Fatigue Management in 12-hour Shift Operations

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Abstract

The adoption of 12-hour shift operations has been widespread in many 24-hour industrial work environments. This move has fatigue implications that must be understood and considered when staffing, training and scheduling personnel. This presentation will highlight the pros and cons of the 12-hour shift and describe strategies to ensure levels of fatigue risk that are acceptable to all stakeholders. The importance of striking a balance between personnel needs and operational requirements will be discussed. An overview of the role of fatigue risk management systems will also be presented.

1. Introduction

The move to 12-hour shifts has been very popular in the power and petroleum industries, to the point where it is almost universal. Over the last decade many articles have been written reporting on research that has investigated the safety and effectiveness of 12-hour shifts [1], [2], [3], [4], [5], [6], [7] [8]. Every one of these articles dealt with different 12-hour shift structures and arrived at varying results. Comparisons between 8-hour and 12-hour shifts [9], [10], [11], [12], [13], [14], [15] also showed different results, again examining shift structures that were not comparable between studies. This makes reviewing the literature difficult, but still very useful. Generally, workers love the 12-hour shifts, but the negative effects of these shifts on health and performance may still be of concern. Most of the authors caution that the structure and management of the shift is the key to its success.

2. Studies on 12-hour shifts

The literature mostly supports the adoption of 12-hour shifts but there are interesting caveats that may be of importance to those applying these shifts. Firstly, many of the researchers caution that it will depend on how the shifts are implemented. If the work involves high workload, the longer shift will lead to increased levels fatigue and potential for error and injury toward the end of the shift, particularly for older workers [1], [4], [11]. Very low workload may also pose a risk toward the end of the 12-hour night shift as well, due to the effects of increased sleepiness due to inactivity [11] and the alertness nadir that occurs near the end of the night shift. Secondly, the structure of the shift will also determine the impact of the shift on personnel. Working two 12-hour days/nights, then having three or four days off, before returning for another two opposite shifts (i.e. 2 on - 3 off - 2 on, 4 off, etc.) allows plenty of time to pay back any sleep debt and attend to domestic responsibilities that would cut into the between shift rest period. Alternatively, working for 4 or five days or nights in a row, and then getting the equivalent number of days off will cause greater disruption to the biological clock and could result in a larger sleep debt, particularly on nights [1], [5]. The first couple of days off will likely involve paying back this sleep debt, again particularly following a string of night shifts. However, this will depend on whether personnel can obtain enough restful day sleep during their time off between night shifts.

3. Studies comparing 8-hour and 12-hour shifts

Most studies examining the impact of a change from an 8-hour to a 12-hour shift found that very little difference in sleep quality, performance, and sleepiness [4]. Earlier studies did find that these factors were worse for 12-hour shifts at both the beginning of the implementation of the change, and three to five years later [16]. Some studies have indicated increased stress on 12-hour night shifts [2], alertness and mental performance decrements for nuclear power plant operators working 12-hour shifts [9], and increased sleepiness over the course of the shift cycle [5]. Reviews of the literature [4], [8] have shown that the variation in schedules when comparing 8-hour to 12-hour schedules can lead to equivocal results. Comparisons of an eight-hour schedule that starts very early in the morning (e.g. 05:00) to a 12-hour schedule that starts at 07:00 often shows higher levels of sleepiness, fatigue, and errors on the 12-hour shift [6]. An eight-hour shift also requires more shift changeovers and this can increase the number of changeover-related errors [4]. Other explanations for the 12-hour shift lacking any increased levels of sleepiness and decreased operator performance include:

- more continuous time spent at the plant during maintenance operations, improving the operator's understanding of the flow of maintenance tasks and their effect on the plant's configuration;
- less disruption to the body's biological rhythms where, for example, the change involves moving from 5 days/nights per 7-day work/rest cycle to 2 days/nights per 7-day cycle;
- more time available between blocks of shifts for recovery (i.e. more than 48 hours).

12-hour shifts also received greater support from personnel because the longer shift allows them much more time off to engage in off-duty activities. Employees found that they were less stressed, could plan off-duty activities more easily, felt that they were more able obtain restful sleep, and that it was easier to keep fit and eat more healthily [12].

