CHAPTER

I

Section-I

INTRODUCTION

&

A MINI REVIEW
In the first few decades of this century technology progressed tremendously so also the methods of production in order to satisfy increasing needs of the contemporary society. This probably evolved methods leading to a more effective use of the available natural resources and manpower. Many industrialized countries, then introduced and adopted shift work system with a view to optimize utilization of human resources and to ensure continuity in operation of industries and various other production houses (Knutsson, 1989). Consequently, the population of shift workers grew and this phenomenon is still in operation. At present nearly one fifth of the total global work force works in shifts. The reasons for growing number of shift workers are manifold: (1) Modern industries depend upon expensive machines and continuity in their functioning is extremely mandatory and cost effective. Therefore, these machines have to be manned by workers round the clock; (2) Shift work determines dimension of the return on capital investment and (3) Quality in the current day life style demands immediate and round the clock service from various indispensable sectors, such as public health, transport, security (both internal and external), communication & media. All these sectors need men to be posted/deployed round the clock. Thus, shift working has become a routine feature and shall be absolutely inevitable in future if the present character and the rate of growth and development in industries are to continue.

WHAT IS SHIFT WORK?

The term shift work defined as an arrangement of work hours that uses two or more teams (shifts) of workers in order to extend the hours of operation of the work environment, beyond that of the conventional office hours. The varieties of shift work include stable/permanently displaced work hours in which the work schedule used does not require a person to normally work more than one shift (including night work), rotating shift work in which an individual is normally required to work more than one shift, changing from one shift to another and unscheduled work hours. On call shift is also a special form of shift work, where in case of emergency the particular group of workers are called for their duties. The most widespread shift system is when production is organized in eight hour shifts called morning, evening and night shifts (Knutsson 1989).
According to the International Labour Office (1986) **shift work** is defined as: A *method of work organization under which groups or crews of workers succeed each other at the same workstations to perform the same operations, each crew working a certain schedule or shift so that the undertaking can operate longer than the stipulated weekly hours for any worker. Often the term is used when more than one work period is scheduled in a workday or when most of the working hours fall outside the standard workday, such as, evening, night or weekend shifts.

**PREVALENCE**

Past few decades have witnessed a tremendous growth in the population of shift workers specially in developed and highly industrialized countries. Developing countries are also not free from experiencing this phenomenon (Kogi, 1985). In the USA, almost two decades ago over 27% of male workers and 16% of female workers were working in shifts (Danchik et al., 1979). At the comparable time in Great Britain the proportion of employees in manufacturing industry doing shift work increased from 12.5% in 1954 to 25% in 1968 (National Board for Prices and Incomes, 1970). In the Netherlands and France the shift workers were estimated to be around 19% and 21%, respectively, in the Seventies (Anonymous, 1980).

Surprisingly, similar types of statistics are not available for India (Census, 1991). Census (1991) does not differentiate night shift workers/rotational shift workers from the entire population of industrial workers. It is indeed essential that a database should be created separately for all types of Indian shift workers.

**CONSEQUENCES OF SHIFT WORK**

Several workers have studied the problems of shift workers, in relation to three important factors, namely circadian, sleep and social/psychosocial/domestic factors (Monk, 1988; Folkard, 1988, 1990; Danel and Potasova, 1989; Härma et al., 1990, Novak et al., 1990, Skipper et al. 1990). These factors should be considered while determining the shift work coping ability of a worker. According to Monk (1988) the circadian factors include type of shift rota, type of work to be done, age, mental and physical health, personality type and competing
Figure 1.1 Shift work coping factors (after Monk, 1988).
zeitgeber exposure. Sleep factors essentially include age, sleep need, shift system, drug/alcohol use and/or abuse, sleep hygiene and on job sleep availability. Social/psychosocial/domestic factors include moonlighting, child care and housework, commuting time, community support and housing quality (Figure 1.1). Without taking into consideration all these factors it would be difficult to develop full proof concepts that would eventually help in optimization of scheduling human shift work.

ALTERATION/MODULATION OF CIRCADIAN RHYTHMS

It has been well established that most of the animals including man exhibit circadian rhythms with a period of approximately equal to 24 hours (Aschoff, 1960, 1979, 1981). Human circadian rhythms in various physiological, biochemical, immunological, psychological and behavioural end points under natural conditions, exist and exhibit circadian ($\tau = 24$ h) periodicity (Enright, 1980; Haus et al., 1980; Reinberg et al., 1980, 1981; Smolensky et al., 1980; Halberg, 1981; Minors and Waterhouse, 1981; Wilson et al., 1983; Monk et al., 1983; Halberg et al., 1983; Toutou et al., 1986; Pati et al., 1987; Levi et al., 1987, 1992; Cornelissen et al., 1989). There are, however, several compelling situations that lead to deviation of the period from 24 h and upset temporal organization. Jet lag and rotational shift work are the best known examples of such situations (Aschoff et al., 1975).

There is sufficient evidence to prove that rotational shift work affects human health and performance by disrupting circadian rhythms and by causing numerous alterations in behaviour and physiology of organisms (Zeibt et al., 1989; Phillips et al., 1991; Deacon and Arendt, 1994). Internal desynchronization of several rhythms in shift workers have been reported (Harrington, 1978; Rutenfranz, 1982; Folkard et al., 1983; Reinberg et al., 1984, 1989; Pati and Saini, 1991; Gupta and Pati, 1993, 1994a).

The desynchronized circadian rhythms may lead to certain clinical complications. The chronopharmacologic effects of shift work include impaired metabolism and impaired efficacy of medications because of unusual sleep-wake cycles and circadian rhythms.
Phillips and Brown (1992) reported that disrupted circadian rhythms and fatigue from rotating shifts have been implicated as a cause of traumatic injuries. According to Monk (1988) desynchronization of circadian system affects the mental and physical health, longevity of the worker as well as public safety. Michel-Briand et al. (1981) documented more cases of depression and affective illness in retired shift workers than in retired day workers, in whom cardiovascular and locomotor problems have been reported to be more predominant. It could well be that in predisposed subjects an internal desynchronization is associated with symptoms which are common to both depression and shift work intolerance.

