers seek professional help before embarking on a testing program.

Error Reporting and Investigation

One very straightforward method of identifying shiftwork-related problems is to implement a formal error reporting and investigation process and track errors that seem to have shiftwork as a direct or indirect root cause. Chapter 14 deals with human error in detail. In Chapter 14, we describe a number of error reporting techniques and formal root cause investigative programs, such as MEDA.

With proper categorization of errors, we can identify problems that have connections to shiftwork-related issues. For example, we might identify a poor shift turnover procedure as one of the root causes of an error or accident. Likewise, we might identify lack of concentration due to poor sleep quality. There are a number of root cause characteristics that can be easily associated with various effects of shiftwork.

Questionnaires/Opinionnaires

The most common method of determining work-related problems or soliciting workers' opinions is simply to ask. Good managers solicit workers' comments and listen to their opinions and complaints. Face-to-face questioning has its drawbacks, however. First, workers are often intimidated by managers and find it difficult to criticize a work practice that their supervisor might favor. Second, individual interviews are so time-consuming that discussing workplace issues with each and every worker can be practically impossible. Third, since workplace interviews tend to be relatively unstructured, it is difficult to cover a variety of topics with appropriate detail without getting side-tracked.

Human factors practitioners recognize these drawbacks and have developed a formal, written method for soliciting employees' opinions, and other information. This method uses structured questionnaires designed to allow workers to provide job-related information anonymously. Questionnaires typically contain items that solicit both objective information *and* opinions. Strictly speaking, written instruments that solicit opinions are called "opinionnaires." However, for simplicity, we refer to the composite document as a questionnaire. Questionnaires and opinionnaires are described in Chapter 1.

Questionnaires are relatively easy to develop, cheap to reproduce, and easy to distribute and analyze. Workers can be given time during their shift to fill out questionnaires, solving the common low response rate associated with mailed questionnaires. Constructing questionnaire items requires skill, if the responses are to be meaningful. We've all seen self-serving surveys in which the phrasing identifies the expected response.

The developer's intent should be to phrase items so they present no particular viewpoint. Users should be encouraged to be direct and candid in their responses. Users should be allowed to respond anonymously; this eliminates any intimidation effect. In turn, managers should be prepared to deal with responses they don't particularly want to hear.

Training

In the human factors domain, we really have only two choices for ensuring the proper functioning of a person-machine system. We can either change the system or the person. Changing the system is a matter of analysis, design, and evaluation. Changing the person is a matter of training.

In the area of shift-related effects, we've seen that many problems are essentially physical and are not within the worker's conscious control. We cannot change underlying physiological mechanisms that cause such problems. Neither can we avoid such fatigue problems simply by pointing out that they exist. This would be similar to trying to enable people to read typography that is too small by simply telling them that the type is too small.

Even with its fundamental limitations, training is a valid method for minimizing shift-related fatigue effects and for mitigating them when they do occur. We can train managers and planners about shift-related fatigue effects and inform them that such widespread effects are not generally under workers' control. By teaching appropriate scheduling algorithms, countermeasures, and coping mechanisms, we increase the likelihood that such techniques will be used.

By teaching workers to recognize the early signs of fatigue and providing appropriate coping mechanisms, we can reduce the likelihood that fatigue-related errors cause serious consequences. This is a similar to pilots being taught to recognize the early symptoms of hypoxia. We can also teach workers (and their families) to structure their off-work activities to minimize the debilitating effects of sleep loss caused by shiftwork.

READER TASKS

As we have shown in this chapter, the topics of shiftwork and scheduling are complex. The effects of shiftwork are only now coming to be understood in the scientific community. Despite their lack of fundamental knowledge about shiftwork and scheduling, however, these types of tasks are among the most common for supervisors and managers. To claim simply that aviation maintenance supervisors lack in-depth understanding of fatigue-related performance effects sidesteps the fact that supervisors *are* asked to perform scheduling tasks.

In this section, we describe a number of fairly common scheduling-related tasks for which we can provide some human factors guidance.

Evaluating Existing Schedules

A reasonable question for supervisors to ask is whether the existing schedules in their organization are likely to cause performance problems for technicians and inspectors. There are large differences among individuals regarding the effects of rotating shifts or of working on any particular shift. Also, as we've indicated in previous sections, people relegate their work schedule to a fairly low priority in their lives. People's preferences for their work schedules are likely to be dictated by their desires to perform non-work-related activities in their off hours. There are several techniques that can be used to determine whether a particular schedule has caused, or is likely to cause, performance problems.

Developing Shift Turnover Procedures

One of the most problematic aspects of shiftwork in the aviation maintenance environment is turning over responsibility from people on one shift to people on the next. This process is typically known as "shift turnover" and is the locus of a number of errors that have resulted in serious aviation accidents.