On the negative side personnel found that the longer shift did cause a greater level of afternoon sleepiness [7] possibly due to a larger sleep debt as compared to that measured while employees were working the 8-hour shift. Other problems included more fatigue effects on the 12-hour shift if prior sleep was curtailed and the sleep debt high [10], and monotonous work while working a 12-hour day shift resulting in the same level of sleepiness as found when subjects are carrying a moderate sleep debt [16].

4. Canadian Nuclear Power Experience

A number of studies have been conducted for the Canadian nuclear industry investigating the impact of 12-hour shifts on operators. The earliest study of the impact of 12-hour shifts on the performance of nuclear power plant operators was conducted by Ontario Hydro, who found that no increase in errors had occurred [17]. Smiley and Moray [18] conducted a study of 7 years of abnormal event data and could not find any increase in errors or degradation in performance of operators following the introduction of the 12-hour shift at Canadian nuclear power generating stations. A more recent study [19] applied a subjective pre/post protocol for a change from 8.5-hour shifts to 12.5-hour shifts evaluating several measures including operator performance, well-being, health, job satisfaction, sleepiness, alertness, and sleep quality and duration. The results indicated that in most measures the 12-hour shift showed no decrements and in some cases, improvement, but subjective sleepiness and subjective job performance were less favourable for the post responses than the pre-change responses.

5. Pros and cons for 12-hour shifts

Figure 1 lists the pros and cons for 12-hour shifts (derived from Wedderburn [1]). It is important to consider that the structure of the shift and implementation will determine its success with personnel and the company. There are many poor 12-hour shifts that will fatigue operators and increase safety risk. It is best to conduct a risk assessment on the various shift structures under consideration or consider one that is already shown to pose a low risk. Every operation will be different such that a participatory approach is best to ensure that the schedule(s) chosen for trial will meet the needs of all of the stakeholders. The most effective way to ensure that the schedule will provide the lowest risk to the operation is to implement a fatigue risk management program where all stakeholders receive training in fatigue management and develop the policies, practices, and strategies that will support the new scheduling.

Pros

- More biocompatible
- Longer blocks of time off
- Better health, well-being, and job satisfaction
- Lower commute frequency
- Less changeovers
- Less time away from plant between shifts
- Symmetry in crew arrangements

Cons

- Longer work day
- Shorter window for commuting, socializing, and sleeping during work cycle
- Not as suitable as shorter shifts for high workload or physical work
- Increased per-shift exposure to environmental stressors
- Greater opportunity to moonlight
- May not appeal to spouse
- Longer time away from day-to-day when on days off

Figure 1 List of pros and cons for 12-hour shifts

6. Strategies for making 12-Hour shifts work best

The following list includes some strategies that may help make the transition to a 12-hour shift more effective and safer:

1. Keep the number of consecutive night shifts to a minimum (max. 4, preferably three or less)
2. Schedules should limit number of consecutive days off
3. Try to ensure everyone gets an equal # of weekends and weekend days off
4. Better to have at least two full nights of recovery sleep after a series of nights before switching to the day shift
5. Use as much symmetry as possible for crews – i.e. same two crews handover to each other
6. Match shift length to workload – moderate workloads for longer shifts – extremely low or very high workloads not suited to longer shifts
7. Ensure start/end times allow a safer commute (i.e. days start after 07:00)
8. Provide napping facilities so that sleepy personnel can have a planned nap before heading home, particularly for those living long distances from the plant
9. Consider the length of the employees' commute times
10. Consider the age and health of personnel – older, less healthy personnel may not be able to perform well on longer shifts
11. Go carefully and involve all of the stakeholder groups
12. Review the success of the schedule with the stakeholders

7. Examples of 12-hour shifts.

Although many 12-hour shifts exist only some actually are biocompatible (i.e. work with the human body's rhythms). The strategies listed above can help make the shift biocompatible without making it impossible to implement. Here are a few examples of 12-hour shift patterns:

I. 2 on – 5 off / 2 on – 2 off / 3 on – 4 off / 3 on 2 off
II. 2 on – 2 off / 2 on - 3 off quick rotating
III. Dupont shift (4 on – 3 off – 3 on – 3 off – 4 on – 7 off)
IV. 4 on - 4 off / 3 on - 3 off moderate rotating