It is suggested that individuals with a circadian amplitude higher than the average are more tolerant to shift work (Reinberg et al., 1978, 1984). It seems that persons who possess weak circadian time structure, i.e., a rhythm with low amplitude are more prone to develop biological intolerance to shift work later in life. However, those with a strong (high-amplitude) time structure are the least prone (Smolensky and Reinberg, 1990).

According to Reinberg and co-authors, tolerance to shift work is independent of age and shift work experience (Reinberg et al., 1984). On the contrary, there are some other authors who believe that aging is associated with a decreased tolerance to shift work, critical age being on an average 40-50 years (Häkkinen and Vuokko, 1968; Koller et al., 1978; Akerstedt and Torsvall, 1981b; Foret et al., 1981; Kerkhof, 1985; Härma and Timarienen, 1987; Tepas et al., 1993).

Available literature indicates that intolerance to shift work is generally associated with desynchronization of circadian rhythms. The question arises that, can desynchronized rhythms resynchronize? Several authors have suggested countermeasures for rhythm entrainment. For example, a change from counterclockwise to clockwise rotation, together with a change from 7-d to 21-d rotation, may improve production and well being for rotational shift workers (Czeisler et al., 1982). A change in the same direction among rapidly (1 d) rotating police officers has been shown to reduce blood pressure and improve well being (Orth-Gomer, 1983). Furthermore, studies on the effects of simulated night work demonstrate that exposure to bright light during night can virtually eliminate circadian maladjustment among night workers. After four cycles of light treatment the endogenous circadian rhythms of body temperature, subjective alertness, cognitive performance, urine production and plasma cortisol secretion
have been observed to be completely adjusted to the new schedule (Czeisler and Dijk, 1995). In addition, exposure to bright light during the night shift has been reported to improve daytime sleep as compared to controls (Rutenfranz et al., 1981; Czeisler et al., 1990). This principle has been implemented for the first time by NASA scientists in manned space flight (Czeisler et al., 1991). NASA is now regularly using the bright light technology (therapy) on all space shuttle missions (Czeisler and Dijk, 1995). Lithium (Engelmann, 1973; Kripke et al., 1981; Johnsson et al., 1979) and to a certain extent other antidepressant drugs (Halberg, 1963; Wirz-Justice et al., 1980a, b), used to control depression and manic-depressive illness, have been shown to act on the period of certain circadian rhythms. The latest drug being used as a rhythm entrainer is melatonin. Its potential use in circadian rhythm disorders has been investigated in field studies of jet lag and shift work and in simulated phase shifts (Redman et al., 1983; Arendt et al., 1984, 1985, 1995).

CONSEQUENCES ON SLEEP

SLEEP DISORDER

Scheduling of sleep timings is a major concern in the life of shift workers, particularly if their work schedule includes night work among others (Rutenfranz et al., 1977; Czeisler, 1982; Robert et al., 1987; Rahman, 1988; Mahan et al., 1990; Khaleque, 1991). Tepas and Mahan (1989) have suggested that night shift workers suffer more often from an insomnia like sleep disorder. This abnormality is characterized by difficulty in falling and staying asleep. Their rigorous work helped build a model that proposes that night shift work results in acute partial sleep deprivation. The latter causes decrement in performance leading to decreased productivity. Continuous work in the night shift may lead to chronic partial sleep deprivation. In addition to performance decrements, chronic sleep deprivation, may lead to various clinical complications. It has been reported that total sleep deprivation may lead to fatal/devastating consequences, such as death as reported in non-human primates (Rechtschaffen et al., 1983). The association between shift work and sleep disruption results in adverse medical and psychologic consequences (Phillips et al., 1991). In many studies, a majority of shift workers admit to having experienced involuntary sleep on the night shift, whereas this is rare on day-oriented shifts (Kogi and Ohata, 1975, Akerstedt et al., 1983, Coleman and Dement, 1986). The rotating shift workers find it difficult to sleep during daytime due to noises at home and in the residential community (Ostberg, 1973, Koller et al., 1978, Akerstedt 1988).
Poor sleep both quantitative and qualitative, leads to sleepiness. Sleepiness has been defined as a drive towards sleep (Dement and Carskadon, 1982) and is traditionally expressed in subjective terms, although there are clearly pronounced behavioural and physiological expressions. It has been documented that the main causes of sleepiness in workers working in irregular work hours are, the circadian phase modulation (Folkard and Akerstedt, 1992; Akerstedt, 1995), the amount of prior wakefulness (Folkard and Akerstedt 1992), the length of work shift (Rosa et al., 1989), the speed of rotation (Knauth, 1993) etc.

Czeisler et al. (1980) and Zulley et al. (1981) demonstrated that in subjects who have the option to select their own preferred sleep/wake pattern under total isolation from external time cues exhibit circadian rhythm of sleep. Dijk and Czeisler (1994) have recently suggested that a natural disposition of circadian rhythm of sleep seems to consolidate sleep and wakefulness. Several investigators have documented a significant circadian rhythm in subjective drowsiness/sleepiness in apparently healthy human subjects (Reinberg et al., 1989; Gupta and Pati, 1994a, 1994b). The drowsiness rhythm in these subjects exhibit peak between 21:00 to 23:00 with a pronounced circadian period. However, in case of shift workers, rhythm in sleepiness desynchronizes externally as well as internally (Reinberg et al., 1989; Gupta and Pati, 1994a). Shift workers do have problems with sleep management specially because they attempt to have sleep at chronobiologically unsuitable time of the day. The problems include difficulty in initiating sleep and staying asleep. According to Czeisler et al. (1980) sleep is very difficult at the acrophase (maximum) of the body temperature rhythm and very easy at the nadir (minimum). Shift work disrupts the normal relation between rest/activity and the circadian regulation of bodily functions (Akerstedt, 1985). Among the most obvious effects of this disruption is disturbed sleep and increased sleepiness (Rutenfranz et al., 1981; Akerstedt, 1984). Härma et al. (1990) compared the mesors of sleepiness between different shifts in various age groups. They observed that the 24-h arithmetic average of the sleepiness increases highly significantly from morning to the second night shift in various age groups, and acrophase shifts forward 9 h on an average in all groups. Akerstedt (1992) reported sleepiness peak during the early morning in between 04.00 and 07.00 in night shift workers. A secondary peak has also been observed in sleepiness in the afternoon (Akerstedt and Gillberg, 1982).

