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Study on ship officer1's labor intensity and duty arrangement

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STUDY ON SHIP OFFICER'S LABOR INTENSITY AND DUTY ARRANGEMENT

by

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):

(Date): June 27, 2020

Supervised by: Professor xxx

Supervisor's affiliation: Dalian Maritime University

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ABSTRACT

Title of Dissertation: **Study on Ship Officer1's Labor Intensity and Duty Arrangement**

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During the shift of officer on watch, fatigue often occurs due to excessive labor intensity and overload, which is an important cause of ship traffic accidents. The labor intensity of ship's officer on duty refers to the degree of physiological loss and the intensity of psychological load borne by ship's officer in unit time when he is on duty on board. At present, the study on the labor intensity when officer on watch are on duty has not been paid enough attention to. It is very important to ensure the navigation safety of ships to make sure that officers on watch play their due role when they are on duty on board.

This article through the officer study on the intensity of labor, division of different vessels, ship under the condition of the officer on duty on duty the intensity of labor, for the sea ship officer on duty to determine the reasonable working time to provide a certain basis, to strengthen the rationality of the ship officer on duty arrangement, reduce labor intensity is higher for the physical and psychological impact of the navigator, prevention of officer fatigue.

Based on the factors that affect ship officer on duty， the intensity of labor is analyzed, considering the ship the officer's physiological and psychological factors that influence the two aspects of the establishment of a ship officer on the intensity of labor evaluation index system, using the fuzzy comprehensive evaluation method to ship the officer on duty is used to evaluate the intensity of labor, then using the analytic hierarchy process (ahp), determine the weights are related.

Finally, according to the current situation of the on-duty arrangement of marine officer on watch, and combined with the study on the on-duty labor intensity of officer on watch, the flexible on-duty arrangement is proposed, and the on-duty time of officer on watch is suggested according to the on-duty labor intensity of officer on watch.

KEY WORDS: ship officer, labor intensity, arrangement on duty

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AIS	Automatic Identification System
AC	Arctic Council
APM	Associated Protection Measure
BC	Black Carbon
CCS	China Classification Society
CAFF	Conservation of Arctic Fluro and Fauna
CCS	China Classification Society
DNV	Det Norske Veritas
EBSA	Ecologically or Biologically Significant Areas
EEZ	Exclusive Economic Zone
FSA	Formal Safety Assessment
HFO	Heavy Fuel Oil
ICCT	International Council on Clean Transportation
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
MSA	Maritime Safety Administration
WMO	World Meteorological Organization
MSC	Maritime Safety Committee
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
WMU	World Maritime University

1 INTRODUCTION

1.1 Research Background

In the course of navigation, ships often pass through waters with complicated navigation conditions such as dense traffic areas, accident prone areas and ports. At the same time, weather conditions and human factors also change suddenly. Therefore, Zhang (2017) believes that on the ship's steering platform, due to the strict watch arrangement on the ship, the phenomenon of fatigue caused by excessive labor intensity are very common, However, this serious problem has not aroused the due vigilance and attention of most people in the shipping industry.

At present, technical downsizing and market downsizing have become a general trend. According to Wang (2009), a 12,000 DWT tanker needed 40 crew members in 1950, 28 crew members in the 1990s and 20 crew members after 2000. This undoubtedly increased the working intensity of the current crew and caused their psychological fatigue due to the lack of interpersonal communication.

Jim card（2001） points out that 80% of maritime accidents in the world are caused by human error, and Li（2003）points out that more than 50% of the man-made factors of maritime accidents are caused by the fatigue of maritime personnel. According to the Huang（2006）, the factor of "crew fatigue" accounts for 12% of the overall human factors, 15% of the key human factors, 12% of the external human factors and 14.1% of the internal human factors. Li（1996）more broadly classifies that the human factors of shipwreck accidents may be as high as about and have a direct or indirect relationship with crew fatigue. All these, data show that crew fatigue is an important and key factor of shipwreck. If the study on the on-duty labor intensity of the ship's officers is carried out to improve the on-duty condition of the crew, the fatigue condition caused by excessive labor intensity will be avoided or reduced, and the incidence of maritime

traffic accidents will be reduced.

At present, China has been recognized as a seafarer country, ranking the first in the world in terms of number of seafarers, training scale and capability. In terms of the number, China now has 1.55 million crew members, including 510,000 seagoing crew members, more than 1 million inland river crew members, and 170,000 senior seagoing crew members. With such a large crew, how to reasonably arrange and coordinate their working time and workload has become an important research content, especially in the context of human-oriented thought.