Developing an effective and appropriate shift turnover process is fraught with difficulties, not the least of which is the widely-held view that shift turnover is, or should be, an easy, common-sense process. Research related to developing a usable shift turnover form for aviation inspectors shows just how difficult such a task can be.[33]

Implementing Countermeasures

Ideally, everyone would work days or evenings, eating and sleeping on a "normal" schedule. This ideal is not universally obtainable, especially in aviation maintenance organizations. A certain number of people must work on a shift that does not allow a "normal" wake-sleep cycle, and a good percentage of these people will suffer from the effects of such schedules. These effects are not totally unavoidable. Intense research in this area has provided a number of techniques, or "countermeasures," for reducing the effects of schedule-induced fatigue. Some of these countermeasures actually attack the underlying mechanisms causing fatigue.

Introducing Coping Mechanisms

Fatigue is not by itself necessarily debilitating. Workers can learn to recognize the symptoms of fatigue and cope with the symptoms. It is much the same as coping with any other stressful situation in life. Since we can't entirely avoid potentially stressful circumstances, we must learn to recognize and cope with their effects.

Supervisors can help workers cope with shift work by explicitly recognizing and dealing with the effects. Pretending that such effects don't exist is neither wise nor effective. The maintenance organization can also officially recognize the error-inducing nature of working at night and implement procedures to identify and mitigate the effects of the errors that will inevitably occur as a result of night work.

GUIDELINES

The following guidelines are keyed to the tasks described in the preceding section.

Evaluating Existing Schedules

The most fundamental action that can be taken with regard to shift scheduling is to determine the present state of affairs. A schedule can be evaluated for a number of different purposes. The most obvious reason is to determine whether workers are experiencing excessive fatigue, or performance or safety problems. Another, less-obvious purpose might be to identify workers who might prefer to work on a different shift.

Just as there are different reasons for evaluating a shift schedule, there are different methods that are appropriate for varying circumstances. The easiest, cheapest, and most generally applicable evaluation method is the questionnaire. Questionnaires are routinely used in scientific studies of shiftwork effects. They are fairly easy to develop, reproduce, distribute, and analyze.

In addition to their ease of use, questionnaires use anonymous responses. This is an important consideration when you are asking workers to provide information that might adversely affect their performance appraisals. For example, admitting that one has fallen asleep on the job isn't ordinarily something one would like to admit to one's supervisor.

You will find a typical shift evaluation questionnaire in Table 4-2. In this example, we've attempted to include items that can be used for all of the purposes described above. A questionnaire used for one specific purpose would consist of some subset of the items. Scales are certain questionnaire and opinionnaire items that have been developed exclusively to measure attributes like "sleepiness" and "mood".[34,35] Since analyzing such scales requires expertise in psychology and statistics, they are normally used only by professional researchers. Any evaluation that is more in-depth than the level we are describing here should be undertaken only with the help of a professional human factors practitioner.

One procedural issue you should note is that workers should be given an opportunity to respond to evaluation questionnaires while working on their shift. In fact, certain items can be replicated several times on a questionnaire and used to analyze workers' before-, during-, and after-shift feelings. A good example is an item related to the worker's present level of fatigue. One would expect subjective fatigue ratings to increase as a shift progresses. Thus, questionnaires could be divided into sections that can be answered at particular times during a shift.

Table 4-2. Example of a questionnaire used to evaluate the existing shift schedule.

	Schedule Evaluation Questionnaire		
Shift: ____________	Time: _________		Date: _________
Name: __________________________ (Optional)		Job Title: ______________	
Gender: ___Male ___Female (Optional)			Age: _____
General Schedule and Shift Preferences			
1. How long have you worked on this schedule? _________ (weeks, months, or years)			
2. During this rotation, how long have you worked on this shift? _________ (days or weeks)			
3. Have you ever worked on other shift schedules? ___Yes ___No			
4. Have you ever worked on other shifts? ___Yes ___No			
5. Do you prefer rotating shifts or staying on one shift? ___Rotating ___Stay on one shift			
6. Of the shifts you've worked, which do you prefer? ____________			
7. Of the shifts you've worked, which do you like the least? ___________			
8. Which shift change do you find most difficult? For example, mornings to mids.			
Present Shift			
The following questions relate to the shift you are presently working.			
9. Do you ever feel sleepy while working on this shift? ___Yes ___No			
10. On the following scale, place an "X" at the point that best describes how frequently you feel sleepy while working on this shift. You don't have to place the "X" directly on one of the labeled scale marks. If you feel it should go between two labeled marks, then put it there.			
|----------------|--------------|------------------|----------------|----------------|----------------| Never / A few times a year / A few times a month / Once a week / Several times a week / Every day / Several times a day			11. Have you every been so sleepy that you've actually

fallen asleep while on this shift?
___Yes
___No

Table 4-2. Example of a questionnaire used to evaluate the existing shift schedule (cont.)

12. How often do you fall asleep while on this shift?
|----------------|--------------|-----------------|----------------|-----------------|
Never A few A few Once a Several Every Several times a times a week times a day times a year month week day

13. How sleepy do you ... scale below.
|-------------------------------|-----------------------
Just a tiny sleepy I'm about to fall asleep Not sleepy but not wide awake I'm ext... slee...