The first and second shift patterns are the best for biocompatibility, while the last two are moderate. However, some aspects of these shifts are less compatible with the operation. For example, the Dupont shift allows too many days off at the end of the pattern. Operators lose touch with the plant upon their return to work after 7 days. They feel out of the loop after being away from work for too long. The last shift pattern has four nights in a row. By the fourth night considerable sleep debt has built up and the first two days off are spent recuperating and adjusting (i.e. paying back the debt and adjusting for the change to the upcoming day shift).

Ideally, a compromise that is both biocompatible and operationally feasible will likely be accepted by all of the stakeholders more readily. Of course the key is to involve members of each stakeholder group when designing schedules. It also is wise to use a software package that provides analyses of the schedule over the long term and assesses the levels of fatigue risk that can build up over time.

8. Managing Fatigue Risk

Fatigue risk must be managed. This involves reducing the levels of fatigue in plant personnel, and improving the work environment to accommodate those who are fatigued. This is a very tricky balance that must be handled properly so that all personnel can work safely and still retain their health. Getting good sleep is a key prerequisite. Providing the opportunity for good sleep is also a key component. However, recognizing that operators cannot always get the full eight hours they need, such as during strings of night work, the design of equipment and the working environment must be such that it does not add additional stressors to the situation. Workload, lighting, equipment design, procedures, and additional support (napping rooms, availability of nutritious food, opportunity to exercise, etc.) all will contribute to how well personnel will function during longer shifts. Identifying sleep disorders, informing personnel of the importance of good sleep and how to get it, and helping management develop the facilities and support that personnel need to maintain their performance over the long haul, will help ensure that personnel will be able to perform well and stay healthy.

8.1 Fatigue Risk Management Programs

Fatigue risk management programs (FRMP) or systems are not a new idea. Many industries have implemented these programs in some form or other, with varying degrees of success. It has become evident that the more integrated and complete the program, the more effective it will be [20], [21]. A comprehensive program to manage fatigue, integrated into the way the company does business will be enduring and effective. Just making everyone aware of the dangers of fatigue will not be effective if there are no policies, procedures, or facilities in place to support good fatigue management practices.

8.1.1 Experience of other industries

The trucking, aviation, marine, petrochemical, and mining industries have a long history of developing and nurturing fatigue management systems and programs. These industries have learned a great deal of what works and the effectiveness of good strategies. They have also seen the value of such programs.

8.1.2 Benefits of managing fatigue

Managing fatigue will help:

- Reduce errors
- Improve quality
- Improve productivity
- Reduce lost time illnesses and injuries
- Improve system, worker, and public safety

8.1.3 Risk-based approaches

A fatigue management approach should be risk based and auditable. The workloads and criticality of tasks and consequences of errors made by personnel should be considered when scheduling personnel. The FRMP should include benchmarks for fatigue levels imposed by schedules, amount and quality of sleep personnel obtain, measures of performance and job satisfaction by personnel, and measures of corporate support and benefits. Questionnaires can be used to find out where problems may be occurring or where improvements should be considered. The program should be evaluated using the benchmarks to provide information on how well the program is working and where changes are necessary.

9. References

[1] Wedderburn, A., *Compressed Working Time*, European Foundation for the Improvement of Living and Working Life: Bulletin of European Studies on Time (BEST), Number 10, 1996.

[2] Ognianova, V.M., Dalbokova, D.L., and Stanchev, V., Stress states, alertness and individual differences under 12-hour Shiftwork, *International Journal of Industrial Ergonomics*, Vol. 21, iss. 3-4, 1998, 283-292.

[3] Smith, L., Hammond, T., MacDonald, I., and Folkard, S., 12-h shifts are popular but are they a solution?, *International Journal of Industrial Ergonomics*, Vol. 21, iss. 3-4, 1998, 323-332.

[4] Smith, L, Folkard, S., Tucker, P., and MacDonald, I., Work shift duration: a review comparing eight hour and 12 hour shift systems., *Occupational Environmental Medicine*, Vol. 55, 1998, 217-229.

