REGDOC-2.2.1
CNSC Human Performance: Managing Worker Fatigue and Hours of Work

Review and Public Comment
Submitted by
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1 EDP SOFTWARE

EDP Software is an established pioneer in the software development and consulting industry. We have been in operation since 1981. We are engaged primarily in the consulting, research and development of computer-based information systems and software.

Our emphasis is on SchedulePro, a sophisticated and easy to use web based employee scheduling software service. Our other main product is JISPro, a court case management system.

SchedulePro is experienced in managing schedules at nuclear facilities. Point Lepreau Generating Station, located in New Brunswick, uses SchedulePro to manage their hours of work limits, a form of the proposed CNSC rules.

SchedulePro is also used at all of the Shell refineries in the United States to manage Recommended Practice 755 (RP 755). RP 755 is a guideline for fatigue management in refineries and petrochemical facilities. SchedulePro automatically creates schedules that follow RP 755 rules, and generates reports to track and prove compliance with the regulations.

2 LIMITS ON HOURS OF WORK AND RECOVERY PERIODS COMMENTARY

The basis for the analysis comes from comparing our experience with automating fatigue risk management at Point Lepreau Generating Station in New Brunswick, as well as our experience with implementing hours of work policies in the oil and gas industry. Our experience applying fatigue management policies in a number of facilities and industries provide us with insight into the practical application and day-to-day requirements of scheduling and compliance.

2.1 Limits on Hours of Work

2.1.1 Multiple Limits – Soft and Hard targets

To account for extenuating circumstances, the limits should incorporate some soft and hard limits and also account for outage scenarios. Planning for exceptions to the rules will ensure there is a built in buffer in case it is needed, and establish a reporting and documentation process for managerial oversight.

There is a natural incentive to maximize the utilization of existing resources. It is more cost-effective for companies to staff overtime hours rather than to increase organization headcount (to a limit). For employees, working overtime can have a significant financial benefit to their take-home pay.

The result of this incentive is that schedules will push employees to the specified fatigue limits. When the inevitable exceptions occur, the only response is to then schedule employees past the limits. The result is a schedule with no built-in buffer or precautionary warning mechanism.

A potential solution to this catch-22 scenario is to have a base limit and a hard limit. Exceeding the base limit requires written manager approval and the maximum limit cannot be deviated from. This approach has the following key benefits:

1. The schedules have built in buffer to handle exceptions
2. Managers need to be notified when fatigue levels are reaching the maximum limit and they are then in a position to take proactive steps to address staffing levels if needed
3. There is an audit trail so that the number of exceptions given can be counted and reviewed later

2.1.2 Site Outage Limits

When a site outage occurs, all possible resources are needed to bring the facility back online safely. During these windows, adhering to the regular run and maintain fatigue levels may not be feasible. Applying a more relaxed fatigue policy during outages or suspending certain policies is a common approach to handle these scenarios. This approach is employed by the Point Lepreau Generating Station today, and also serves as the standard practice in the oil refinery industry.

The second aspect that should be defined for outages is the practice for moving employees out of an outage and back onto their regular schedules. When an outage ends, a facility needs a few days to cycle all workers through a rest period as part of the process of moving back to a regular operating schedule. If this grace time is not provided, all employees involved in the outage would require a rest period on the day following an outage and there may not be enough resources to staff the facility.

A standard suggestion would be to specify that all employees involved in an outage must have a rest period within 7 days of the end of an outage before returning back to a regular operating schedule. The standard length of such a rest period should be specified.

2.1.3 Rolling Windows

The hours of work limits do not specify if the limits are to be enforced for fixed windows or for rolling windows of time. Point Lepreau Generating Station currently uses the following choices for rolling vs. fixed windows.

Time Frame	Rolling or Fixed Window
24 hours	Rolling
48 hours	Not used by Point Lepreau today
7 Days	Rolling
14 Days (not in CNSC draft)	Rolling
6 weeks	Fixed
12 weeks (not in CNSC draft)	Rolling
12 Months	Fixed

Table 1 - Point Lepreau Generating Station rolling vs. fixed window rules

2.1.4 Limits on Hours of Work Summary Comments

EDP Software recommends the following additions to the Hours of Work Limits:

- Base limit requiring manager approval
- Upper limit which cannot be deviated from
- Limits to be used during an outage

Suggested changes to the proposed limits are described below and highlighted in yellow. The values for the outage limits are basic proposals, but additional investigation of standard outage staffing at applicable sites would be needed to suggest correct limits.