There are several studies which suggest that the majority of shift workers experience sleepiness during the night-shift work, whereas day work is associated with no or marginal sleepiness (Akerstedt and Torsvall, 1978, Folkard et al.
1978; Dahlgren, 1981b; Verhaegen et al., 1981; Wagner and Garcia, 1986; Torsvall and Akerstedt, 1987; Torsvall et al., 1989; Gold et al., 1992; Paley and Tepas, 1994; Åkerstedt, 1995; Czeisler and Dijk, 1995). Usually, the relation of subjective sleepiness with performance is a close one, with major performance lapses occurring at the higher levels of sleepiness (Gillberg et al., 1994). Åkerstedt (1995) emphasized that not only sleepiness is experienced during the night shift, a considerable increase in sleepiness has also been observed in workers while they return to day work soon after the night shift. Furthermore, when the starting time of the morning shift is advanced, more sleepiness is experienced during the day (Hak and Kampman, 1981; Moors, 1990; Kecklund et al., 1994). This also decreases sleep length and sleep quality (Hak and Kampman, 1981; Moors, 1990).

UNTIMELY SLEEPINESS/DROWSINESS

In general, sleep disturbance is one of the major complaints of shift workers (Brief and Scala, 1986; Reinberg, 1986; Åkerstedt, 1987, 1990; Shah, 1990; Chang et al., 1993; Gillberg, 1995). Sleep disturbances and sleepiness (Åkerstedt, 1995) are caused mainly due to displacement of sleep to the trough timing where the sleep-promoting properties of the circadian rhythm are at their maximum (Åkerstedt, 1987). The proportion of shift workers suffering from sleep disturbances is usually above 50% compared to 5-20% for day workers (Åkerstedt, 1984). Women shift workers have been reported to experience more sleep disturbances than men and suffer more frequently from drowsiness during work, especially when working in the morning shift (Oginska et al., 1993). Chan (1994) reported that in case of female shift workers, the added responsibilities of looking after the home and young children may aggravate sleep problems and tiredness associated with shift work, thus adversely affecting their health. Sleep disturbances in shift workers are also associated with age (Kundi et al., 1979; Reinberg et al., 1980; Forêt et al., 1980, 1981; Åkerstedt and Torsvall, 1981b; Webb et al., 1981). Torsvall et al. (1981) reported more superficial sleep in middle-aged shift workers. It has been demonstrated that the poor adjustment of the older shift workers to shift work is associated with the greater amount of the sleep disturbances (Hakkinen and Vuokko, 1968; Koiler et al., 1978; Åkerstedt and Torsvall, 1981b; Forêt et al., 1981; Harma and Ilmaninen, 1987). The sleep disturbances reported by shift workers are both qualitative and quantitative and may lead to increased use of alcohol and hypnotics (Phillips et al., 1991). A number of studies demonstrated that compared to the permanent day workers,
sleep quality and quantity seem to be poorer for the rotating shift workers (Rahman, 1988; Tepas et al., 1990; Regestein and Monk, 1991; Siebenaler and McGovern, 1991; Chang et al., 1993; Harrington, 1994). Tilley et al. (1982) concluded that the quantity and quality of sleep are degraded and deteriorated as a result of working at night.

**SLEEP LENGTH**

Several studies on experienced night shift workers have repeatedly revealed that night work decreases sleep length and may result in an increase in sleep complaints (Walsh et al., 1981; Armstrong, 1982; Tepas 1982a, 1982b; Tilley et al., 1982; Gersten, 1987; Chan et al., 1993; Paley and Tepas, 1994; Barak et al., 1995). The reduction in sleep length found among night shift workers is perhaps one of the most important findings in the concerned research domain. According to Kripke et al. (1979) short sleep lengths are associated with decreased life expectancy. Tepas and Carvalhais (1990) reported that permanent night shift workers sleep longer on their days off, but they still sleep almost 4 hours less per week than the day workers do. Similar results have also been obtained by several other research workers/authors (Lille, 1967; Kripke et al., 1971; Bryden and Holdstock, 1973; Dahlgren, 1981a; Tepas et al., 1981; Walsh et al., 1981; Tilley et al., 1982; Verhaegen et al., 1987; Tepas and Mahan, 1989; Folkard et al., 1990; Tepas and Carvalhais, 1990; Totterdel and Folkard, 1990). Dahlgren (1981a) has found that sleep length reduces to 4.5 h on the first night shift, but increases again over six consecutive night shifts to reach a level of 5.7 h. Further, it has been documented that workers on the afternoon/evening shifts sleep the longest, workers on the day shift sleep slightly less, and night shift workers sleep the least (Rutenfranz et al., 1976; Åkerstedt and Torsvall, 1981a, 1981b; Tepas et al., 1985; Williamson and Sanderson, 1986; Tepas and Carvalhais, 1990). Workers exposed to on call shift work have also shorter sleeping time (Imbernon et al., 1993). Studies from several laboratories have shown that sleep duration is dependent on the time of sleep onset (Czeisler et al., 1980; Åkerstedt and Gilberg, 1981; Zulley et al., 1981). Sleep duration has been found to be the shortest among shift workers if it is started some hours after the circadian trough in activity/body temperature (?) rhythm, whereas sleep started close to the trough is somewhat longer (Foret and Lantin, 1972). This conclusion is also supported by field studies, showing that sleep duration
decreases when sleep onset is delayed after the night shift (Knauth and Rutenfranz, 1981). Sleep on morning shift days can also be shortened, especially if work starts early in the morning (Radosevic-Vidacek and Vidacek, 1994).

