# THE IMPACT OF ARTIFICIAL LIGHTING ON THE CREW OF THE MARITIME TRANSPORT SHIPS

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**Abstract:** the work presents the complex influences of the activity program on the crew of the maritime transport ships from the point of view of the fragmentation during the day, as well as the fact that the technical personnel has mainly indoor activities which require artificial light, and thus causing the biological rhythm and the circadian cycles to lose correlation.

Key words: ship crew, circadian cycles, natural light

#### General aspects

The personnel destined to ensure the various services of assistance and maintenance of the equipment that is needed on board of a maritime transport ship works in accordance with very strict cyclic programs organized as follows: 4 hours of watch keeping,4 hours of technical assistance, followed by 4 hours of rest, after which the cycle repeats. Also, another specific characteristic is the fact that most of the work takes place in the machine room inside the ship, thus meaning that the personnel is mainly subjected to artificial light. It has already been proven by research and studies that the natural light is extremely important to man, both through the visual effects and through physical, psychological and physiological benefits that the artificial light cannot replace. Considering this, the technological search of natural light imitationis very easily justified, not just for chromatic distortion caused by unsuitable light color temperature avoidance.

By nature, the human body is synchronized with the natural light through the circadian cycles. When man is forced to work daily in an environment that lacks natural light, disorder are very likely to appear when it comes to biorhythm. There are some very well-knownexamples in this field when the sailing personnel could not adjust to the rhythm alterations and was forced to guit. In other cases, after a long period of activity, the disorders were very difficulty corrected naturally or through treatment, while in some cases, certain routines could not be adjusted. In order to avoid or reduce the alteration of these biological cycles, one solution could be imitating through artificial light as many of the natural light benefits as possible. One very important aspect that must not be neglected in this parallel is the fact that the characteristic properties of natural light change constantly throughout the day: the light flow and the color temperature.

### Reasons for imitating the natural light

In nature, light is vital. Light and heat are generated by the Sun and reach the Earth in the form of radiation which is part of the electromagnetic spectrum including both gamma radiation and radio waves. Living beings have adapted to light in different ways, and for human beings (as well as other species), light not only produces optical effects, but it is also being "translated" in different ways by photoreceptors distributed all over the body. The eyes, the skin, the blood, and the scalp are sensitive both to visible light and to infrared-ultraviolet spectrum. When light reaches the eye surface, the photoreceptor cells send signals to the brain, where they are being interpreted as images. The visual aspect is the most commonly considered, and the main reason why we turn to artificial lighting. Aside from this aspect, there are also the physical, physiological and psychological effects of light that must be taken into consideration.

### The Physical impact of natural light

The simple touch of light modifies/alters the state of the exposed areas, as skin and eyes, through the quantity of transmitted and absorbed light, as well as through the exposure time and wavelength. A very common effect is the strengthening of the protective pigmentation during summer (the tan) as a result of extended exposure to ultraviolet light. But not all effects are positive, meaning that a too large amount of light is dangerous as it can cause sickness.

Another very important effect is the influx of energy necessary to certain chemical processes that take place in the body. The light energy coming from infrared light is needed in order to excite the molecules just enough to produce chemical reactions between them, but a too large amount of it can cause negative effects as disjunctive reactions of the proteins and nucleic acids.

# The Physiological impact of natural light

When light reaches the eye, it is being transmitted further through two different ways: the first way is the one of the lateral geniculate nucleus that leads further to the visual cortex where sight is produced. The second way is the one of the suprachiasmatic nucleus that leads to the thalamus, hypothalamus, septum, midbrain, and the spinal cord. It is through this second path that the light sets into motion the two main communication systems of the body: the endocrine system and the autonomic nervous system which ensure the communication between all body organs. The endocrine system determines the rhythm of hormonal secretion, and in the hypothalamus, the circadian neuroendocrine regulation is made (this constitutes the key to all physiological processes). The hypothalamus allows the body to respond accordingly when subjected to environment changes - this process is known as homeostasis and at the same time, allows the body to anticipate the probable moment of external stimuli appearance and to initiate adequate answers.

The physiological processes are primordial and need to be initiated in the correct sequence and at the right time. The sequence timing is known as the biological clock, and the body, in order to simplify the "management, bases the biological clock on the natural light, thus explaining the importance that the artificial light has for the body.

# The Psychological impact of natural light

The psychological dimension is essentially represented by the expression of the physiological level. A series of very complex aspects that are very easily overlooked even if they are met daily must be taken into consideration.

The alteration of the day/night patterns disrupts the biological clock and causes loss of appetite and even anxiety and depressive moods. Two relevant examples are the jetlag disorder caused by trans-meridian flights, and the change to and from daylight saving time in spring and autumn. The effects are not linked to the hour itself, but to the properties of the natural light at that hour.