14. How easy do you find it to adjust to working on this shift? We're asking about your sleeping, eating, and social patterns, as well as your ability to perform work on the shift.
|----------------|--------------|-----------------|----------------|-----------------|----------------|
No adjustment required Very easy Fairly easy Neither easy nor difficult Fairly difficult Very difficult Impossible

15. Which factors in your life figure most prominently in adjusting to working on this shift? Place a check mark by all that apply.
___ Sleeping ___ Eating ___ Spouse's schedule
___ Kids (including child care, school, etc.) ___ Socializing
___ Commuting ___ Recreational activities ___ Television
___ Other

____

16. To what extent do you feel you are an integral part of the company and that your needs are considered by management?
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
I'm part of the family My needs are usually My needs are often About average My needs are sometimes My needs are I don't

rarely exist
met met met met

17. To what extent are you included in company planning and social functions?
|--------------------|-------------------|-------------------|---------------------|------------------|---------------------|
Always Usually Often Sometimes Not Often Very Rarely Never

Table 4-2. Example of a questionnaire used to evaluate the existing shift schedule (cont.)

18. Have you ever seen an accident or near accident that you feel was caused mostly by fatigue or sleepiness related to th

19. Have you ever been involved in an accident or near accident that you feel was caused mostly by fatigue or sleepiness

20. If you answered "Yes" to item 16 or 17, would you please describe, very briefly, the circumstances of the accident, esp

____

21. If you have any suggestions or recommendations regarding the present shift schedule, please list them briefly below.

____

Developing Shift Turnover Procedures

The quality, even the existence, of shift turnover procedures differs among various aviation maintenance organizations. Conceptually, the importance of good shift turnover practices is universally recognized. However, as a practical matter, there is little regulatory (or other) guidance regarding what constitutes a "good" shift turnover process. In this section, we provide a number of definitive guidelines related to shift turnover procedures. This material is derived from research done in the aviation maintenance setting, as well as applicable regulatory information and standards from the Department of Energy.

Conceptually, shift turnover can apply in three different situations. The first, and most common, occurs when operations are manned on multiple shifts and an outgoing shift must turn over job and task responsibilities to an incoming shift. The second applies when going from an unmanned to a manned condition. That is, perhaps a maintenance facility is unmanned for some period of time each day or week. An incoming shift of workers must assume all responsibilities as the facility is made operational.

The final shift turnover condition applies when a worker's job responsibilities must be assumed by another person before the end of the first worker's shift. This happens when on-the-job illness, personal emergencies, etc., require a worker to leave her job before her scheduled quitting time.

In this section, we will concentrate on the most common shift turnover condition -- an incoming shift must relieve an outgoing shift. Except for the shift turnover meeting, however, all of the components of the shift turnover process are applicable to other turnover situations as well.

Effective shift turnover depends on three basic elements:

1. The outgoing worker's ability to understand and communicate important elements of the job or task being turned over to the incoming worker.

2. The incoming worker's ability to understand and assimilate the information being provided by the outgoing worker.

3. A formalized process for exchanging information between outgoing and incoming workers and a place for such an exchange to take place.

DOE shift turnover standards stress two characteristics that must be present for effective shift turnover to take place: ownership and formality. Individual workers must assume personal ownership and responsibility for the tasks they are performing. They must want to ensure that their tasks are completed correctly, even when those tasks extend across shifts. The antithesis of this mentality is the "It didn't happen on my shift" attitude, which essentially absolves the outgoing worker of all responsibility for what happens on the next shift.

Formality relates to the level of recognition for shift turnover procedures. Formalism exists when shift turnover procedures are part of written operating rules and managers and supervisors are committed to ensuring that cross-shift information is effectively delivered. Workers' perceptions of the importance attached to shift turnover are directly related to the willingness of the organization to provide ample shift overlap time, adequate job aids, and dedicated facilities for effective turnover to take place.

An effective shift turnover process is composed of at least four components:

- Shift turnover meetings
- Turnover walkdown
- Turnover checklists
- Work status markers

We will provide guidelines for each of these elements, below. All should be included in the turnover process.

Shift Turnover Meetings

The shift turnover process should include at least two meetings. It should begin with a meeting among incoming and outgoing supervisors. The purpose of this meeting is to acquaint the incoming supervisors with the general state of the facility and the status of all work for which each will be responsible. Outgoing supervisors should summarize any significant problems they encountered during their shift, especially any problems for which solutions have either not been developed or are still in progress. Table 4-3 lists the topics that should be covered in the supervisors turnover meeting.

After the outgoing and incoming supervisors meet, they should meet with the outgoing and incoming workers as a group. The purpose of this meeting is to summarize the progress of the outgoing shift and acquaint the incoming workers with any general considerations that might affect their tasks. Prior to this meeting, the incoming workers should be assigned to the tasks they will be performing during the upcoming shift. The general topics to be covered during this meeting are essentially the same as those listed in Table 4-3.

During this combined shift turnover meeting, supervisors should make general announcements related to company policies, work schedules, etc. Both incoming and outgoing workers should raise issues they want addressed in a general forum.

Walkdowns

While general issues are addressed in the turnover meetings, individual AMTs and Inspectors must exchange detailed information related to individual jobs and tasks. The most effective way to communicate this information is for the incoming and outgoing workers to go over task issues while examining the actual work location(s) and component(s). A mutual inspection and discussion of this nature is called a "walkdown".