It has also been demonstrated that age has a pronounced impact on sleep length in rotating shift workers (Åkerstedt and Torsvall, 1981b). Increasing age has some association with decreasing sleep length for workers on the afternoon/evening and night shifts, and increasing sleep length for workers on a morning shift. Similarly, Pavard et al. (1982) reported that sleep length may decline with age and the rate of decline has been shown to be the largest among the night workers.

The sleep length for female night shift workers is strongly influenced by added social burdens. The short sleep of these women has been associated with greater family responsibilities (Gadbois, 1981; Tepas et al., 1993).

Reduction in sleep length is associated with decrements in performance (Tepas, 1982b; Tilley and Wilkinson, 1984; Carskadon and Roth, 1991; Gillberg and Åkerstedt, 1994), decreased alertness (Carskadon and Dement, 1982), higher incidence of accidents and increased probability of precipitation of health problems among/ by night workers (Tepas and Mahan, 1989; Tepas et al., 1993). Changes in mood state, increased feelings of fatigue, sleepiness and irritability, inability to concentrate, and periods of misperception also occur on account of reductions in sleep length in night shift workers (Johnson and Naitoh, 1974; Rutenfranz et al., 1976; Åkerstedt and Torsvall, 1981a; Tepas et al., 1985; Williamson and Sanderson, 1986; Tepas and Carvalhais, 1990).

In many studies it has been demonstrated that rotational shift workers report more fatigue than do day workers (Åkerstedt, 1988; Alfredsson et al., 1991). Usually, the fatigue is particularly widespread on the night shift, hardly appears at on the afternoon shift, and is intermediate on the morning shift (Gupta and Pati, 1993). Kecklund et al. (1994) suggested that morning shifts (starting between 04:00 and 07:00) is usually perceived as extremely fatigue inducing. Rosa and Colligan (1987) demonstrated that the 12-h night shift produces higher ratings of fatigue than 8-h night shifts.
The shift workers have been shown to experience a number of psychological disturbances and family dysfunctions, as a result of which there is a serious impact on the family and social life (Mott et al., 1965; Rutenfranz et al., 1977; Froberg, 1981; Wedderburn, 1981; Åkerstedt, 1990; Chang et al., 1993). The irregular work hours affect the whole family: the worker, his/her spouse and children. The difficulties in social life are mainly due to a discordance between work schedules of shift workers and those of other day workers. Thus it is difficult for shift workers to participate in regular meetings and in other social events/activities (Mott et al., 1965; Carpentier and Cazamian, 1977).

It has been documented that various psychosomatic complaints are more common among shift workers (Koller et al., 1978; Knutsson et al., 1987; Oginska et al., 1993). However, there is no evidence that shift work is related to manifestation of psychiatric ailments. Shift workers also complain more frequently about depression, helplessness and stress. Healy and Williams (1988) and Healy et al. (1993) proposed that the psychosocial disruptions leading to depression, may produce a state of circadian disrhythmia and consequently it is likely to lead to helplessness type of cognition as a result of disturbances in neurovegetative functions. There are also common core complaints in shift work and depression, such as disturbed sleep, disturbed appetite, lethargy, apathy, poor concentration and neuroticism (Healy and Waterhouse, 1991). Any disorder related to shift work maladaptation syndrome lies at the core of the affective disorders. Thus it seems clear that the psychosocial dislocations, which depression brings about produce a dysrhythmia (Tsujimoto et al., 1990; Souetre et al., 1991).

An important relationship has been detected between night shift dose and psychosocial stress (Cervinka, 1993). Taking into account the worker's well-being and health, the result suggests that psychosocial and environmental stress factors at work act independently from shift-related stress factors. He also found a moderate correlation between night shift dose and other variables, such as stress at work, job satisfaction, and unspecific complaints. According to Frese and Semmer (1986) stress at work is an important predictor of ill health independent of shift work. They argue that the impact of stress at work (working conditions) other than shift work itself, on ill health, deserves more concern than what is being considered so far. Kandolin (1993) reported that female nurses in three-shift work experience more stress symptoms and often this leads to less
enjoyment in their work than women in two-shift work. Male nurses reportedly have the same amount of burnout and stress in both two- and three-shift work. It has also been noted that the early start of the shift puts the nurses under considerable stress (Bauer, 1993).

Of the mental health, it has been recently reported that I-shift workers enjoy more degree of positive mental health than the II- and III-shift workers. Further, positive mental health is better in II-shift workers than III-shift workers (Kumar, 1995). Also, positive mood ratings have been noted to be the lowest and negative mood ratings the highest on the night shift in firefighters and that the opposite are true on the afternoon/evening shift (Paley and Tepas, 1994). Of the profile on mood states, the scores for depression and fatigue have been found to be significantly higher after a night on call (Engel et al., 1987). Similarly, a decline in reaction time, and deleterious change in mood scales have been reported after a night of emergency admission call (Deary and Tait, 1987; Orton and Gruzelier, 1989).

Rutenfranz et al. (1976) proposed a model for the disease mechanism in shift workers. This model suggests that the major disease mechanism is brought about by disturbed circadian rhythmicity, which leads to stress. The stress reaction is responsible for complaints, such as lowering of well-being and probably adverse health states. The intervening variables, such as housing standards, sleeping conditions, the family situation, personality, and psychological adaptability are also responsible for such complaints. These intervening factors determine whether a particular person is able to cope with shift work successfully (Rutenfranz et al., 1981). Social environment may play a key role in an independent pathway, from shift work to disease (Akerstedt and Fröberg, 1976; Haider et al., 1988).

