Risk Reduction of Occupation Diseases by Optimization of Schedule of Work and Rest on Example of Workers of Electrolytic Production

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Abstract. The article considers the actual question of risk estimation of non-evident professional diseases. On the basis of the conducted assessment of the acting schedule of the work of a pot operator of molten salts of one of the departments of the Urals aluminum smelter and determined unaccounted peculiarities of daily dynamics of the behavior of biological processes in the human organism while work scheduling, the authors have developed rational shift schedule, in which the time of a worker’s night shift is maximally cut. The proposed schedule is aimed at preventing accidents and decreasing the risk of occupation diseases of employees. The provided material has a great practical significance as the main principle of the management system of professional risks is health maintenance in the process of production activity.

1. Introduction
According to the definition of International Labor Organization (ILO) an occupation disease is a disease, developing as a result of the impact of risk factors, determined by labor activity [1]. In contrast to the accidents in the workplace, occupation diseases especially such as psychiatric and musculoskeletal system disorders often go practically unnoticed. But according to the data of ILO yearly in the world about 2.02 million people die from various occupation diseases and 160 million get non-fatal diseases.

The list of occupation diseases, acting in the Russian Federation, is based on the etiological principle and is approved by the order of the Ministry of health and social development. Along with the diseases, determined by the influence of chemical (dust, aerosols, fumes, chemical compounds), physical (different radiances, electromagnetic field, pressure, noises) and biological factors (microorganisms, allergens, viruses), the list includes the diseases, connected with physical overloads and functional overexertion of separate organs and systems. The overloads and overexertion of the systems of the human organism, arising at non-rational organization of the schedule of work and rest, increase the risk of contraction of occupation and professionally conditioned diseases [1-3].

In 2010 Russia ratified convention № 187 of ILO “Of the bases, promoting safety of labor protection”, supposing the introduction of the management system of professional risks. The assessment of professional risks is the initial stage of the management of safety and health protection of employees of all kinds of organizations. This should take into account all the risks, but not only immediate and obvious.

The non-obvious professional risks may include the risk of health loss of people, having to work at night. According to the statistics in our country their number comprises up to the quarter of all working people. These are security staff, controllers, employees of defense and law enforcement agencies, medical personnel, air and other means of transport staff, the employees of petrol stations, printing offices, industrial enterprises and many others [4-6].

While working night, there is a change of the sleep rhythm, which has a ruinous impact on the society health according to the estimations of medical professionals. Such diseases become widespread, as syndrome of chronic fatigue, hypertonia, insults, infarcts and nervous illnesses and etc. appear at a younger age [7]. “Chronic sleep deprivation” is a habituate an organism, depriving of a proper rest. As a result
people become aggressive, irritable or, on the contrary, absent-minded and inattentive, they quickly accumulate fatigue, they are more prone to “professional burnout”. Together with this, sociologists mention that these problems are characteristic only for those, who work nights more often than 2 times a week.

In accordance with the international classification the term “night labor” means any work, which is carried out during the period of the duration of no fewer than 7 hours in a row, including the interval between midnight and 5 a.m. In Russia the time from 10 p.m. to 6 a.m. is considered as night time [8].

The researches show that people, working nights, sleep less than those who have to work during the day. When the fatigue has been accumulated, the productivity may dramatically fall. This effect intensifies if a person tries to catch on sleep on his day-off and his hours of sleep change, i.e. the main value of a person’s labor activity, productivity, is becoming worse, which is characterized by the quantity and quality of work for certain time. The productivity is defined by functional, psychic abilities of the human organism to fulfill certain work and ranges in accordance with day, week, month, year biological rhythms. The organism reacts to physical and nervous-emotional load differently not only day-and-night but also during the working day.

On the physiological curve of the dynamics of twenty-four-hour productivity (figure 1) two minimums stand out clearly.

![Figure1](image)

**Figure1.** – Physiological curve of the dynamics of twenty-four-hour productivity

During the day the least productivity, as a rule, is seen between 12 and 2 p.m., the second minimum accounts for night time, from 3 to 4 a.m. It is obvious that working at night, the person violates his organism in a certain way that is why production load during the night shift must be significantly lower than during the day.

During the working week the person’s productivity is not also the same: it is as one of the halves of the working day. On the first working day, on Monday, warming-up happens, on Tuesday, Wednesday and Thursday the productivity reaches a high level and on the following days it suddenly falls, reaching minimum on Saturday, which is connected with the organism fatigue. That is why in 1967 at most enterprises a five-day week was introduced to exclude the phase of the developing fatigue and the greatest number of mistakes, connected with it.