Previous studies on improving the working status of the crew have been carried out by strengthening crew management and increasing crew manning, etc. However, no attention has been paid to the studies on the working time and workload of the crew.

Ship manning to reduce, leading to mate the intensity of labor is increased while on duty, ship officer work in the case of high labor intensity, very easy to cause the ship officer fatigue phenomenon, long-term work under the condition of high labor intensity, will lead to the watchkeeper’s physical and psychological harm, cause the ship excessive fatigue, and even lead to ship officer produce chronic occupational disease. At present, although many experts have paid enough attention to the fatigue phenomenon of officer on watch and conducted in-depth studies on it, they have not paid enough attention to the related studies on the labor intensity of officer on watch when they are on duty, and the studies on it are still in the preliminary stage.

1.2 Research Significance

The research topic of this paper is to study the labor intensity of officer on watch on duty at sea and adjust and arrange the time of officer on watch on duty at sea according to the labor intensity of watch. In order to classify the on-duty labor intensity of officer on watch, the corresponding on-duty arrangement can be made according to different

grades of labor intensity, so as to reduce the working time of officer on watch in the environment of high labor intensity and relieve their physiological and psychological pressure.

The purpose of this article is based on the research of the ship the officer on the intensity of labor, considering the factors that affecting the officer on the intensity of labor, using the analytic hierarchy process (AHP) and fuzzy comprehensive evaluation method, to officer evaluation index system of the intensity of labor to build a ship, the ship officer to quantify the intensity of labor of duty.

The research of this paper can be used to classify the labor intensity of officer on watch on duty, and the results have the following practical significance.

Firstly,determine the degree of influence of various factors affecting the on-duty labor intensity of officer on watch, and adjust the on-duty labor intensity of officer on watch by controlling key factors.Secondly,classify the labor intensity level of ship officers on duty to make the arrangement of ship officers on duty more reasonable.Thirdly,reduce the working hours of officer on watch at higher labor intensity levels and reduce the pressure they bear.Fourthly,protect the physical and mental health of ship officers and reduce the probability of occupational diseases of ship officers;

Can provide certain reference for the shipping company to arrange the ship officer to work on the ship and rest on the ship;

It is of great significance to protect the healthy development of China's huge crew;

To study the prevention of crew fatigue from the perspective of officer on watch' labor intensity can provide a brand-new method to study and prevent the phenomenon of crew overwork.

1.3 Literature Review

At present, the domestic and foreign studies on the labor intensity of ship officers on duty are not very extensive, but the studies on the labor intensity and ship officers' fatigue in other fields are relatively in-depth. Here, this paper briefly introduces the current situation of these studies.

First of all, domestic and foreign research focuese on labor intensity:

Foreign studies on labor intensity are earlier than domestic studies. In Japan, the attention on labor intensity began in the 1850s (Hosokawa,1988), and some studies appeared successively (Tanaka and Tokunaga 1974; Nishiyama et al., 1979; Nakaseko et al., 1982; Ohara et al.1982). The research object of the intensity of labor, while also including engaged in high-intensity physical labor of the employees, but not completely put research focus on this type of job. It includes the study of personnel from all walks of life, for their labor intensity, work environment and psychological factors related to adaptability. The purpose is to improve the quality of staff work, but at the same time reduce to the staff health damage.

At present, many domestic scholars have published articles on the issue of labor intensity. In this article, only selected parts are chosen to give a brief introduction.

The method of fuzzy mathematics was applied in the evaluation of labor intensity(Jin and Ma,2007). By analyzing the fuzziness of labor intensity classification, according to the fuzzy set, in the process of operation energy consumption amount, oxygen consumption, heart rate, rectal temperature, sweat rate are determined. The factors established the grade of membership function of the different factors characterized according to the expert investigation method given the weight of each factor, got a fuzzy comprehensive evaluation model, and applied to the intensity of labor measurement

example, gives a reasonable measurement results. Wang(2007) discussed energy metabolism, oxygen consumption, pulmonary ventilation or heart rate hierarchical single physical labor intensity, labor intensity index or energy metabolism value classification work manual labor intensity, should consider the factors and how to establish scientific and reasonable method of classification. This paper proposes a method to calculate the oxygen consumption, lung ventilation and energy metabolism rate by measuring the heart rate, so that the grading standard of physical labor intensity can be widely used. Through statistical analysis, the average values of heart rate, oxygen consumption, energy metabolism rate, pulmonary ventilation volume, oxygen pulse and oxygen ventilation equivalent under each load, as well as the maximum heart rate, maximum oxygen consumption and maximum ventilation value of men and women were obtained, and the differences were analyzed. The relationships among heart rate, oxygen consumption, pulmonary ventilation and energy metabolism rate were fitted with the curves. Finally, the paper used the heart rate, oxygen consumption and energy metabolism rate as indicators to divide the physical labor intensity level.

