Better shift systems?

There is probably no such thing as a "good" shift system. However, according to Ronny Lardner and Bob Miles, some are better than others

Prior to embarking on their careers in industrial psychology, Lardner and Miles both worked shifts, one as a police officer and the other as an aircraft fitter. Lardner worked a traditional 28-day cycle continental shift system (see Table 1b, p29). The system was easy to administer, but had major drawbacks for quality of sleep, fatigue and social life.

Through studying industrial psychology he learned that, from an ergonomic viewpoint, this widely-used shift pattern was arguably the worst possible design. So what would an "ergonomic" shift system look like, why would it be better, and what evidence is there to support adoption of such systems in process industries?

The fundamental problem is that people were not designed to work at night. Throughout evolution we have been subject to only minor variations in day length, and have had whole seasons to adjust. The exceptions to this rule are shiftwork and jet travel, which require us to make massive and rapid
adjustments to day length and timing.

Ergonomics and shiftwork

Ergonomics is the science of the "fit" between jobs and people, taking in to account the demands of work and individual anatomy, physiology and psychology. Like an ergonomic chair, an ergonomic shift system must optimise functionality for the organisation and comfort for the user. The continental shift system described above did not meet the latter criteria.

Job and organisational demands

The first question to be addressed is what type of work needs done, and when? Does workload vary over the day, week or year? Can some tasks be so organised that the need for shiftwork is eliminated, for example scheduling routine maintenance during the day?

An interesting and creative international example of designing out the need for shiftwork is the re-routing of customer service and product support enquiries to the time zone and part of the world where staff are working during the day.

Identifying and quantifying the non-negotiable workload and manning parameters sets the limits within which a new shift system can be designed.

Circadian rhythms

Many human physiological and psychological functions follow a circadian cycle (*circa* = about, *dies* = day). For example, in a dayshift worker alertness and body temperature fall during the night to a low at about 4am and then begin to rise. Many night-shift workers will recognise this low point, which can be particularly acute during the first couple of nightshifts before body rhythms begin to adjust to nightwork.

When people work during the night, it takes time for their circadian cycle to adjust — in other words to "shift" by 12 hours so they can sleep during the day and be more alert at night. Thus people feel more adjusted to night work at the end of a week of nightshift. It seems likely that adjustment is always only partial, and that full adjustment is not achieved on any shift system. The downside of becoming progressively more adjusted to night work is that a period of readjustment is required at the end of a long period of nightshift, which typically takes place on rest days. A further consideration is that nightworkers typically have a shorter sleep duration than dayworkers, therefore a sleep deficit can build up over a long period of successive nightshifts.

Two solutions are theoretically possible to overcome the problem of adjustment/readjustment of circadian rhythms: permanent nightwork, with workers remaining on nightshift hours during their rest days, and a quickly-rotating shift system in which workers do not adjust to night work, and therefore do not have to readjust to a day routine. There is sure to be a shortage of volunteers for the first option, but the second is feasible.

The direction in which a shift pattern rotates is also important. Experimental studies in sleep laboratories have deprived people of the many cues used to judge time of day such as daylight, clocks and routine activities. In such circumstances, individual circadian rhythms conform to a 25-hour cycle, not a 24-hour cycle. Thus it seems the body prefers to follow a shift

system which progresses forwards in time (morning/evening /night).

To fit with circadian rhythms which are embedded in our physiology, an ergonomic shift system would:

- minimise night work;
- rotate quickly to minimise adjustment/readjustment;
- rotate in a forward (early/late/night) direction.

People can be categorised as larks (early risers) and owls (late risers). These individual differences play a significant part

in individual adaptation to shift patterns, and appear very stable over time. It is also becoming clear that individuals vary as to how quickly they can adjust their body clocks. Those who adjust quickly have less difficulty with several successive night-shifts as they can adjust/re-adjust readily at the start and end of each week. Those who adjust slowly may cope better with a fast-rotating shift system as they never fully adjust, and stay largely fixed on normal time. The lesson to bear in mind is that there may be deep-rooted physiological reasons why two individuals may prefer different shift patterns.

Social demands

People value certain blocks of time more than others. Evenings and weekends are highly valued for family, social and cultural activities. Yet with many shift systems such quality time is either in short supply, or comes all at once.

For example, a continental shift system may involve seven nights, two rest days, seven evenings, two rest days then seven earlies and a weekend off. The shiftworker is virtually excluded from free evenings and weekends for 16 days, and is tempted to make up for this by burning the candle at both ends when on early shift, resulting in increasing levels of fatigue as the early shift week progresses. This can be exacerbated by an early start time on the morning shift, as a 7am start means a 5.30am rise to eat, dress and travel.

From a social viewpoint, an ergonomic shift system would need to:

- maximise free evenings, Saturdays and Sundays;
- avoid a very early start on morning shift.

The principle adverse effect of shift systems on performance is via the influence of circadian performance rhythms being at a low point, difficulty in staying awake and cumulative sleep deficit.