[5] Rosa, R. and Colligan, M., Long workdays versus restdays: Assessing fatigue and alertness with a portable performance battery, *Human Factors*, Vol. 30, iss. 3, 1988, 305-317.

[6] Gillberg, M., Subjective alertness and sleep quality in connection with permanent 12-hour day and night shifts, *Scandinavian Journal of Work, Environment, and Health*, Vol. 24, 1998, 76-81.

[7] Tucker, P., Smith, L., Folkard, S., Shift length as a determinant of retrospective on-shift alertness, *Scandinavian Journal of Work, Environment, and Health*, Vol. 24, 1998, 49-54.

[8] Bendak, S., 12-h workdays: current knowledge and future directions, *Work & Stress*, Vol. 17, iss. 4, 2003, 331-336.

[9] Rosa, R., Colligan, M., and Lewis, P., Extended workdays: Effects of 8-hour and 12-hour rotating shift schedules on test performance, subjective alertness, sleep patterns, and psychosocial variables, *Proceedings of the 30th annual meeting of the Human Factors Society*, Vol. 2, 1986, 882-884.

[10] Axelsson, J., Kecklund, G., Akerstedt, T., and Lowden, A., Effects of alternating 8- and 12-hour shifts on sleep, sleepiness, physical effort, and performance, *Scandinavian Journal of Work, Environment, and Health*, Vol. 24, 1998, 62-68.

[11] Lowden, A., Kecklund, G., Axelsson, J., and Akerstedt, T., Change from an 8-hour shift to a 12-hour shift, attitudes, sleep, sleepiness and performance, *Scandinavian Journal of Work, Environment, and Health*, Vol. 24, 1998, 69-75.

[12] Smith, P., Wright, B., Mackey, R., Milsop, H., and Yates, S., Change from slowly rotating 8-hour shifts to rapidly rotating 8-hour and 12-hour shifts using participative shift roster design, *Scandinavian Journal of Work, Environment, and Health*, Vol. 24, 1998, 55-61.

[13] Rosa, R. and Colligen, M.J., Extended workdays: Effects of 8-hour and 12-hour rotating shift schedules on performance, subjective alertness, sleep patterns, and psychosocial variables, *Work Stress*, Vol. 3, 1989, pp 21-32

[14] Rosa, R. Performance, alertness, and sleep after 3-5 years of 12-hour shifts: a follow up study, *Work & Stress*, Vol. 5, 1991, 107-116.

[15] Baker, T. L., *Alertness, Performance, and Off-Duty Sleep on 8-Hour and 12-Hour Night Shifts in a Simulated Continuous Operations Control Room Setting*, NUREG CR-6046, Washington D.C., Nuclear Regulatory Commission, 1995.

[16] Sallinen, M., Härmä, M., Akila, R., Holm, A., Luukkonen, R., Mikola, H., Müller,K., and Virkkala, J., The effects of sleep debt and monotonous work on sleepiness and performance during a 12-h dayshift, *Journal of Sleep Research*, Vol. 13, 2004, 285-294.

[17] Ontario Hydro, *Analysis of the Impact of 12-hour Shifts on Human Performance at Ontario Hydro Nuclear Generating Stations*, Toronto, Ontario Hydro Report, 1986.

[18] Smiley, A. and Moray, N., *Review of 12-hour shifts at Nuclear Generating Stations*, Ottawa, Atomic Energy Control Board, Report No. 2.131.1, 1989.

[19] Heslegrave, R., Gil, V., and Rhodes, W., *Le travail par quart et la santé du personnel de la centrale nucléaire Gentilly-2*, Hydro Québec, Gentilly, 1998.

[20] Heitmann, A., Guttkuhn, R., Croke, D., and Moore-Ede, M. Innovative fatigue management approach in the trucking industry, *PROCEEDINGS of the Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, 2005, 271-277.

[21] McCulloch, K., Fletcher, A. and Dawson, D. (2003) *Moving Towards a Non-Prescriptive Approach to Fatigue Management in Australian Aviation: a Field Validation*, Civil Aviation Safety Authority: Canberra, Australia, www.casa.gov.au/