Secondly, the current research status of ship officer fatigue at home and abroad are also discussed.

Many countries have given considerable attention to the phenomenon of ship officer fatigue, and many experts and scholars at home and abroad have conducted many studies on the phenomenon of ship officer fatigue.

According to Resolution a.772 18 of the international maritime organization, the factors that lead to crew fatigue can be roughly divided into four aspects: crew, ship, management and external environmental factors.

US coast guard consultants have come up with a fatigue assessment. Currently, the procedures and training followed by the international Shanghai ombudsman are

included in the study, which also includes a more comprehensive human factors investigation procedure. A section of the study was devoted to the problem of fatigue. In the report, a new scientific method for assessing the possibility of fatigue or the cause of marine accidents is proposed. Based on the statistical analysis of the accident data in the coast guard database, the method applies the "fatigue evaluation index," and the formula can be listed as follows:

FI S= (W H×6.1) - (S H×4.5) +(S×21.4)

Where W H is the working hours within 24 hours before the accident;

S H is the sleep time within 24 hours before the accident;

S number of fatigue symptoms experienced while on duty before the accident.

There are seven types of fatigue symptoms: forgetfulness, slowness of movement, difficulty opening eyes, restlessness, muscle tension and the desire to sit and lie down.

The evaluation method is like this. if FIS > is 50, there is an 80% probability that fatigue is the cause of the accident. If FIS is less than 50, there is an 80% chance that fatigue is not the cause of the accident.

At present, many experts and scholars in relevant fields in China have also carried out research on the fatigue of officer on watch.

In the comprehensive evaluation of crew fatigue factors and safety. Chen(1998) analyzed the impact of crew fatigue on ship safety navigation by taking the ship as an evaluation system. Considering that different positions of the manning staff have different influences on the safe navigation of the ship, the system is divided into several sub-systems according to the position of the ship officer. The same index is used to evaluate the safety of each subsystem. Finally, the safety of the whole system is determined according to the weight relationship of each subsystem.

Chen(2002) analyzed the factors influencing the crew fatigue from the crew,ship,Environment and management four aspects, then put forward some measures for controlling crew fatigue. Liu(2006) proposed the crew fatigue factor analysis index system from the crew, ship, environment and management four aspects, and established the hierarchical analysis model based on the unascertained information. By using the three-value reciprocal scale method and the principle of correlation transformation, the attribute judgment matrix is obtained, and the influence coefficients of each sub-factor on crew fatigue factors are obtained. From the basic elements of environment, Miu and Wu（2007）analysis of personal physical, psychological and technology's influence on the factor of driving fatigue, puts forward to comprehensive construction environment difference of driving fatigue factor index system, applying hierarchical analysis method to evaluate the system.

At present, domestic and foreign studies on duty for Marine officer strength study is not very comprehensive, and they have for preventing ship on officer fatigue on duty are mostly to strengthen bank supervision, management and other aspects, with respect to ships from adjusting the officer's duty arrangement to prevent the ship haven't in-depth research of officer fatigue.

1.4 Research aims, and processes

This paper studies the classification of labor intensity of ship officers and the establishment of models.

There are many factors affecting the on-duty labor intensity, which need to be considered from the macro perspective.

The intensity of the physical factors and psychological factors are the two main aspects.

The main aim of this paper are as follows. First, the introduction of the concept of ship officer on duty, the intensity of labor, the influencing factors and the relationship between ship officer fatigue, from affecting the officer on the intensity of labor of physiological and psychological factors carry out specific analysis on two aspects, summarizes the main factors of affecting the officer on the intensity of labor. And then, using the analytic hierarchy process and fuzzy comprehensive evaluation method, the method of establishing a ship officer on the intensity of labor hierarchy evaluation model, determine the navigator on the intensity of labor in the end, according to the navigator on the intensity of labor hierarchy evaluation model, and combined with the status quo of the current Marine officer on duty arrangement, flexible scheduling method was proposed to reduce the labor intensity of higher for ship officer's physical and psychological effects, avoid or reduce shipping officers due to the intensity of labor is too large and the fatigue phenomenon.