Fatigue is a psychological state of a person, arising as a result of the completion of work of a great difficulty, tension and duration and expressing in quantitative and qualitative worsening of results. This physiological state of the person is reversible if the productivity restores by the beginning of the next period of work. Otherwise the fatigue may accumulate and change into overfatigue – a more stable decrease of productivity, which leads to the decrease of stamina and disease development. The fatigue and overfatigue are often causes of traumatism at work.

Two types of the fatigue are differentiated: quickly and slowly developed, the first arises at very intensive work (the work of a metallurgist, a person of creative work), the second – at long monotonous work (the work of a driver job, an assembly worker). Physical fatigue appears as a result of excessive heaviness of labor, mental – as a result of excessive tension of labor. The person copes with physical fatigue more easily as muscles rehabilitates more quickly. At the same time in the condition of heavy physical fatigue mental work is counterproductive, and in mental fatigue the person suffers physical fatigue. The tension, appearing as a result of fatigue, influences the sleep quality and duration, especially after working night. In its turn insufficient sleep leads to quicker formation of fatigue and its consequence – tension [9].
In the process of mastering a job and profession warming-up period reduces the person gets work skills, summons up functional systems more quickly, carrying their activity off to the level, corresponding work needs of the organism. In people with undeveloped professional skills the warming-up stage gives way to the stage of overcompensation, when in the organism full correspondence between presented load to him and the reaction of the necessary physiological systems to it has not been reached yet. In professionals, having working skills, the overcompensation stage is absent. In this case the warming-up stage changes into the stage of stable productivity.

So, for works at night, according to a staggered schedule at the electrolytic aluminium smelting it is necessary to engage experienced workers, being masters of effective safety practices, skills of work and its organization, having allied professions, which does not ensure only the interchangeability of workers in “force majeure” circumstances but also decreases the impact of hazardous production factors in the unfavorable conditions of labor.

Taking into account the topicality of this issue, the aim of the research has been in the assessment of the work schedule a pot operator of molten salts of one of the departments of the Urals aluminum smelter (UAS).

Based on the target aim, the following tasks have been defined:

1. to carry out the analysis of laws and regulations and scientific literature on this topic;
2. to estimate the acting work schedule a pot operator of molten salts;
3. to elaborate a rational shift schedule, decreasing night work to a maximum extent.

2. Results and Discussion

The sphere of activity a pot operator of molten salts is metallurgy, aluminium production and alloys based on aluminium, participation in the electrolytic process and electrolytic refining of aluminium, magnesium, titanium and rare metals. Labor process of a pot operator of molten salts is characterized by a great variety of operations and frequent switching of kinds of activity (to 50-60 times a shift), going on in the conditions of the impact of chemically and physically hazardous factors. It should be noted that the aluminium electrolytic process is a nonstop one.

The productivity of a person during the week undergoes cyclic changes, in a week dynamics the phase of high productivity accounts for Tuesday, Wednesday and Thursday. The similar dynamics is also characteristic for a shift schedule where the phase of high productivity accounts for Tuesday and Wednesday of the studied below schedules that is why it is necessary to use these days to a maximum extent in the production interests. In the system of events on Scientific Organization of Labor (SOL) an important place is given to the elaboration of ration schedules of work and rest, ensuring high labor efficiency and health maintenance of the enterprise personnel. While elaborating work and rest schedules the following should be taken into account:

● rational balance of work and rest as one of the means of fatigue prevention should be carried out while fulfilling all work (functions);
● while improving work and rest schedules it is necessary to consider the impact of work conditions on the human organism, its productivity;
● to follow the unique principles and methodology of the definition of a quantity and duration of rest breaks at six- and eight-hour shifts;
● to keep in mind that regulated rest is more effective than chaotic breaks in work at the discretion of workers. Accidental downtime because of the drawbacks in the organization of labor and production cannot be considered as a proper rest as it causes the break of work dynamic stereotype and negative emotions;
● the contents of rest and its duration should be subject to one goal – maximum fatigue decrease and maintaining of high and stable productivity during the working day (shift).

The work schedule is characterized by the duration of the working day, shiftwork and the regulation of rest during the shift. While estimating the tension factors of labor process functional peculiarities of workers, technological instructions are studied, the surveys of employees are carried out.