It has been proven that phototherapy helps restore the biological rhythm, which constitutes a remarkable proof of the importance of natural light.

# The circadian biological rhythms

Most of the biological processes work in accordance with a cycle dictated by the biological clock. The term "circadian rhythm" comes from the Greek circa (environment / surrounding) and diano (day), and describes some of the biological

rhythms that rule both the autonomous nervous system and the endocrine system, responsible with regulating the melatonin and cortisol secretions. Melatonin and cortisol are two hormones that are strongly linked to the sleep and wake states: the melatonin levels are very low during the day, and increase as the night comes, only to decrease again as the sunrise approaches. On the opposite side, the cortisol level is high in the morning, peaks at noon and then drops as the evening approaches.

Just as these two hormones are being regulated by the circadian cycles, other hormones are also controlled: prolactin, noradrenaline, adrenaline, and blood pressure and heart rate. All these processes determine the physical efficiency and human intellect, and the circadian cycles are synchronized with the clear sky days, meaning that the cloudy sky days determine an alteration of these cycles.

# The influence of artificial lighting

As it has been shown, light has e very big influence on the human body. The use of artificial light often disrupts the circadian rhythms and prolonged exposure to the same type of light affect the body in a negative way because the body expects the light to change characteristics throughout the day. The presence of an artificial light that does not vary, stimulates the homeostasis in trying to stabilize the cycle in accordance with the perceived environment conditions. Normally, the body knows that it must continue the cycle, but the functioning is hampered by the stimuli. The dangerous effects manifest depending on the time spent being exposed to the same light, and the use that society gives to artificiallight combined with the adaptive ability of the body, make the effects to be long-term.

Usually, the place where these are most felt is the work place, where man spends most of his day in an environment that does not change when it comes to light (office buildings, factories. institutions, etc. that require permanent and strict control of light). Depending on the light, the environment can be hyper stimulating or under stimulating.

The under stimulating environment relaxes the mental activity and weakens the reflexes, can cause sleepy moods, or even apathy. Among the psychological effects that derive from this environment, we must mention the lack of interest for learning and self-improvement, and even loss of self-esteem and depression.

- The hyper stimulating environment has opposite effects as it stimulates the mental activity and focus, and sharpens the senses. After a long exposure time, the body starts to "ask" for a rhythm change, even if the environment conditions indicate the opposite. At this point, errors of focus and nervousness start to appear, the individual becomes irritable and aggressive, and the tension can eventually turn into stress with all the aspects that derive from it.

It becomes very clear that the artificial light must mind the ambient light composition in order to not alter the circadian cycles. A white light with wave lengths between 450-500 nanometers can stimulate attention and memory (hyper stimulating environment) and it corresponds to the time of day when sun is at its highest point. An extensive exposure to this kind of light can easily cause stress on a long term. An adequate lighting must have wave lengths that match the varying ones of the natural light. For this reason, it is important to study the color temperature which is influenced by 4 major factors: the position on the globe (latitude), the season, the moment of the day, and the climatic factors.

The moment of the day influences the natural light color. Due to Earth's curvature, the sunlight crosses the atmosphere at different angles depending on the hour, causing the color temperature to change. In the morning and evening, the color temperature is warmer, at around 3500° Kelvin. The value slowly rises from dawn to noon, meaning that the color temperature will cool until around 5600° Kelvin, and after this point will start to drop again until sunset.

In the table below is shown the variation of color temperature depending on the hour of the day.

		Table 1.
Hour of the day	<i>Temperature</i> [°Kelvin]	
06:00	2200 K	
07:00	3540 K	
08:00	4320 K	
09:00	4850 K	
10:00	5020 K	
11:00	5400 K	
12:00	5600 K	
13:00	5400 K	
14:00	5020 K	
15:00	4850 K	
16:00	4320 K	
17:00	3540 K	
18:00	2200 K	

- The day of the year / the season is the second factor that must be taken into

consideration when studying natural light. Earth axis inclination determines variations in daytime during the year.