The research will be conducted by the following five steps.

First the current research on ship officer labor intensity enough in-depth, ship officer on duty some concepts such as the intensity of labor is not clear definition, but other field investigations of the intensity of labor is relatively broad, this paper according to the status of research on other fields for the intensity of labor, for Marine officer the labor intensity of some basic concepts on duty gives some reference definition.

Secondly,analyze the factors affecting the on-duty labor intensity of officer on watch, and select the main factors as the final evaluation indexes for the on-duty labor intensity for officers on watch.

Thirdly, use the method of fuzzy comprehensive evaluation to comprehensively evaluate the on-duty labor intensity, and then use the analytic hierarchy process to determine the weight of each evaluation index.

Fourthly, determine the membership functions of each evaluation index.

At last, according to the evaluation model of labor intensity established and the current common provisions on ship officer's on-duty, the system of ship officer's flexible on-duty arrangement based on ship officer's on-duty labor intensity is proposed.

2 Overview of the labor intensity of ship officers on duty

2.1 Introduction to the on-duty labor intensity of officer on watch

At present, the domestic and foreign studies on ship officer's on-duty intensity are still in the initial stage, most of which are about ship officer fatigue. Based on the previous studies on ship officer fatigue, this paper makes some studies on the labor intensity of ship officer's on-duty.

2.1.1 Concept of on-duty labor intensity of officer on watch

At present, there is no clear concept about the labor intensity of officer on watch on duty.

In the exploration of labor intensity theory, a general definition is given to labor, that is, the degree of tension of laborers in the process of labor, that is, the degree of "tired" as people say in life.

In the fuzzy measurement of labor intensity, labor intensity refers to the intensity of labor. That is, the amount of labor consumed at the same time. The more labor a worker consumes at the same time, the greater the labor intensity and vice versa.

In a preliminary study of quantitative analysis of labor intensity, it is pointed out that labor intensity usually refers to the intensity and intensity of labor, and to the consumption of labor (or labor force) per unit of time. This definition is more general, ignoring the psychological load of labor, only applies to physical labor, and is not suitable for comprehensive measurement. Labor intensity is not only the consumption in the physiological sense, but also the burden in the psychological sense. Therefore, in this paper, labor intensity is defined as the degree of physiological loss and the intensity of psychological load of laborers engaged in labor per unit of time.

Labor intensity is defined as the amount of labor per unit time, including muscle energy and nerve energy paid. It is a comprehensive index, which should reflect both the physiological and psychological load of workers.

Through the definition of the above, it can be seen that labor intensity is not only related to the physiological loss of laborers but also related to the psychological load. Therefore, labor intensity is defined as labor intensity, which refers to the degree of physiological loss and the intensity of psychological load of laborers engaged in labor within a unit of time.

As a ship officer, physiological loss and psychological burden occur in different degrees in the course of duty. Therefore, according to the definition of labor intensity, this paper defines the on-duty labor intensity of officer on watch as the degree of physiological loss and the intensity of psychological load borne by officer on watch in unit time when they are on duty on board.

2.1.2 Labor intensity measurement standard

In economic activities, for the labor intensity of the comprehensive subjective and objective factors, there are currently roughly three standards or measures. These three standards have their own characteristics, and their own advantages and disadvantages in different circumstances.

The first is the subjective evaluation standard, that is, from the subjective feelings of the workers to evaluate the intensity of labor. This kind of standard comes from individual feeling. The operation is simple, more reflecting the main body position of laborer, and paying attention to laborer welfare. However, this standard is based on the subjective feelings of the evaluation subject, and is closely related to the individual's physique, experience, culture, quality, belief and values, etc., so the comparability

between individuals is relatively poor. Therefore, the standard is more suitable for measuring and comparing the labor intensity of the same labor subject in different labor processes.

The second is indirect measurement standard, that is, indirect measurement of labor intensity through other factors that are related to and measurable in the labor process. Indirect measurement standard is often used in production, its advantages are simple and easy to use, objective and accurate, emphasis on work performance, not different from person to person. The results are comparable, more certain, especially suitable for different labor subjects engaged in the same labor when the measurement and comparison. However, because the indirect measurement standard indirectly reflects the labor intensity through the inspection of the material, it leaves the labor subject and cannot truly reflect the labor cost, fatigue degree and subjective effort of the laborer due to many interfering factors. It is also easy to ignore the laborer's welfare, resulting in excessive labor intensification.