Table 4-3. Topics for supervisors' shift turnover meeting

- General Facility Status
Construction
Off-limit areas
HVAC/Ventilation
Hazardous storage
Workstands/Docks
Visitors

- General Job Status
Aircraft in facility
Scheduled incoming/outgoing aircraft
Deadlines

- General Manning Status
Coverage
Injuries
Training
Other personnel issues

- Problems
Outstanding/Status
Solved

- Information
AD's, AC's, etc.
Manufacturers' notices
Company policy notices

An important psychological and procedural aspect related to individual shift turnover is when it actually begins. The common perception is that shift turnover occurs only at the transition period between shifts. However, DOE shift turnover standards make the point that shift turnover should really begin as soon as the previous shift starts. Throughout their shift, workers should be thinking about what information should be included in their walkdown with their counterpart in the succeeding shift.

A number of topics should be covered during the shift turnover walkdown. These topics will vary slightly between shop and floor technicians and between AMTs and Inspectors, but the general topical areas will be consistent across various job categories. Table 4-4 provides a reasonable topical outline with which to structure turnover walkthroughs.

Table 4-4. Topics for turnover walkthroughs

- Jobs/Tasks in process
- Workcards being followed
- Last step(s) completed
- Problems encountered
  Outstanding/Status
  Solved
- Unusual occurrences
- Resources required/available
- Location(s) of removed modules, parts, fasteners, etc.
- Parts and tools ordered and when expected
- Proposed next step(s)
- Communication with support people, vendors, etc.
- Communication with managers and supervisors

Checklists

Walkdown information exchange should be structured with a checklist. There are essentially two schools of thought regarding shift turnover checklists. One maintains that these checklists should be written documents, i.e., all turnover information should be written on a checklist form and the filled-out form should be passed from the outgoing to the incoming worker. Such written checklists can also be used to pass shift information to supervisors.

Shift turnover information can also be given verbally from outgoing to incoming workers. In this case, checklists are used to structure the turnover conversation and ensure that the outgoing worker doesn't inadvertently fail to pass along important information. This mode of operation is the same as various cockpit procedures that are governed by checklists, such as takeoff, landing, in-flight engine re-start, etc.

1. The only objective research related to shift turnover communication in the aviation maintenance domain involved written shift turnover inspection logs.33 These researchers stressed the importance of writing down important information. Their rationale noted that verbal information, while more convenient, is also more prone to distortion and simple forgetting.

We should note here, however, that the job of Inspectors is at least qualitatively different than that of maintenance technicians. Whereas Inspectors routinely write down observations and comments, AMTs are typically more concerned with completing steps in a procedure on a workcard. It appears that verbally exchanging turnover information, according to a formal checklist, is more likely to conform to the way AMTs typically work. The more compatible the procedure, the more likely it is that AMTs will follow it.

We recommend that readers prepare shift turnover checklists that cover all of the topics in Table 4-4. If particular types of information, not found in Table 4-4, are required for particular job categories, then specialized checklists should be developed for these jobs. Checklists should be no more than one page in length and should conform to the formatting requirements for workcards. Once the checklists are written, they should be laminated, and provided to all AMTs and Inspectors.

Work Status Markers

We have noted in the INTRODUCTION and BACKGROUND sections that working at night exposes a maintenance organization to a number of conditions that increase the likelihood of errors. The components of a shift turnover process are designed to reduce errors that are the result of splitting tasks across shifts. Many types of shift turnover errors have been identified and discussed in various publications. However, all are based on the lack of effective communication.

A serious type of shift turnover error occurs when an incoming worker assumes that the outgoing worker has completed a job when it has not, in fact, been completed. A very simple way to address this potential error is to provide explicit work status markers that can be affixed to, or in the vicinity of, a worksite or component being repaired. This is the same idea as attaching "remove before flight" streamers to certain aircraft components.

Color-, pattern-, and shape-coded "work complete" and "work in progress" cards can be attached to each workcard. When an AMT completes all the steps in a workcard procedure, he or she places the "work complete" card on the module or structure being worked. If a shift ends before the work is complete, then the "work in progress" card is placed on the work site. When each job is inspected, the inspector removes the "work complete" card and returns it to the workcard control group.

This technique will prevent an incoming technician from assuming that work on a particular module is complete, when, in fact, it is still in progress. Of course, this information should be transmitted during the walkdown discussion. However, the idea is to provide more than one barrier to prevent human error from propagating through the system.

Implementing Countermeasures

The adverse effects of night shift work can be mitigated, at least somewhat, by various supportive strategies. For workers who regularly rotate among different shifts, these strategies include structuring shift rotations and non-work activities so they are able to rapidly acclimate to shift changes. In aviation maintenance, workers are typically assigned to a particular shift for an extended period, so we must adopt countermeasures more appropriate to this situation.

Workers' overall physical and mental well-being are major determinants of the presence and magnitude of fatigue effects. The most effective countermeasures to shift-related performance problems is described below. Readers should understand that no countermeasure is 100% effective. The idea is to minimize rather than eliminate the bad effects of forcing workers to work at night.