One of the factors, influencing the fatigue, labor tension of the worker at the place of production with hazardous unfavorable conditions of 36-hour reduced working week is the shift schedule, shift length, vacation. The efficiency of introduced work and rest schedule depends on how properly the regularities of day-night dynamics of the flow of biological processes in the human organism are considered, as the strength and direction of the reactions change in relation to the time of the day. In the morning and
Afternoon the most important psychophysiological functions of a man are characterized by highest activity and at night – by lowest activity. Taking into account the unfavorable influence of night shifts on the health of workers and their production values, it is necessary to find ways to reduce works at night, in particular, by using rational shift schedule, shortening night work.

Table 1

| Shift Dates of month | Variants of shift rotation | Days of week |
|----------------------|---------------------------|--------------|
| 1                    | A 1 B 2 C 4 D 3 E 1       | Monday       |
| 2                    | A 1 B 2 C 4 D 3 E 1       | Tuesday      |
| 3                    | A 1 B 2 C 4 D 3 E 1       | Wednesday    |
| 4                    | A 1 B 2 C 4 D 3 E 1       | Thursday     |
| 5                    | A 1 B 2 C 4 D 3 E 1       | Friday       |
| 6                    | A 1 B 2 C 4 D 3 E 1       | Saturday     |
| 7                    | A 1 B 2 C 4 D 3 E 1       | Sunday       |
| 8                    | A 1 B 2 C 4 D 3 E 1       | Monday       |
| 9                    | A 1 B 2 C 4 D 3 E 1       | Tuesday      |
| 10                   | A 1 B 2 C 4 D 3 E 1       | Wednesday    |
| 11                   | A 1 B 2 C 4 D 3 E 1       | Thursday     |
| 12                   | A 1 B 2 C 4 D 3 E 1       | Friday       |
| 13                   | A 1 B 2 C 4 D 3 E 1       | Saturday     |
| 14                   | A 1 B 2 C 4 D 3 E 1       | Sunday       |
| 15                   | A 1 B 2 C 4 D 3 E 1       | Monday       |
| 16                   | A 1 B 2 C 4 D 3 E 1       | Tuesday      |
| 17                   | A 1 B 2 C 4 D 3 E 1       | Wednesday    |
| 18                   | A 1 B 2 C 4 D 3 E 1       | Thursday     |
| 19                   | A 1 B 2 C 4 D 3 E 1       | Friday       |
| 20                   | A 1 B 2 C 4 D 3 E 1       | Saturday     |
| 21                   | A 1 B 2 C 4 D 3 E 1       | Sunday       |
| 22                   | A 1 B 2 C 4 D 3 E 1       | Monday       |
| 23                   | A 1 B 2 C 4 D 3 E 1       | Tuesday      |
| 24                   | A 1 B 2 C 4 D 3 E 1       | Wednesday    |
| 25                   | A 1 B 2 C 4 D 3 E 1       | Thursday     |
| 26                   | A 1 B 2 C 4 D 3 E 1       | Friday       |
| 27                   | A 1 B 2 C 4 D 3 E 1       | Saturday     |
| 28                   | A 1 B 2 C 4 D 3 E 1       | Sunday       |
| 29                   | A 1 B 2 C 4 D 3 E 1       | Monday       |
| 30                   | A 1 B 2 C 4 D 3 E 1       | Tuesday      |
| Number of working days/days off in a month | 24/6 24/6 24/6 24/6 24/6 |

Note: * – day off.

From these positions let’s consider the existing schedule (presented in table 1) of works at the electrolytic production. This schedule is a one with a reverse order, i.e. after the evening shifts in the cycle there are day ones and the day shifts are followed by night ones. In table 1 five shifts are shown, of 6-hour length of 36-hour working week, during the day-night four shifts are working shifts and one is an off-day shift:

- Shift 1 – from 1 to 7 a.m.,
- Shift 2 – from 7 a.m. to 1 p.m.,
- Shift 3 – from 1 p.m. to 7 p.m.,
- Shift 4 – from 7 p.m. to 1 a.m.
The order of shifts is reverse, four days are working days and one is a day off. Let’s consider A-shifts as an example: in the schedule there are 4 working days in the first shift in a row, 1 day off, next 4 working days in Shift 4, etc. The re-shifting comprises 18 hours. Letters A, B, C, D, E show possible variants of shift rotation.