Time Frame	Base Limit	Upper Limit	Limit During Outage	Recommend Rolling vs. Window	Comment
24 Hours	12	16	16	Rolling	The 12 and 16 hour limits come directly from the current chart Is manager approval required for any shift longer than 12 hours? Limit for number of 16 hours shifts in a time period? - 1 every 7 days - 2 every 28 days
48 Hours	28	28	28	Rolling	The limit for 48 hours should be increased from 26 to 28 hours. This will allow an employee to work a 12 hour shift on Day 1, and then handle a 16 hour emergency on Day 2. Without this change, a 16 hour shift has a "cascading" effect causing more people to work extended shifts. Day 1: Employee 1 handles emergency and works 16 hours Day 2: Employee 1 can only work 10 hours. Leaves 2 hours early. Employee 2 is called in 2 hours early for her shift. For 12 hour shift workers, starting a shift early can be very disruptive to sleep patterns. Allowing an employee to work an extended shift and then continue to complete their regular schedule would not cause a second employee to incur an extended shift. Isolating the fatigue to a single employee is advantageous over spreading the fatigue to other members of the team.
7 Days	72	72	76	Rolling	A rolling 60 hour limit is too low for general scheduling. Looking at common rotating 12 hour patterns used across several industries (DuPont 12 hour pattern and Every Other Weekend Off pattern), the base schedules themselves have employees working 6 days in some rolling windows. To provide the necessary flexibility to run a 12 hour pattern, EDP's suggestion is that the limit be set to 72 hours in a 7 day period. The flexibility to work 6 shifts in a 7 day rolling window will provide facilities the flexibility to rotate individuals through working and non-working days and also have the manpower needed to provide long recovery breaks as required.

Time Frame	Base Limit	Upper Limit	Limit During Outage	Recommend Rolling vs. Window	Comment
6 week	312	316 or 320	Waived	Rolling	Applying a 6 week limit requires consideration on the type of scheduling pattern used at the facility. **Different Length rotations:** Not all facilities or even units within a single facility will use a 6 week rotation pattern. Point Lepreau Generating Station is split between 6 week and 5 week rotation pattern. 4 week patterns can also be common in other industries. **Upper Limit:** The suggestion of a 320 hour upper limit is to provide flexibility to schedule an employee for an extra 4 hour hold over (16 hour shift) in the case of some last minute coverage need. If an entire 6 week rotation schedule has been constructed, the buffer to add the extra 4 hour will allow for coverage without cascading new openings for the rest of the rotation.
12 month	2400	2400	N/A	Fixed	A fixed window period is recommended for simplicity in reporting and management. A rolling window is possible, but would require schedulers to look backwards 1 year and forward 1 year to evaluate schedules and may add undue administrative burden.

Table 2 - Hours of work limits commentary summary

2.2 Recovery Periods

2.2.1 Clarification on Continuous Shifts vs. Work Sets

Section 3.2.2 Recovery periods of REGDOC-2.2.1 does not define what is meant by consecutive shifts. It raises the question of which circumstances define if a set of shifts is continuous or not. Clear specification should be provided for the cases where a break between shifts does not meet the minimum recovery period guidelines.

Work Sets Instead of Continuous Shifts

The term 'continuous shifts' can be misleading in the context of fatigue management. For the well-being of employees, it is more important to focus on extended periods of uninterrupted recovery rather than a continuous cycle of days-on and days-off which provides the minimum amount of rest. In other words, a long rest period after five consecutive shifts is better than working on alternate days indefinitely.

The American Petroleum Institute (API) moved to a definition called 'work sets'. A work set refers to the number of shifts worked until a mandatory recovery period is completed. This paradigm makes it easier to ensure that a break shorter than the required time does not reset an employee's shift count.

Examples

Ex.1 48 hour break required after 2 consecutive night shifts. 72 hours required after 3 or more.

Employee Schedule:

Date	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day Shift	-	-	OFF	OFF	OFF	OFF	Works Day
Night Shift	Works Night	Works Night	OFF	Works Night	OFF	OFF	OFF

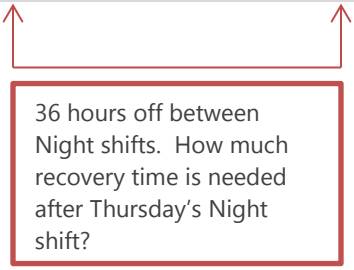

Table 3 - Counting of continuous working shifts for recovery periods

Counting using the term 'Continuous shifts'

- Monday and Tuesday night shifts are continuous. The rules state that 48 hours off is required.
- Thursday's night shift occurs after only 36 hours.
- Does this count as 3 continuous night shifts and therefore requires 72 hours off after Thursday's night shift?
- Does this count as 2 continuous night shifts and a violation because there was only 36 hours off? If this case is true, does the violation go away if we were to add a shift on Wednesday night and make it 4 continuous nights? Adding work to the schedule should not cause a fatigue violation to go away.