Chan (1994) has reported that about 20% of those who start shift work may find it difficult to continue in such work, usually due to social rather than medical reasons. Workers exposed to on-call shift work have also disturbed psychologic equilibrium and family and social life (Imbernon et al., 1993). Akerstedt (1990) indicated that shift work that involves night shifts strongly influences the psychology and psychophysiology of the individual.

Socially, the individual's opportunities are restricted from full participation in the social activities which are designed mostly for day time work. Aschoff et al (1971) have documented that social cues are of primary importance for retention
of the circadian rhythms. Giedke et al. (1974) have also suggested that the social zeitgebers are capable of sustaining human circadian rhythms. According to Barton et al. (1994) the change from a delaying to an advancing system results in an increase in sleep difficulties, but a decrease in social disruption. The decrease in social disruption has been thought to result from the specific sequence of the shifts and the discontinuous nature of the shift system, particularly, the long week-end off every third week.

The study conducted by Costa et al. (1989) indicates that the characteristics of flexibility of sleeping habits, ability to overcome drowsiness, and lower manifest anxiety, are associated with better tolerance to shift work.

The first ever study of shift work which included a participation of nurses for various variables like altered neurovegetative function, perceived criticism from others, sense of purpose and control, and psychosomatic complaints has exhibited a marked changes in all these variables. Subsequently these findings may have implications for circadian rhythm hypothesis of depression and also for a methodology for future studies on psychosocial variables in depression (Healy et al., 1993). In contrast, Skipper et al. (1990) have suggested that shift work is not significantly related to the nurses' physical health and mental depression.

PERFORMANCE

Global performance decrement is one of the harmful effects of shift work. In industries and factories, performance variables are of immense importance because they are related both to productivity and safety. The worker's inability to adapt to shift work schedule can lead to a loss of physical and psychological well being and can produce negative safety and performance consequences. These studies conducted in various laboratones demonstrated that performance deteriorates during the night time.

A number of studies demonstrate the presence of circadian rhythm in the performance variables (Aschoff, 1978; Monk, 1988; Pati and Saini, 1991; Gupta, 1992; Gupta and Pati, 1994b). However, the characteristics of circadian rhythm in performance depend upon the nature of task being performed (Folkard, 1990; Folkard et al., 1993). A circadian rhythm of performance in maximal speed of tapping and time estimation of 10 sec has been demonstrated (Aschoff, 1978)
According to Tilley et al. (1982) night shift work is associated with reduced reaction time and poor mental arithmetic on the night shift. A higher error rate in performing addition problems and fewer signal detections during the night shifts have been demonstrated by Tepas et al. (1981). Bjerner et al. (1955) reported that error in meter reading over a period of 20 years in a glass work has been shown to have a pronounced peak on the night shift. A secondary peak has also been reported during the afternoon shift. Browne (1949) showed that performance declines in telephone operators on night shift. Similarly, Hildebrandt et al. (1974) found that locomotive engineers fail to operate their alerting safety device more often at night than during the day, with a secondary peak around 15:00.

The results of our study conducted on shift working nurses clearly reveal circadian rhythm desynchronization in performance variables, viz., finger counting speed (FCS), random number addition speed (RNAS) as compared to diurnally working healthy human subjects (Pati and Saini, 1991; Gupta and Pati, 1994a). In case of RNAS, circadian mesor increased in shift workers as compared to control subjects. This suggests that shift workers take longer time than their day working counterparts to do the aforesaid jobs (Pati and Saini, 1991). Further, some authors have found a lower accident rate, a higher performance rating and a lower rating of effort in permanent night workers as compared with the rotators (Tasto et al., 1978; Jamal and Jamal, 1982; Coffey et al., 1988; Alward and Monk, 1990; Gold et al., 1992; Totterdell et al., 1994).

Poor sleep quantity (sleep deprivation) and quality have been considered as the key factors in modulating the performance of shift workers during the night shift (Koller et al., 1978; Ehret, 1980; Freese and Harwick, 1984; Siebenaler and McGovern, 1991; Harrington, 1994). Furthermore, in shift workers sleep deprivation and desynchronization of biologic rhythms lead to impaired physical performances (Smolensky et al., 1985). Performance decrement has been reported in nurses during the night shift although there has been no sleep deprivation in a study conducted by our group. Thus the results negate the hypothesis that implicates sleep deprivation or sleep debt as one of the major reasons for performance decrement (Gupta, 1992; Gupta and Pati, 1993). Could it be that sleep during the habitual timing, but not the length of sleep is imperative for normal human performance?

The circadian rhythm and sleep wake cycle are mainly related to the psychophysiology of shift work. People working either in rotating shifts or in a static/shift system have to work during the night at low phase of their circadian
rhythm. On retiring to bed although they fall asleep rapidly but are prematurely awaken due to the high phase of their circadian rhythm. This leads to severe sleepiness and reduced performance (Akerstedt, 1990).

The results of studies conducted by Gupta (1992) and Gupta and Pati (1994a) indicate that the shift rotation pattern is also important for normal performance. Studies on performance of shift workers working in three different type of rotational patterns revealed that 12 h night shift system for 15 consecutive days was the worst one as compared to other two shift patterns (Gupta, 1992; Gupta and Pati, 1994a).

In summary, the level of work performance efficiency on a night shift depends primarily upon several factors, namely (1) the demands of task; (2) the type of shift system and hence potential for both short and long term adjustment; (3) individual differences between shift workers in the degree to which their rhythms adjust to night work, and (4) sleep deprivation (Folkard and Monk, 1979; Vidacek et al., 1986; Phillips et al., 1991; Gupta and Pati, 1994a).

ON DUTY INJURIES AND/OR ACCIDENTS

Several studies have documented that accidents and injuries are imputed to sleep deprivation and disruption that occur on account of shift work (Moore-Ede and Richardson, 1985; Mitler et al., 1988).

Table 1.1. Time of occurrence of some major industrial accidents.