Diet and Exercise

A major determinant of the effects of shift-induced fatigue is an individual's general physical well-being. Several countermeasures are related to the preparation of each worker for the rigors of shiftwork. A worker's diet should be nutritionally balanced, regular, and adequate in amount. Dietary rules for shiftworkers are actually the same as for non-shift workers -- the major difference is that shiftworkers often eat meals at odd (non-traditional) times of day. The pre-bedtime meal should be high in complex carbohydrates; the wake-up meal, high in protein. Workers should not use alcohol, caffeine, or nicotine for several hours prior to bedtime.

As we noted in our discussion of the concept of sleep inertia, we aren't capable of performing life or job functions at full capacity immediately after waking. Workers should be encouraged to take regular exercise, especially on arising. Regular exercise has been shown to contribute to a worker's overall sense of well-being. In addition, exercise after waking serves as a warm-up for the rest of the day's activities. Finally, regular, vigorous exercise makes an individual more capable of handling various types of physical and mental stress.

Resynchronization

Most problems associated with shiftwork are related to the chronic and cumulative sleep loss caused by a person's work schedule becoming de-synchronized with his or her circadian rhythms. One obvious countermeasure is to resynchronize work and circadian cycles as quickly as possible, but this is much easier said than done. Until recently, it wasn't clear that there are actions that consistently speed the synchronization process. Even now, there is only one safe and effective method to speed resynchronization.

It has been known for some time that the body's internal clock is reset by exposure to bright light. Recent research has shown that we can intentionally *reset* that internal clock by selectively exposing a person to very bright light.28 A person working during nighttime can cause his or her internal clock to reset by spending time in a brightly lit area. In this way, a person can minimize the fatigue effects caused by being de-synchronized *and* rapidly resynchronize his or her internal body cycles to the work schedule. Unfortunately, the resetting effect essentially can be destroyed by exposure to other bright lights, such as daylight, *after* the workday is finished.

Organizational Effects

Many of the effects of shiftwork, or at least the severity of certain effects, are moderated by a worker's psychological sense of well-being and belonging. Night shift workers often feel isolated from the rest of the organization. During their off hours, these workers are essentially isolated from the rest of the population, since people socialize according to their work schedule. It is common for night-shift workers to feel cut off from the rest of society. If workers carry this perspective into the workplace, they can quickly develop an "us vs. them" attitude and mentality.

Managers can minimize these types of effects by including off-shift workers in briefings, presentations, etc. Day-shift workers have access to services and people that are often inaccessible to night-shift workers. For example, it is relatively easy for day workers to visit a credit union, get a benefits-related question answered, attend a training seminar, etc. As much as possible, these same opportunities should be made available to night-shift workers (see Table 4-3).

Managers should encourage a sense of professionalism and pride in work quality among all workers, but make a special effort to do so for those working the night shift. The methods for accomplishing this are the same as for day workers, including incentives, recognition among peers, common quality standards, proper and immediate feedback, etc.

Finally, managers should ensure that night workers are included in all social events and activities available to other employees. Workers should be encouraged to participate in an active social life tailored to their off-duty hours. The company can help by maintaining contacts with business and social organizations that cater to individuals who work during non-traditional hours.

Introducing Coping Mechanisms

If existing studies are any indication, there is no countermeasure that completely eliminates fatigue and sleepiness during nighttime work hours. Even with an ideal schedule, reasonable shift rotations, and diligent management attention, individual workers occasionally exhibit symptoms of fatigue. Some of these symptoms are simply the result of individual differences; disruptions in wake-sleep cycles affect some people more seriously than others.

Some instances of fatigue occur because of off-shift behavior. People occasionally stay up and watch television, socialize, or do other things when they should be sleeping. Day-shift workers exhibit this behavior, so it is reasonable to assume that night-shift workers also do these things. This is simply human nature. Given that fatigue and sleepiness cannot be completely eliminated, it is important to teach workers how to recognize and cope with the symptoms.

There are essentially four methods of dealing with the symptoms of fatigue (the most common symptom is sleepiness):

- chemical stimulants
- physical activity
- environmental sound
- short sleep periods (naps)

Each of these coping methods is discussed below.

Stimulants

One of the common symptoms of fatigue is a decrease in one's level of alertness or arousal. Many chemicals, when ingested or injected, cause a measurable increase in alertness. The most familiar of these stimulants is caffeine, usually ingested as a component of coffee, tea, or carbonated drinks. Caffeine can also be ingested in pill form, but the dosage and effects are similar to drinking beverages containing caffeine. Other stimulants are available only by prescription or through illegal outlets.

These drugs all have similar effects on one's level of alertness or arousal, i.e., stimulants increase one's overall level of alertness and improve one's ability to concentrate and perform complex mental processing. These effects are short-term and any benefits can be easily overwhelmed by continuous use or overdoses. Everyone is familiar with feeling "wired" after consuming too much caffeine. In this condition, a person certainly is awake and alert; at the same time, he or she is also nervous, fidgety, unable to concentrate, and physically unsteady. These effects are exaggerated with stronger stimulants, such as amphetamines.