Counting using the concept of 'Work Sets'

- Monday and Tuesday shifts are back to back. Part of the same work set. 2 night shifts means that a 48 hour break is required.
- Thursday night shift only provides a 36 hour break. Adequate recovery is not given and therefore Thursday's night shift is part of the work set and that means there are now 3 night shifts in the set.
- Sunday Day shift only provides 60 hours of break. A 72 hour break is required and therefore adequate rest is not provided. There are 2 ways this can be interpreted:
    - Sunday Day shift is included in the work set. At that point there will be 4 shifts in the set. Employee could work 1 more shift until they hit 5 shifts in the set and then MUST have the 72 hour break.
    - Enforce that the required break must occur before moving between shifts. This interpretation is helpful for fatigue as it forces breaks when moving from Day shift to Night

shift or vice versa. This gives workers time to move their sleep schedule and adjust prior to returning to work on the alternate shift.

2.2.2 Recovery Time When Moving Between Day and Night Shift Sets

As described in Section 2.2.1 of this document, moving between day shifts and night shifts can have significant fatigue implications for workers. Switching between day and night patterns puts stress on the natural circadian cycles. A minimum transition time provides time for workers to adjust their sleep cycles.

Elements that should be defined for transitions:

- Minimum transition time between day and night shifts and vice versa (a 48-hour window is recommended).
- Determine if a full recovery period must be enforced before the transition can occur or if a single work set can contain both day and night shifts.
  E.g. After working 3 night shifts, a full 72-hour break must be enforced before returning for a day shift.
- If a work set includes both day and night shifts, the standard rules for minimum recovery time still apply.
  E.g. After working 3 night shifts, the worker can return for 2 more day shifts. Once the 5 shift limit is hit, then a full 72hour recovery break must be provided.

2.2.3 Recovery Period for 8 Hour Workers and Managing Shift Schedules

We recommend that the minimum recovery period for 8-hour workers be moved to be 32 hours instead of 36 hours. A 32-hour period allows a facility to operate on a 3-shift rotation and maintain complete weekend coverage. The charts below illustrates the issue with 36-hour recovery periods and covering weekend night shifts.

Example - Worker on straight day schedule and weekend work

From a fatigue standpoint, one of the most ideal schedules would be a standard 5x8 schedule. That is, Monday to Friday, 8 hours per day. In this ideal schedule, the fatigue rules should allow for a facility to obtain weekend coverage.

<table>
<tr><th></th><th>Friday Day</th><th>Friday Eve</th><th>Friday Night</th><th>Saturday Day</th><th>Saturday Eve</th><th>Saturday Night</th><th>Sunday Day</th><th>Sunday Eve</th><th>Sunday Night</th><th>Monday Day</th></tr>
<tr><td></td><td>Worked</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Worked</td></tr>
<tr><td>36 Hour from Friday</td><td>Worked</td><td colspan="5">RECOVERY TIME</td><td></td><td></td><td></td><td></td><td>Worked</td></tr>
<tr><td>36 Hour from Monday</td><td>Worked</td><td></td><td></td><td></td><td></td><td colspan="4">RECOVERY TIME</td><td>Worked</td></tr>
<tr><td>Availability</td><td>Worked</td><td colspan="4">AVAILABLE</td><td>BLACK OUT</td><td colspan="3">AVAILABLE</td><td>Worked</td></tr>
</table>

Table 4 - Weekend coverage for a 5x8 schedule with 36 hour recovery

Table 4 above illustrates the blackout period that is created with a 36 hour recovery period. The overlapping required recovery periods (illustrated in yellow) show the period by which the employee is less than 36 hours away from finishing their shift on Friday and less than 36 hours away from starting back on Monday. The result is an 8-hour window where no employee can work, even though it is just a single shift on the weekend.

The following illustration will adjust the recovery period to 32 hours. This will relieve the blackout period issue.

	Friday Day	Friday Eve	Friday Night	Saturday Day	Saturday Eve	Saturday Night	Sunday Day	Sunday Eve	Sunday Night	Monday Day
	Worked									Worked
32 Hour from Friday	Worked	RECOVERY								Worked
32 Hour from Monday	Worked					RECOVERY				Worked
Availability	Worked	AVAILABLE								Worked

Table 5 - Weekend coverage for a 5x8 schedule with a 32 hour recovery

In Table 5, the same weekend coverage is illustrated with a 32 hour recovery period. In this case, the employee can work one of the 2 weekend days and the facility can schedule coverage throughout the weekend period. There is no blackout period where nobody on staff would be available.

3 REQUIREMENTS AND GUIDANCE COMMENTARY

The Requirements and Guidance section of REGDOC-2.2.1 outlines the requirements that each facility must fulfill in order to meet the regulations and it provides some guidance on how to meet the requirements. In order to ensure that each organization/facility is adhering to those requirements, specific metrics need be measured and tracked – words alone are not enough. Then, what follows is defining and setting expectations for each metric.