<table>
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<tr>
<th>Accidents</th>
<th>Time</th>
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<tbody>
<tr>
<td>Bhopai gas tragedy</td>
<td>Past-midnight</td>
</tr>
<tr>
<td>Chernobyl nuclear disaster</td>
<td>01:23</td>
</tr>
<tr>
<td>Three mile island incident</td>
<td>04:00</td>
</tr>
<tr>
<td>Rhine chemical spillage</td>
<td>Early morning</td>
</tr>
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</table>

A number of studies has demonstrated that the rate of serious accidents is higher at night (Table 1.1) than during the day (Tepas et al., 1986; Glazer, 1989; Folkard, 1990; Gupta, 1992, Harrington, 1994, Akerstedt, 1995). Furthermore,
it has been observed that despite considerable reduced traffic during night, single vehicle accidents occur past-midnight at a significantly higher rates (Harris, 1977; Hamelin, 1981, 1987; van Ouwerkerk, 1987). Studies conducted on train drivers also revealed that they tend to overlook and/or issue more warning signals during the night shift. Various kinds of industrial injuries have also been shown to be 2-3 times higher during the night shift as compared with the evening shift (Lee and Cho, 1982; Root, 1981; Levin et al., 1985; Leigh, 1986; Kreiger, 1987; Novak et al., 1990).

The accidents resulting in injury are more frequent in machine-paced workers at night (Smith et al., 1994). It seems likely that the higher rate of injuries at night necessarily reflect on the individual’s circadian rhythm in performance capabilities and alertness that on all probability failed to adjust sufficiently to the night shift (Folkard and Monk, 1979; Smith et al., 1994). Several authors have also found that the rate of accidents increases across 4-5 consecutive night shifts due to inadequate circadian adjustment, an accumulation of sleep deficits (Quaas and Tunsch, 1972; Vinogradova et al., 1975) and social factors (Monk and Wagner, 1989).

Most of the available accident data on night shift has been obtained in transport area. Most of these accidents are thought to be due to sleepiness associated with lack of alertness. With respect to air accidents Ribak et al. (1983) found that military air mishaps mostly occur in the early morning. Fatigue on account of improper work scheduling appears to be one of the most important causes of civil air transport accidents (Price and Holly, 1981). A number of spectacular nuclear accidents have been partly attributed to fatigue-inducing work schedules (Mittler et al., 1988).

In contrast, in some other studies the lowest number of accidents have been observed to occur during the night shifts with a slight increase in the probability of occurrence after midnight, however, despite of the lowest level of plant activity at that time (Wojtczak-Jaroszowa and Jarosz, 1987).

Some studies indicate that the number of injuries increases as the clock-hour progresses (Levin et al., 1985; Kreiger, 1987). Wojtczak-Jaroszowa and Jarosz (1987) went further to suggest that factors, such as increased worker’s activity or density may be of greater importance in the occurrence of an occupational injury.
It was noticed that a diurnal variation in the rate of accidents approximately parallel to the circadian rhythm of activity of the plant as a whole rather than to the activity of shift workers alone, with a peak at or around 11:00.

HEALTH PROBLEMS

It is well known that humans sleep during the night and remain awake and active during the day. Therefore, human mind and body have not been evolved to cope with the burden of shift work in night or in any other unsuitable and uncomplimentary work schedules. Shift work can lead to a host of problems attributed to the disturbances of the circadian system in some people. Health problems imputed to shift work can broadly be classified as: disturbances of sleep, impaired physical and psychological health, and disturbed social and domestic life. Rotational shift work in general and shift work during night in particular have been proposed to be detrimental for human health by way of temporal dysfunction of human biological clock. According to several authors the circadian physiological rhythms of shift workers seldom adjust completely to the night shift (Dahlgren, 1981b; Knauth et al., 1981; Knauth and Rutenfranz, 1982; Åkerstedt, 1985; Hildebrandt et al., 1987; Folkard, 1988; Czeisler et al., 1990; Eastman, 1990). The phenomenon of aging has been found to aggravate the adverse health effects of shift work, the critical age being on an average 40-50 years (Hakkinen and Vuokko, 1968; Koller et al., 1978; Åkerstedt and Torsvall, 1981b; Foret et al., 1981; Harmä and Ilimarienen, 1987). A deterioration in health has also been noticed after many years of shift work in some shift workers (Angersbach et al., 1980; Costa et al., 1981; Kundi et al., 1986). Koller (1983) has distinguished shift workers from day workers in that the health problems appeared earlier among the former than among the latter.

CARDIOVASCULAR COMPLICATIONS

In industrialized countries, one of the most commonest causes of death is cardiovascular disease. Several studies have reported circadian periodicity in myocardial infarctions (Myers and Dewar, 1975, Pedoe et al., 1975, Reinberg and Smolensky, 1983; Muller et al., 1985), angina pectoris (Valle et al., 1988) and sudden cardiac death (Willich et al., 1987) with a peak in the morning hours. A secondary peak in the late-evening hours has also been observed by these authors. These findings provide some support for the hypothesis that a rhythmic
increase in coronary tone or coronary spasm that occurs in the morning could be responsible for the increased incidence of acute symptoms of coronary heart disease (CHD) (Muller et al., 1985).

Knutsson (1989) found a higher risk of cardiovascular disease among shift workers as compared to day workers. Similar findings have been documented in some other studies (Alfredsson and Theorell, 1983; Akerstedt et al., 1984; Alfredsson et al., 1985; Moore-Ede and Richardson, 1985; Tuchsen, 1993; Chan, 1994; Harrington, 1994).

Koller et al. (1978) carried out a cross-sectional study of a sample of the employees at an Austrian oil refinery and they have reported a higher prevalence of cardiovascular symptoms and complaints among the shift workers. The morbidity for disease of the circulatory system has been reported to be 20% in shift workers, 7% in day workers and 15% among ex-shift workers. The difference has been shown to be statistically significant between shift workers and day workers. Similarly, Angersbach and co-workers (1980) have found a slight but nonsignificant excess of cardiovascular disease (CVD) morbidity among shift workers. The incidence has been noticed to be 14.8% for the day workers and 16.8% for the shift workers.