The third is the physiological measurement standard, that is, through the physiological response of the workers to measure the intensity of labor. The human body is not only the undertaker of human sports, but also the material basis of human spiritual activities. The way and degree of body movement must be reflected as certain physiological phenomena, and mental activities can only be realized through certain physiological processes, so there will be some physiological reactions. Through such measurement, it can provide an objective method for the measurement of labor intensity and take into account individual differences. However, the technical and environmental conditions required for physiological measurement are very demanding, and even physical labor intensity is difficult to economically and practically conduct on-site measurement.

Three kinds of labor intensity can be obtained by measuring the same labor process based on three measurement standards, namely, the labor intensity of subjective feeling,

the labor intensity of objective reflection and the labor intensity of physiological reaction. These three kinds of labor intensity are in general consistent, but there will be some big or small deviation. In addition, people with different physical and psychological qualities experience different labor intensity and physiological response under the same objective conditions. These three kinds of standard which person give priority to, what person is complementary cannot be generalized. In the analysis of actual labor process, there are different specific purposes for measuring labor intensity, and appropriate standards or combinations of standards should be selected according to the characteristics of different purposes.

In addition, there are some grading standards for labor intensity, commonly used in foreign countries: Christensen standard, according to the average of European and American people, weight of 70kg, body surface area of 1.84 ㎡. It is divided into five grades: light, medium, strong, strong and strong. According to the energy metabolism rate, the evaluation labor intensity index released by the Japanese institute of labor science is divided into five grades: A, B, C, D and E. The international bureau of labor released six levels of indicators in 1983. In 1983, China formulated the national standard for grading physical labor intensity according to the labor intensity index GB3869.

2.1.3 Connotation and extension of the labor intensity of ship officers on duty

According to the three measures of high labor intensity mentioned above, the connotation and extension of the on-duty labor intensity of officer on watch can be understood from the following four aspects.

2.1.3.1 The physical labor intensity and mental labor intensity of officer on watch on duty

When a ship officer is on duty, it is not only a process of coordinating the movements

of his limbs and organs, but also a process of concentrating his willpower and bearing mental pressure. The frequency and strength of body movements determine the intensity of labor, and the time to concentrate willpower and mental pressure also determine the intensity of labor. Therefore, the on-duty labor intensity of officer on watch can be divided into mental labor intensity and physical labor intensity. However, in reality, mental labor intensity and physical labor intensity are not completely separated. All kinds of specific labor processes are the combination of mental labor and physical labor to a certain extent. Therefore, the corresponding labor intensity is also a combination of mental labor intensity and physical labor intensity.

2.1.3.2 Stress degree and frequency of on-duty work of officer on watch

The intensity of labor in the process of ship officer's watch is reflected in the intensity of the moment and the frequency of labor. If the instantaneous tension degree of blacksmithing labor is high, but the frequency of the action is low compared with typing, and the labor that carry a load is to maintain high tension state for a long time, it is durative. In general, it is difficult for labor with a high degree of tension to have a high frequency, and it is difficult for labor with a high frequency to bear a high degree of tension. Therefore, it is necessary to consider the intensity and frequency of ship officers' labor when understanding the intensity of officer on watch' on-duty labor.

2.1.3.3 Local concentration of on-duty work of officer on watch

Almost no labor can mobilize the various tissues and organs of the human body in a balanced way. There are always some individual tissues and organs that undertake a greater amount of activity and intensity. When people work, they tend to feel tired only because some main parts of the work are too tired. When the labor is more balanced by each part of the body to share, and in the psychological and physiological load between the appropriate arrangements, people will not easily tired and even feel happy. Generally speaking, the greater the degree of concentration in the local area, the stronger the fatigue caused by the same weight will be more likely to cause fatigue on

one shoulder than on both shoulders. Therefore, the intensity of ship officer's on-duty labor should be adjusted according to the degree of local concentration of ship officer's on-duty labor. The higher the degree of concentration, the greater the intensity of ship officer's on-duty labor.