Even when consumed in moderation, stimulants can make it more difficult to "come down" after work. The benefits of stimulants can come at the price of further disruptions in a person's wake-sleep cycle. The bottom line for chemical stimulants is that only caffeine can be used routinely without a doctor's prescription. Taken in moderation, it can improve short-term alertness and delay the onset of sleepiness. If used excessively, even caffeine can cause performance decrements as severe as the fatigue effects it is meant to eliminate.

Physical Activity

It's within our common experience that time seems to move more quickly when we are busy. In fact, the enemy of alertness is boredom and inactivity, especially during the early morning hours. A worker can at least somewhat delay the effects of fatigue by staying active during a work shift. Also, fatigue symptoms can be reduced by a few minutes of vigorous physical activity.

A worker's job determines the extent to which he or she participates in physical activity. A person who is removing or installing a complex aircraft system is moving around, changing positions, and exerting various types of forces throughout his or her shift. On the other hand, a worker conducting a checklist procedure might be relatively inactive throughout his or her shift.

Workers should be encouraged to take regular breaks during their shifts and to walk around, go outside, stretch, and do other things to break the monotony of their work. Activity breaks are also beneficial for avoiding the soft tissue injuries associated with static work postures.

Sound

Certain types of sounds in our environment can cause us to remain alert, even when we are otherwise fatigued. Other sounds can cause us to become sleepy, even when we are not particularly tired. We are all familiar with the soothing effects of rain on the roof, ocean surf, and water running in a nearby stream. Likewise, we've all been kept awake by a creaking shutter, a dripping faucet, or other annoying noise.

Environmental sound can be a compelling stimulus in the workplace. Of course, we don't want to subject workers to the effects of noise that is so loud as to cause physical damage or stress effects, such as the inability to concentrate. We also don't want to mask the sounds of alarms or important announcements. However, a certain level of environmental sound can increase alertness in the presence of fatigue.

A good example of reasonable type and level of environmental sound is playing music on a radio. It is a common strategy to play the radio when driving at night. While we will eventually become too fatigued to drive, the radio music will serve to increase our general level of alertness.

Unfortunately, many (probably most) industrial organizations have rules against doing un-work-like things (like playing the radio) in the workplace. Given the proven beneficial effects of music on alertness, these policies eliminate one of the few coping mechanisms shown to be effective against the effects of fatigue.

Naps

Once a person reaches a certain level of fatigue and sleepiness, it is impossible for him or her to stay awake by an act of willpower. The effects of other coping techniques, such as physical activity and chemical stimulants, are only temporary. The ultimate coping mechanism for sleepiness is to fall asleep. Although it is very difficult for most managers to accept the idea that workers should be paid for sleeping, at least one study of cockpit crews on long, over-water flights, has shown that performance decrements associated with sleepiness and fatigue can be drastically reduced when crew members are allowed to take a short nap during their shift. Fatigue effects were reduced when crew members were allowed to sleep as little as one-half hour during their watch.[25]

In the aviation maintenance domain, there are few instances where workers' tasks include long periods of essentially no activity, like pilots on over-water flights. The research results cited above are probably not directly applicable to aviation maintenance. However, the fact remains that crew members could fall asleep during their watch and that a short nap virtually eliminated fatigue effects; we can probably expect similar effects for maintenance workers. A work policy that allows workers to nap a certain number of times during the month (or year) might actually increase overall worker productivity. At the very least, workers should not be required, or even allowed, to continue working once they exhibit symptoms of severe fatigue.

WHERE TO GET HELP

The Human Factors and Ergonomics Society is a good place to begin looking for help related to any human performance issue -- including shiftwork and scheduling.

Human Factors and Ergonomics Society
PO Box 1369
Santa Monica, CA 90406
Phone: (310) 394-1811
Fax: (310) 394-2410
Web site: http://hfes.org
Email: hfes@compuserve.com

In this *Guide*, we generally do not recommend specific, for-profit organizations as sources of help for readers. However, only one company has been licensed to apply light resynchronization technology to shift-related fatigue symptoms. Shiftwork Systems is presently working with at least one government agency, the Nuclear Regulatory Commission, to alleviate night shift fatigue.

Shiftwork Systems
Attn: Nick Murphy, Senior Project Manager

One Kendall Square
Building 200, 4th Floor
Cambridge, MA 02139
Phone: (617) 374-9340
Fax: (617) 374-9210

FURTHER READING

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EXAMPLE SCENARIOS

The scenarios presented below represent some of the typical kinds of scheduling-related tasks that you can expect to encounter in the workplace. The purpose of including these scenarios in the *Guide* is to demonstrate how the authors foresee the document being used. For each scenario, we describe how the issues raised in the scenario can be resolved. There is usually more than one way to approach these issues, so the responses given below represent only one path that users of the *Guide* might take.

As a general rule, always start to look for information by using the Search function. There will be instances that you already know where required information is located. However, unless you frequently use specific sections of the *Guide*, you might miss information pertaining to the same issue located in more than one chapter. The Search will allow you to quickly search all chapters simultaneously.