Koller (1983) has reported a dose-response relation between years of shift work and cardiovascular disease in oil refinery workers. Results obtained by Knutsson et al. (1986) indicated that shift work is associated with increased risk of ischemic heart disease (IHD), at least during the first two decades of shift working. The association is independent of age and smoking habits. The relative risk of IHD has been noticed to fall sharply after twenty years of shift work. In case of female shift workers exposure to 6 or more years of shift work may increase the risk of coronary heart disease (Kawachi et al., 1995).

There are several factors that may increase the risk of developing cardiovascular diseases. The major risk factors for CVD are: smoking, hypertension and high blood cholesterol. Knutsson and Zamore (1982) and Koller et al. (1978) have demonstrated an increased prevalence of risk factors for CHD in shift workers. Similarly, an association has been witnessed between hypertension and shift work (Knutsson and Zamore, 1982; Lang et al., 1988).
However, in the contrary, results of several studies do not indicate that high blood pressure is more common among shift workers (Knutsson et al., 1988; Knutsson, 1989).

Several studies demonstrated that smoking habit seems to be more common among shift workers than among day workers (Angersbach et al., 1980; Knutsson and Zamore, 1982; Rosen et al., 1987; Knutsson et al., 1988; Knutsson, 1989). One possible explanation for this smoking behaviour may be that a predilection for a smoke is influenced by the working hours, perhaps as a stimulant or as a way to pass time during the night shift. Shift schedules may also influence the smoking behaviour and the latter makes a shift worker more prone to cardiac complications (Williamson and Sanderson, 1986).

The cholesterol level has been witnessed to be higher in shift workers as compared to day workers (Thelle et al., 1976). De Backer et al. (1984) found that workers with the most irregular working hours may tend to have significantly higher total cholesterol. Knutsson (1989) has also found higher total cholesterol levels in shift workers than day workers, but the differences seem to be small and statistically insignificant. Furthermore, high serum triglyceride levels have been shown to be more prevalent among the shift workers than the day workers (Thelle et al., 1976; Knutsson and Zamore, 1982; Orth-Gomer, 1983; Knutsson et al., 1988; Knutsson, 1989; Roman et al., 1992). Several authors have concluded that the level of serum triglycerides is a risk factor for coronary artery disease (Carlsson and Bottiger, 1972, 1981; Carlsson et al., 1979). Also, it has been found that rotating shift workers have abnormally elevated norepinephrene levels which if not controlled, may lead to higher cardiovascular risks (Ely and Mostardi, 1986).

Lennernäs et al. (1994) documented that dietary intake is lower during night shifts than during morning shifts and afternoon shifts. According to them the redistribution of food intake from diurnal eating to nocturnal eating is related to serum total cholesterol, LDL cholesterol and HDL cholesterol, which might increase the risk for cardiovascular diseases. Even if the dietary intake and quality is similar in day workers as well as shift workers, there are still differences in eating habits that might contribute to differences in levels of serum lipids (De Backer et al., 1987; Roman et al., 1992). This makes night workers vulnerable to the risk for cardiovascular diseases (Knutsson, 1989; Tuchsen, 1993) Fujiwara
et al. (1992) found that sleep factors, namely the onset of sleep and/or the total sleep length seem to be more potent in modifying the circadian rhythm of serum cortisol specially in night shift workers. It has been documented that circadian rhythms in serum cortisol and urinary free adrenaline disappear in workers while on night shift (Fujiwara et al., 1992).

Most of the studies discussed above show some or the other relation of cardiovascular diseases with shift work. This means that the harmful effects of shift work on health have to be regarded as more serious than has previously been thought.

GASTROINTESTINAL COMPLICATIONS

It is well known that the dietary intake is of immense importance to nutritional status and health (Gibson, 1990; WHO, 1990). In addition to a balanced intake, also the time of the day for consumption and the frequency of intake may be equally important. In fact, the time of the day for consumption may affect uptake, digestion and metabolism depending on the phase of individual’s circadian rhythms (Malmlöf, 1986; Halberg, 1989; Méjean et al., 1992; Moore, 1992). Meal timing is considered as an important socio-environmental synchronizer of the circadian rhythms and influence human metabolism: the temporal distribution of food intake has also an influence on human performance (Graeber et al., 1978; Costa et al., 1987).

Rotating shift work has well known harmful effects on human health and well-being. It disturbs sleep, wakefulness, eating patterns, social life and in the long run, often results in gastrointestinal diseases. Several authors have documented an association between shift work and gastrointestinal disorders (Angersbach et al., 1980; Costa et al., 1981; Rutenfranz, 1982; Rutenfranz et al., 1985; Gaffuri and Costa, 1985; Brief and Scala, 1986; Knutsson et al., 1990). This association may be mediated by many factors. One may be the irregular eating habits of shift workers, since there are some indications that the temporal distributions of food intake as well as the qualitative and quantitative food intake may affect health (Reinberg et al., 1979; Armstrong, 1980; Adams and Morgan, 1981; Lennernas et al., 1985, 1987; Verbeke-van de Venne and Westerterp, 1991; Moore, 1992). It can be argued that the gastrointestinal disturbances result from eating food at wrong time with abnormal patterns of gut
motility and gastric acid secretion being likely (Lenzi et al., 1985; Kumar et al., 1986). No doubt this is a factor, but other possibilities include: the lack of provision of hot food at night so that there is a reliance on sandwiches, etc.; the tendency to nibble rather than take full meals; the higher intake of carbohydrate, caffeine and alcohol, and the higher consumption of tobacco. All of these changes have been observed in night workers and might play some role in increasing the prevalence of gastrointestinal disorders (Folkard et al., 1985). Gastrointestinal complaints of gastric upset, disturbed appetite, gas, constipation, diarrhea, poor eating, dyspepsia, epigastric pain, gastroduodenitis, peptic ulcer etc. are strongly correlated with shift work in a number of studies (Aanonsen, 1964; Kolmodin-Hedman and Swensson, 1975; Andlauer et al., 1979; Shift Work Committee, 1979; Costa et al., 1981; Moore-Ede and Richardson, 1985; Brief and Scala, 1986; Reinberg, 1986; Kalterma et al., 1990; Mazzetti et al., 1990; Oginska et al., 1993; Chan, 1994). However, there are contradictory reports suggesting no links between shift work, eating habit and associated complications (Debry and Bleyer, 1972; Roman-Rousseaux et al., 1986; Lennernäs et al., 1990; Tepas, 1990).