Few shift workers fully adjust, and performance on a variety of tasks drops during the night. As previously mentioned, alertness is at a low around 4am, and people experience difficulty staying awake, particularly if their work involves passive monitoring of machinery or displays. The average sleep duration reported by individuals taking part in a large US health study was eight hours. By contrast the average day-sleep duration from studies of nightworkers on various types of shift systems ranges from 5.8-6.7 hours. Disrupted circadian rhythms and interruptions and noise when trying to sleep during the day account for much of the difference in sleep duration. There is some evidence that shift workers increase their sleep length on rest days to "recover" their sleep deficit.

Length of night shift is also relevant when considering performance. For example, a recent study[1] compared chemical workers on eight and 12-hour shifts. 12-hour shiftworkers' ratings of alertness were significantly lower towards the end of the night shift than those of colleagues working an eight-hour night shift. Night shift is often seen as being the only "problem shift" for sleep loss.

Table 1a: An ergonomic shift system, nine-week cycle. Note that forward rotation of shifts fits with body clock, free time on Saturdays and Sundays is maximised, there are at least three evenings off every week and the 7am start time minimises sleep deprivation

Week	Day of week: M	T	W	T	F	S	Su
1	M	L	L	N	N	-	-
2	-	M	M	L	L	N	N
3	-	-	-	M	M	L	L
4	N	N	-	-	-	M	M
5	L	L	N	N	-	-	-
6	M	M	L	L	N	N	-
7	-	-	M	M	L	L	N
8	N	-	-	-	M	M	L
9	L	N	N	-	-	-	M

Key
M Morning shift, 7am-3pm *L Late shift, 3pm-11pm*
N Night shift, 11pm-7am *- Day off*

Table 1b
Traditional continental shift system, 28-day cycle. Note slow rotation with problems of adjustment and readjustment of body clocks, 16 consecutive days on anti-social shifts with little respite, seven consecutive early rises (4.30am-5am), and backward rotation which does not fit into body clock

Week	Day of week: M	T	W	T	F	S	Su
1	N	N	N	N	N	N	N
2	-	-	L	L	L	L	L
3	L	L	-	-	M	M	M
4	M	M	M	M	-	-	-

Key
M Morning shift, 6am-3pm *L Late shift, 3pm-11pm*
N Night shift, 11pm-7am *- Day off*

As we have seen, social pressures to burn the candle at both ends can result in cumulative sleep deficits with a succession of very early rises. Not only are many shiftworkers unwilling to go to bed early to ensure sufficient sleep before a very early morning start, there is a "forbidden zone" around 9pm during which it is very difficult to initiate sleep.

The so-called "quick turnaround" which features in some shift systems presents another source of fatigue. Typically workers will move from working an evening shift one day to morning shift the next day, with a maximum of eight hours off duty. When travelling, unwinding and eating time are subtracted, a maximum of 5.5-6 hours is left for sleep.

To address these performance problems, five features would need to be built into an ergonomic shift system:

- minimum use of night shifts;
- quickly rotating shift systems which help prevent cumulative sleep deficits;
- avoiding use of long (12-hour) shifts;
- designing out quick changeovers;
- not scheduling very early start times on morning shifts.

Practical applications

This all sounds good in theory. What would an ergonomic shift system look like, and would people prefer it in practice? Table 1a (p29) presents an example ergonomic shift system, and shows how it embodies the features described. This can be contrasted with a traditional continental shift system in Table 1b. Remember both can deliver the same number of people on the ground for the organisation

An important point to bear in mind is that there is not one ergonomic shift system. Rather there are examples which do or do not conform to ergonomic criteria. The temptation to pick a new system for your organisation from a range of examples used elsewhere should be avoided. Start with what the business needs, add in the ergonomic criteria listed in this article, consult with end-users and develop a system suited to the organisation and the end-users.

The acid test

So what happens when such systems are tested by that most critical of audiences, the shiftworker? German research with 26 separate groups of shiftworkers in a range of industries, including chemicals, oil-refining and other process industries, has recently been published[2].

These studies carefully measured sleep and social problems and self-reported health under "traditional" shift systems, then repeated these measures after introduction of a variety of quickly-rotating shift systems designed according to ergonomic criteria. In most cases the measures either improved or remained constant. The most striking results were obtained after a 6-12 month trial period, when workers voted whether to retain the new shift system or return to the *status quo*. With two exceptions, an average of 90% of the workforce voted to retain the new system. Two groups voted to retain the new system by much narrower majorities, 54% and 59% respectively. Perhaps significantly, both of these groups had not been consulted or involved in the design of the new shift system.

Recent UK Health and Safety Executive-sponsored research by Oxford University has shown that giving workers a say in the choice of shift pattern significantly increases their satisfaction with the pattern chosen.■

Further reading

1. *Comparison of eight and 12-hour shifts* by P Tucker *et al*, *Occupational and environmental medicine*, 1996:53, 767-772.

2. *Designing better shift systems* by P Knauth in *Applied ergonomics*,1996:27(1): 39-44.

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Mini survey

Which aspects of industrial psychology are of most interest to you (please tick):

- ❑ selecting the right staff
- ❑ safety culture
- ❑ human error
- ❑ workplace stress
- ❑ what really motivates staff
- ❑ training and development
- ❑ competencies
- ❑ career changes
- ❑ management of safety
- ❑ other (please fill in)

Please return completed mini-survey to Sean Ottewell at *TCE*, 165-189 Railway Terrace, Rugby CV21 3HQ, fax 44 1788 547262