Scenario 1 – It didn't happen on my shift!

In the past few months, your inspectors have found at least three instances in which AMTs missed major steps in various C-check jobs. Investigations into these incidents point to poor handoff between shifts. When questioned, the AMTs involved in these tasks claim that any problems occurred on other people's shifts.

You have decided to stress the importance of shift turnover and have told your supervisors to bring up this topic in their pre-shift meetings.

Issues

1. From our description of the problem, does there appear to be any major element missing, either organizational or procedural, in your workplace?

2. Is this new emphasis on shift turnover likely to cause AMTs and inspectors to be more effective in passing important information between shifts?

3. Are there other shift turnover strategies that will be more effective than your plan? If so, what are they?

Responses

In the GUIDELINES section, we pointed out two essential requirements for effective shift turnover – ownership and formality. It is obvious from our description of this scenario that these AMTs lack a sense of task ownership. When questioned about work-related errors, their typical response is that it didn't happen on their shift. We would hope that workers care enough about their jobs to want them completed correctly – regardless of which shift on which they are completed.

Not likely! The proposed shift turnover process is probably no better than what currently exists. The GUIDELINES section stresses ownership, which we've covered above, and FORMALITY, which our new process lacks. In effect, we are telling our workers to make sure they pass along important information to the oncoming shift, but we're not giving them any tools or support elements to make sure this occurs. We are not setting aside any time for the shift turnover to take place. We are not providing any type of job aids. In short, we are not giving our workers any of the things they need to make sure our shift turnover strategy is effective.

Yes. In the GUIDELINES section, we give a list of four components that should be included in an effective shift turnover process: meetings, checklists, walkdowns, and work status indicators. In this scenario, we would expect to see the following elements:

- planned meetings among supervisors and between incoming and outgoing workers
- a series of checklists for AMTs and inspectors
- planned walkdowns involving incoming and outgoing workers sharing the same job tasks
- a plan to develop work status cards that will be attached to work cards.

Scenario 2 - Shift-related Errors

Some of your inspectors are questioning whether workers on particular shifts commit more errors and have more accidents than workers on other shifts. You know that the same people work on all shifts since they rotate their work schedules.

Issues

1. What are some good methods to determine whether people really are making more errors or having more accidents on particular shifts?

2. Even if the actual number of errors and accidents is the same for all shifts, is there any way to find out whether there are more "near accidents" (or critical incidents) on a certain shift?

3. How can you determine if the work done on each shift is "equal" in terms of exposure to various hazards?

4. Is there anything wrong with simply asking people about accidents and errors in face-to-face interviews?

Responses

1. This issue isn't specifically addressed in the *Guide*. However, if accidents and errors are reported, direct measurement can be used to make this determination. For example, examining records of injuries reported to the company infirmary, analyzing workers compensation claims, and

reviewing OSHA 200 reports for each shift can provide a pretty good picture of how injury-producing accidents are spread among different shifts.

Depending on the nature of an error, it may or may not be reported or recorded. Inspection records are likely to contain as much information in this regard as any other source of information. Omitted steps and work that must be redone can be considered errors in the sense of this scenario.

2. Fortunately, accidents and outright errors are generally rare occurrences. Of much more interest from a human factors perspective are instances where workers *almost* committed an error or had an accident, but corrected the situation in time to prevent it. The critical incident method is specifically geared toward identifying near-accidents. The questionnaire contained in Table 4-2 contains three items specifically concerned with critical incident reporting.

3. This is a reasonable question, but it appears deceptively simple. Just because night-shift workers experience more accidents or commit more errors than workers on other shifts doesn't necessarily mean that the schedule is the root cause of these problems. Perhaps more, and more hazardous, procedures are done on the night shift. Since this issue is fraught with so many subtle methodological problems, we don't provide any guidelines related to it.

4. The subsection on "Questionnaires/Opinionnaires" contains a discussion related to the shortcomings of face-to-face interviews. Aside from the time and structure requirements imposed by interviews, the biggest drawback is that workers tend to be intimidated and defensive when answering direct questions about errors they, or others, have made.

Scenario 3 - Evaluating Worker Opinions

We seem to get a lot of complaints about our shift rotation scheme. We'd like to know what our workers really think about the way our shifts are defined and rotated, and we want to avoid a situation where a few "squeaky wheels" push us into doing something that most workers don't want.

Issues

1. How would you go about evaluating the existing shift structure and rotation schedule?
2. Who would you include in your list of people that provide information?
3. What physical measures should you take, if any? These might be measures related to people or to the work environment.
4. How would you analyze the information once you have it?

Responses

1. This scenario addresses the general issue of evaluating an existing schedule. This topic is treated in detail in the "Evaluating Existing Schedules" subsection of the GUIDELINES section. We recommend that an existing schedule can most easily be evaluated by using a questionnaire such as Table 4-2.