Shift work causes a prominent change in the pattern of secretion of gastrin/acidopepsin (Tarquini et al., 1986). This may be one of the causes of more frequent occurrence of peptic ulcer disease in night workers than in day workers. An earlier occurrence of gastrointestinal disease have also been reported among rotating shift workers than among day workers (Angersbach et al., 1980).

Furthermore, several studies have indicated that shift work is associated with disturbances in nutrient intake, both regards to the sequence and time of meals and the composition of the food (Reinberg et al., 1979; Lennernäs et al., 1985, 1987). The reported poor eating satisfaction in shift workers (Duchon and Keran, 1990) probably reflects irregular meal times rather than malnutrition.

Nocturnal eating in connection with night work might have negative consequences in terms of metabolism due to circadian rhythm factors (Armstrong, 1980; Halberg, 1989; Méjean et al., 1992; Moore, 1992; Strubb, 1994; Lennernäs et al., 1994, 1995). Thus frequent night eating to be related to undesirable metabolic effects, for example, increased levels of serum lipids or an increased body mass index in shift workers.
Armstrong (1980) speculated that an early night meal and early morning meal might disturb the overall circadian rhythmicity of the anabolic and catabolic processes which maintain constant phase relationship with the cycle of sleep wakefulness. This phenomenon might, in turn, causes an imbalance in the endocrine rhythms associated with fat metabolism. Shift work unequivocally upsets the temporal distribution of meal timings, which in turn may act unfavorably both on the digestion and the psychophysiological conditions (Rutenfranz et al., 1977; Angersbach et al., 1980; Costa, 1984). Meal timings have also been known to act as a powerful synchronizers of circadian rhythms in various physiological functions.

According to Costa et al. (1989) subjects with digestive disorders (gastroduodenitis, peptic ulcer) show a greater phase shift and a reduction of the amplitude on night-work, suggesting a possible relationship between the short-term circadian adjustment and the long-term tolerance to shift work.

SHIFT WORK AND PERSONALITY

There are two identified species of people in this world: Homo larkensis (better known as the lark people or the morning types) and Homo owlensis (also referred to as the owl people or the evening types) (Minors and Waterhouse, 1989). These are called the chronotypes and are identified in the local population by their peak phase of body temperature. Some workers have also specially designed inventories for identification of different chronotypes in the population (Östberg, 1973; Gupta and Pati, 1995).

In this context circadian rhythm in body temperature assumes significance specially because it has been considered as a marker rhythm for several other rhythmic functions in humans (Reinberg et al., 1980, 1983, 1984; Motohashi et al., 1987). The body temperature rhythm has also been shown to vary as a function of morningness and eveningness. According to the time of going to bed and awakening time the owl people go to bed almost past midnight while the lark types go to sleep around 22 h or even earlier than this. In contrast, as the day proceeds a subtle change slowly becomes evident in both species. The lark people show signs of fatigue first Alert and sharp in the morning, they begin to slow down and ease up as sunset approaches. The owl persons on the other hand have a long way to go still.
According to Minors and Waterhouse (1981) the metabolic effects of eating during different times of the day might also be related to the chronotype. Individual differences, for example being morning active or evening active types, can explain some of the variation in adaptability to shift work (Kleitman, 1963). Evening types appear to experience fewer problems in adapting to night work (Ostberg, 1973; Fiala and Klepac, 1988). According to Akerstedt (1990) older age and morningness personality are related to higher than average problems in adjusting to shift work. Breithaupt et al. (1978) observed that it is predominantly morning types who react to late shift work with sleep deficiency and its accompanying pathological symptoms. According to them it is not that morning types have a less efficient adaptive capacity than evening types, but rather the evening types have a constitution which is inherently less vulnerable to delayed sleep, simply because of their delayed circadian phase position (Breithaupt et al., 1978).

A population study conducted earlier which included 582 subjects, those representing human population living in hot and dry tropical climatic conditions revealed that 75%, 16% and 9% have been found to be morning active, evening active and intermediate type individuals, respectively (Gupta and Pati, 1995). With regard to phase position of the circadian rhythms a statistically significant difference has been witnessed in oral temperature, heart rate, and random number addition speed rhythms (Gupta and Pati, 1994b). The acrophase timing of oral temperature rhythm in evening active individuals has been located in the late evening hours (around 19.4 ± 0.55 h). It has been observed that the morning active individuals have their peak about 4.9 h earlier (14.5 ± 0.65 h) than their evening active counterparts (Gupta and Pati, 1995). It has also been witnessed that the morning active subjects remain at their best between 8.6 - 10.7 h with reference to the performance variable, random number addition speed, whereas, evening active subjects remain at their best between 16.9 - 20.2 h, approximately six hours later.

By the differences in their time of awakening and going to bed time Folkard (1990) suggested that it would seem that in situations where safety is paramount the solutions to the problems of shift work adaptation is the creation of nocturnal sub-society that are not only always work at night but also remain on a nocturnal routine on rest days. This seems impractical to some extent because this suggestion advocates creation of a sort of isolated world for a human sub-population of desired dimension. It is almost certain that the suggestions of Folkard (1990) if implemented would invite enumerable social and psychosocial complications. It is indeed difficult to locate any perspective subscribers for Folkard's doctrine.