The drawback of this schedule is more than one night shift in a row, which leads to the fact that adaptation mechanisms of the human organism need more time to start working and the rehabilitation of psychophysiological parameters of a man becomes difficult and the tension of the labor, arising because of sleep loss and fatigue in passing from one night shift to another, increases, the labor monotonous appears due to the growth of cycles of shift repetition.

| Dates of month | Variants of shift rotation | Days of week |
|----------------|-----------------------------|--------------|
| 1              | 1   *   *   2   3           | Monday       |
| 2              | 2   1   *   3   *           | Tuesday      |
| 3              | 3   2   1   *   *           | Wednesday    |
| 4              | *   3   2   *   1           | Thursday     |
| 5              | *   *   3   1   2           | Friday       |
| 6              | 1   *   *   2   3           | Saturday     |
| 7              | 2   1   *   3   *           | Sunday       |
| 8              | 3   2   1   *   *           | Monday       |
| 9              | *   3   2   *   1           | Tuesday      |
| 10             | *   *   3   1   2           | Wednesday    |
| 11             | 1   *   *   2   3           | Thursday     |
| 12             | 2   1   *   3   *           | Friday       |
| 13             | 3   2   1   *   *           | Saturday     |
| 14             | *   3   2   *   1           | Sunday       |
| 15             | *   *   3   1   2           | Monday       |
| 16             | 1   *   *   2   3           | Tuesday      |
| 17             | 2   1   *   3   *           | Wednesday    |
| 18             | 3   2   1   *   *           | Thursday     |
| 19             | *   3   2   *   1           | Friday       |
| 20             | *   *   3   1   2           | Saturday     |
| 21             | 1   *   *   2   3           | Sunday       |
| 22             | 2   1   *   3   *           | Monday       |
| 23             | 3   2   1   *   *           | Tuesday      |
| 24             | *   3   2   *   1           | Wednesday    |
| 25             | *   *   3   1   2           | Thursday     |
| 26             | 1   *   *   2   3           | Friday       |
| 27             | 2   1   *   3   *           | Saturday     |
| 28             | 3   2   1   *   *           | Sunday       |
| 29             | *   3   2   *   1           | Monday       |
| 30             | *   *   3   1   2           | Tuesday      |

Number of working days/ days off in a month: 18/12

Note: * – day off.

Having conducted the analysis of the current work schedule of a pot operator and detecting drawbacks, we have elaborated the work schedule, which allows protecting the person with the help of time against the influence of factors of production environment and decreasing labor tension as a result of passing from one night shift into another (table 2). This schedule is a labor schedule of five shifts of a direct order, during day-night there are three 8-hour shifts, 3 working days and 2 days off:
the first working day is from 11 p.m. to 7 a.m.,
- the second working day is from 7 a.m. to 3 p.m.,
- the third working day is from 3 p.m. to 11 p.m.

The increase of the length of the working shift for workers with hazardous working conditions corresponds to the requirements of the Federal law dated 28.12.2013 № 421-FL “About amendment into separate legislative acts of the Russian Federation in connection with the adoption of the Federal law “Of special assessment of labor conditions” (amended and supplemented).

The rest length on days off comprises 48 hours, the length of turnover from shift to shift (shift change) comprises 24 hours.

The important quality of the schedule is its better correspondence to natural psychophysiological peculiarities of the organism and biological rhythms of a person. So the first working night shift coincides with a warming-up stage, beginning of a labor process and the last working day, the 3 evening shift, coincides with the decrease of day-night activity, performance degradation of a person and a smooth exit out of a labor process. The peak of efficiency is in the middle of the cycle on the second working day, when in accordance with biological rhythms the psychophysiological state of the human organism is ready for the greatest loads, counteracting the negative factors of the production and the environment.

The positive peculiarity of this schedule is in creating the conditions under which each second working day in any of five variants of shift rotation – A, B, C, D, E, occurs in the phase of the greatest efficiency both of the day-night and the working cycles, i.e. out of 30 days all the 30 day shifts, from 7 a.m. to 3 p.m., are able to ensure maximum effective productivity of a team of pot operators. The coincidence of natural rhythms of the labor activity of pot operators of all the shifts and the chief of a team of pot operators promotes to it, which is in its turn creates the conditions for the elaboration of the inner-shift regulations of work and rest. This schedule allows singling out 13 days of peak collective productivity of a team of pot operators out of 30 days of the month.

The schedule is aimed at the optimization of labor activity of workers in the electrolytic production, the protection of workers with the help of time against the factors of production environment and the decrease of tension of pot operators. The absence of very short and very long days off in this schedule is a favorable condition for the labor activity of workers [10].

3. Conclusion
So, the proposed schedule takes into account the peculiarities of day-night dynamics of the flow of biological processes in the human organism and focused on the prevention of production accidents and diseases of workers.

The presented material has a great practical significance, as the main principle of the management system of the labor safety is the minimization of the negative influences of the human factor on the production activity and this material can be interesting for the specialists of safety services and human resource management of enterprises while organizing work in the conditions of nonstop production.

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