2. The issue of who should be included in the questionnaire sample isn't specifically addressed in this chapter. However, we have implicitly assumed that people actually working on the shifts in question should respond to the schedule evaluation questionnaire. We note in the last paragraph of the subsection, for example, that workers should be allowed to fill out the questionnaire while working on their shift. The concept of "user population" is discussed in Chapter 1 of the *Guide*.

3. The question of direct measures is answered in the "Direct Measurement" subsection of the METHODS section. Direct measures are difficult to define and extremely intrusive. You shouldn't try to use direct measures as part of a schedule evaluation process.

4. This is really the $64 question. After you go to all the trouble of distributing questionnaires, having workers respond to them, and then collecting them, how do you analyze the information

you've gotten? We've left this issue open in the *Guide*, since there's no single set of recommendations that covers all circumstances.

In this particular scenario, the most obvious way to analyze the questionnaire's results is to aggregate the responses to all the numbered questionnaire items and determine whether a majority of workers has problems with the present schedule. Problems can take the form of poor morale, excessive sleepiness on particular shifts, or safety lapses.

Scenario 4 - Fatigue Countermeasures and Coping

No matter what you try, it seems that people get very sleepy on the night shift. You've found people asleep on the job at various times. This is not a good situation, and upper management wants "something" done about it.

Issues

1. Are there any valid techniques or products that actually reduce the fatigue shift workers feel?
2. Are there any legal drugs that can help sustain alertness? If so, what are they, how long do they last, and what are the effects of continued usage?
3. How effective do you think the motivational approach might be? Can you fire up the troops enough so they can simply decide not to go to sleep on their shift?
4. What other approaches might work?

Responses

1. This scenario deals with countermeasures and coping mechanisms for shift-related fatigue. The "Implementing Countermeasures" and "Introducing Coping Mechanisms" subsections directly address these issues. When we speak of actually *reducing* shift workers' fatigue, we're talking about countermeasures. When we try to cope with fatigue that already exists, we're referring to coping mechanisms.

A number of countermeasures are described in the above referenced subsection of the *Guide*. Among these are modifying diet and exercise, using light therapy for resynchronization, and modifying the shift structure to take advantage of the body's own regulatory mechanisms.

2. Using drugs to overcome fatigue is a coping mechanism. We're assuming the fatigue already exists (or would without the drug) and that we want to mitigate its effects. In the "Stimulants" subsection, we discuss a number of fatigue-decreasing drugs, the most common being caffeine. The critical word in the issue stated above is *legal*. A number of stimulants are legal, if obtained with a doctor's prescription. However, the only over-the-counter stimulant that is legal is caffeine. As with other stimulants, caffeine's effects are temporary and overuse can cause anxiety, gastric disturbances, shaky motor control, and increased fatigue because of a person's inability to fall asleep after his or her shift.

3. We don't directly address this issue in the *Guide*. However, fatigue and sleepiness are largely physical phenomena and are not under the control of the worker. As such, it is not possible to motivate someone not to become sleepy or fatigued. Although there are management and organizational steps that can reduce off-shift workers' feelings of isolation and increase their sense of well-being, it is unrealistic to expect someone to will himself or herself from becoming sleepy.

4. A number of approaches can reduce the onset of fatigue on night shifts and mitigate its effects. We've described a number of approaches in this chapter. You can combine these approaches creatively to increase the effects. For example, work teams could provide peer encouragement for individuals to alter their off-work routines so as to get proper exercise, nutrition, and rest. Teams also provide an opportunity for members to change activities periodically so as to forestall the onset of fatigue caused by monotony.

Scenario 5 - Nap Policy

It has become clear that occasionally a person working the night shift is simply too sleepy to continue. Even if the person could continue working, you know that he or she is likely to commit errors. We need to figure out how to handle such situations.

Issues

1. Is it likely that a short, say 30-minute, nap gives a person enough rest to continue on with the shift?
2. What are the most likely outcomes if we simply adopt a policy that anyone too sleepy to continue work is unfit for duty and is sent home without pay (or is required to use vacation or sick time)?
3. The facility manager has been reading a lot about "work teams" and thinks this might be a good approach for helping individual workers get through the night. Would work teams be a good way of addressing this problem? Why or why not?

Responses

1. In the "Introducing Coping Mechanisms" subsection we provide a discussion of naps as a way to overcome sleepiness. Even short naps have been shown to decrease the effects of sleepiness. While we really don't know the full answer to this question, it is likely that naps would at least help aviation maintenance workers get over their sleepiness and continue to work.

2. Regardless of our policy, people will become sleepy on night shifts. The BACKGROUND discussion shows that most night-shift workers report feeling sleepy every night and that about one-fifth of them actually fall asleep on the job. We can't cause workers to not get sleepy by simply mandating that sleepy people are unfit for duty.

Although we don't provide a direct answer to this issue in the *Guide*, it is common knowledge that people do whatever is necessary to remain on the job. In this scenario, sleepy workers would either try to hide their sleepiness or try to counteract it -- using chemical stimulants or some other means. Either outcome is undesirable.

3. We discussed work teams in the previous scenario. Without repeating that discussion, let's say that work teams can help with some fatigue-related effects. However, teams cannot cause a person who is too sleepy to continue working to suddenly become alert.

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