In doing research we came across an excellent document published by the International Petroleum Industry Environmental Conservation Association (IPIECA) titled "Performance Indicators for Fatigue Risk Management Systems". While this is a guidance document for the oil and gas industry, the leading metrics in the document are applicable in the nuclear industry as well. In the following sections we provide examples of what key metrics can be used in the management of fatigue and hours of work.

3.1 Management of Fatigue and Hours of Work

3.1.1 Roles and Responsibilities

Section 3.1.1 of REGDOC-2.2.1 states that licensees shall define and document the roles and responsibilities of employees managing worker fatigue and hours of work of the stated work groups. There is no mention of using metrics to measure site performance and hold each organization accountable to a minimum standard.

Performance indicators for fatigue risk management systems, published by IPIECA[1] proposes that the following supporting leading metrics be used to measure the success of the development and ongoing maintenance of a fatigue risk management system (FRMS):

Performance Indicator
Percentage of sites that have convened a 'fatigue management working group' recognizing the importance of key stakeholder involvement.
Percentage of sites where supervisor responsibilities about fatigue are clearly defined and documented (e.g. in the job description).
Percentage of job descriptions that include clearly defined and documented employee responsibilities concerning fatigue (e.g. in the job description).
Percentage of audit findings where a deficiency in roles and responsibilities has been identified.
Percentage of audit findings where a deficiency in stakeholder engagement has been identified.

Table 6 - Performance Indicators for ongoing management of FRMS

3.1.2 Training

In section 3.1.2 of REGDOC-2.2.1, guidance is given around the training topics that should be covered for those with roles and responsibilities for managing worker fatigue and hours of work, but again, there is no mention of performance indicators (metrics), which can be tracked to ensure compliance. Specific metrics should be defined so that there is a consistent standard across organizations and facilities.

Performance indicators for fatigue risk management systems, published by IPIECA[1] proposes the following supporting leading metrics be used to develop a competency-based fatigue management training program for relevant target employee groups:

Performance Indicators
Percentage of employees trained per period as compared with the training schedule.
Percentage of supervisors who have received additional specific training regarding their responsibilities per period as compared with training schedule.
Percentage of employees completing refresher training per period as compared with training schedule.
Percentage of training records completed.
Percentage of employees assessed to be competent in the application of their knowledge of fatigue and its application in the workplace based on post-training knowledge/competency tests.

Table 7 - Performance indicators for FRMS training

3.1.3 Identifying and Managing Worker Fatigue

Section 3.1.3 of REGDOC-2.2.1 states that licensees need to have a process to identify and manage workers who have temporary or ongoing fatigue-related limitations. Based on the guidance given in the document the following suggested leading metrics from the IPIECA[1] might be a useful way to measure the controls, which are put into place:

Types of Work Tasks Leading Metrics:

Performance Indicator
Percentage of employees who report that they change tasks or take a break if they start to feel fatigued.
Percentage of safety-critical tasks scheduled outside the window of circadian low.

Table 8 - Performance Indicators for work task metrics in FRMS

Working Environment Leading Metrics:

Performance Indicator
Percentage of shifts exposed to environmental conditions that induce fatigue.
Percentage of shifts that have management strategies in place, or for which alternative duties are allocated.
Percentage of sites that have facilities in place for managing working conditions (e.g. air-conditioned rooms for hot days).

Table 9 - Performance Indicators for work environment factors in FRMS

3.1.4 Problem Identification and Resolution

Quantifying the following leading metrics suggested by IPIECA[1] can play a key role in identifying problems related to fatigue or hours of work:

Performance Indicator
Percentage of 'open' shifts per rolling period.
Percentage of unfilled positions.
Percentage of hours worked that are overtime.
Percentage of employees who have exceeded the maximum number of consecutive working days/hours before taking a rest day.
Percentage of single rest days between shift cycles per rolling period.
Percentage of task swaps intended to reduce the adverse impact of fatigue on employee performance.
Percentage of shifts worked following shift swaps (measure of stability of shift patterns).
Percentage of safety-critical activities performed during the window of circadian low (24:00–06:00).
Percentage of control room watches exceeding six hours.
Maximum length of time between breaks on shift.
Percentage of sites that have dedicated facilities or arrangements to enable workers to practice alertness strategies

Table 10 - Performance indicators for proactive problem identification in FRMS

Performing trend analyses on these metrics can identify recurring problems that may require organizational changes to reduce worker fatigue.

4 REFERENCES

1. OGP-IPIECA, *Performance indicators for fatigue risk management systems*, London, United Kingdom, 2012
2. Health & Safety Executive, *The development of a fatigue/risk index for shiftworkers,* Research Report 446, London, United Kingdom, 2006