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Studying the natural light hours during the year has allowed establishing the average day lengths for each month. It has been noticed that the length of the day does not affect the color temperature itself, but it's duration (it compresses or extends the time in which it remains unchanged). Thus, sunrise, noon, and sunset have the same color temperature in all seasons, and the only thing that is different is the speed at which it changes. The study of monthly light hours has made it possible to establish monthly averages for each color temperature. By simplifying it, the table below shows the period of time in which a color temperature remains constant every month:

Month	Average day length	Constant color temperature time
	,	
January	9h40min	49min
February	10h42min	54min
March	11h57min	1h
April	13h17min	1h7min
Мау	14h23min	1h12min
June	14h56min	1h15min
July	14h43min	1h14min
August	13h43min	1h8min
September	12h27min	1h2min
October	11h07min	55min
November	9h57min	50min
December	9h20min	47min

- Latitude is another aspect that must be taken into consideration, due to the fact that Earth's curvature influences the angle of the sun compared to the horizon, which influences the natural light color temperature. As we go closer to the poles, the noon light is colder, while it becomes warmer as we go closer to the Ecuador. The tables that were shown above are only valid for latitudes between 35° and 55°.

Climatic factor also have considerable influence on the natural light color temperature. For example, in cloudy days, when it rains or snows, the color temperature is lower than the sunny days, due to the fact that clouds act as a filter (the dimension and type of clouds determine small variations)

### CONCLUSIONS

According to everything presented above, it is obvious that the light has a great influence on behavior, physical abilities and mental abilities of people which is easily ignored. Key physiological processes are

194

regulated depending on the environmental light that is perceived throughout the day. This behavior can be different for each individual, depending on age, health, and genetics.

Measurements of the natural light color temperature show how it is warmer at sunrise and sunset, but cooler at noon, and this is why the cooler temperature light is hyper stimulating (around 5000° Kelvin) while the warmer temperature (under 3800° Kelvin) creates under stimulating environments.

In the naval field, the impact of natural light in the context of carrying out the necessary activities by the ship personnel becomes very specific. Thus, the first factor is the ship race, which in many cases, means the need to travel 24h/day for days, or even weeks. In this time, depending on the departure and arrival points, the ship can change time zones, and climatic zones from the Ecuador to the poles and vice versa. Another particular aspect of the activity of the personnel aboard ships is the case of the regular races, when the same ship has the same route for a long period of time (from days, up to several months), depending on the amount of cargo and contract.

The second factor that alters the way personnel is subjected to natural light is the daily schedule on board. In order to ensure the permanent functioning and ability of transportation, most of the companies use the "keeping watch" system. This means that throughout the journey, every employee must keep watch 2 times in 24h. For example, one officer will do this regularlyuntil the end of the trip, with no accepted deviation: from 00:00 to 04:00 and from 12:00 to 16:00. Apart from these, the officer must also perform an agreed number of hours of scheduled or unforeseen repairs.

In the case of deck officers we can eventually talk about a temporary adaptation of the circadian cycles to the quality and quantity of natural light, but the problem becomes much more complex in the case of engineer officers. The latter perform all repairs and keep watch in the ship's engine room. With the severe lack of natural light, it becomes obvious that the circadian cycles of these individuals are completely altered. The shipping companies are aware of the effects caused by the lack of light, and due to the fact that they are interested in having personnel that is capable of fulfilling all duties during the entire journey in order to finish it according to schedule, they are continuously trying to optimize the daily program. There is also a very high pressure put on for this purpose, by specialized organizations and international institutions: International Maritime Organization (IMO), through theSTCW rules (International Convention on **S**tandard **T**raining **C**ertification and **W**atch keeping for Seafarers), establish among other aspects, the legal framework in terms of minimum and maximum hours in the schedule of the personnel on board.

The verification of compliance with the legal framework is done by the International LaborOrganization (ILO), and also by the port services in each state - Port State Control (PSC).

Currently, depending on economic aspects, the available personnel, and the dynamic of the sea transportation, the companies use several work schedules. The options start from journeys with only one-time contract plus minimum one month of rest, and can reach long term contracts when the same salary is paid both for traveling periods and for stay-at-home periods, in combinations of 2, 3, or 4 months travel - 2, 3, or 4 months rest, or 3-2, 4-3 (3 month travel and 2 months rest, 4 months travel and 3 months rest), etc..

Considering the development of the automated equipment for safety and control during the last few years, each day more companies build completely automated ships that allow them to give up the watch keeping schedule and organize an 08:00 to 17:00 schedule for all personnel except for the deck personnel that must ensure permanent service. Thus, at 17:00 the engine rooms is closed, and the technical personnel must take turns in intervening in case of alarm on board. Unfortunately, insurance companies are recommending returning to the watch keeping schedule as the costs are considerably decreased this way.

The work tries to capture through its entire content, the need to address these issues, and to encourage the improvement and increased equipment reliability, in order maintain the automated equipment solution and not return to the watch keeping schedule which cannot be considered a natural working condition.

# BIBLIOGRAPHY

Dascălu, D., A., PhD Thesis, **Perspectives on the evolution of the metro station architecture**", Universitatea de Arhitectură și Urbanism "ION MINCU" BUCHAREST,