2.1.3.4 The content of the on-duty work of the ship's officer is monotonous

The monotonous repetition of work day after day can make people depressed and lack motivation. This will not only increase the subjective feeling of labor intensity, but also reflect the other factors involved in the labor process, which is mainly reflected in the decline of production efficiency. Through long-term accumulation, workers will also be manifested in physiological and psychological adverse reactions. In the analysis of labor intensity in a short period of time, the monotony and richness of labor content are not important, while the monotony of labor content should be taken into account when analyzing labor intensity in a long period of investigation. The drab degree of labor content should also become the adjustment factor of labor intensity. The greater the drab degree is (the more repetitive and tedious), the greater the labor intensity should be. During most of the time when the ship's officer is on duty, the monotonous work is carried out, so the influence of the monotonous degree of the ship's officer on duty should be considered in the evaluation of labor intensity.

2.2 Influencing factors of on-duty labor intensity of officer on watch

By introducing the concept of ship officer's on-duty labor intensity, it can be concluded that the factors affecting ship officer's on-duty labor intensity can be divided into physiological factors and psychological factors. The following is a further analysis of these two major factors:

2.2.1 Physiological factors

There are many physiological factors that affect the labor intensity of officer on watch

on duty, which are mainly divided into the following aspects.

In the case of the mission, some changes in the body of the ship officer were caused by some minor problems, such as the ship officer's slight cold, which had a certain impact on the body of the ship officer, but did not reach the point where he could not carry out normal watch. At this time, the ship's officer's physical health condition is different, and his experience of the situation on duty will be different.

Firstly, standardization of working procedures.

A large part of the work for a ship's officer on board is to work in accordance with the relevant work procedures.

If the working procedures of standardization degree is high, ship officer can clearly know that work steps are finished and matters needing attention.Navigators can better and more easily to finish their task if the ship standardization degree is not high, the working of the ship the officer at the completion of their work when they need to put in more effort. Therefore, the degree of standardization of work procedures on the ship will have an impact on the labor intensity experienced by officer on watch when they are on duty.

Sencondly,rationality of work allocation.

All the work on the ship is assigned by the senior officer in charge, and then completed by the crew.

Whether the arrangement is reasonable or not also has a very important influence on ship officers. If the allocation is reasonable, the officer's labor are on average and each person's level of fatigue is not large. The impact is relatively small, If the allocation is

not very reasonable, some ship officer workload is bigger, some ship officer workload is small. This can cause more fatigue, if the officer had not rested well in time. Moreover if he is on duty to ship bridge, its physiological intensity of labor will be relatively large.

Thirdly,age status

Ship officers are the same as ordinary people, with the growth of age, the physiological characteristics of ship officers

According to research, older people are generally more likely to give birth than younger ones

This means that older people experience more physical stress in the same environment.

Fourthly, sleep status

The human body mostly relieve the pressure of the bear, through sleep,sleep condition is good or bad

Every tissue function of the human body will be affected by sleep. The sleep condition of the ship's officers on board also has an impact on the ship's officers when they are on duty. Ji(1999) through to the landing craft air crews in the sea for a long time and take a period of medical students and the sea voyage and investigate at ordinary times, discovery crew sailing and sailing schedule 'sleep questionnaire score was significantly lower than control, avowed fatigue grading and evaluation questionnaire scores students is significantly higher than control, neural behavior than students a number of test results is high, the index during the navigation period no significant improvement in the jackboots, sleep and subjective fatigue status and multiple neural behavior index had significant correlation.

2.2.2 Psychological factors

There are also many psychological factors that affect the labor intensity of officer on watch on duty, which are mainly divided into the following aspects in this paper:

First, recreational facilities allow the ship's officers to relax from their busy work hours and interact with the crew.

When the entertainment facilities are complete, and entertainment activities are well carried out, the relationship between the crew members will be harmonious, the atmosphere of the whole ship will be active, and the crew's work enthusiasm will be relatively improved. On the contrary, the lack of recreational activities on the ship can easily lead to the crew's depression. Therefore, recreational facilities on the ship are very important to the psychological impact of the crew.

Second, the world maritime organization makes it clear that seafarers are good people except for instruments and equipment that are safe to operate

International relations also help to ensure the safe navigation of ships. Seafarers form a unique social organization group with a special occupation as a bond, which is quite different from the interpersonal relationship between the people on land. Seafarers work on ships for a long time, often far from busy and noisy cities, and form a small social group of a dozen or more people. In this special "small society of pure men", the monotonous and lonely life at sea makes the seafarers want more to be cared for, cared for and cooperated with each other by the seafarers, so as to establish and maintain good interpersonal relationship with the seafarers. However, the mobility of the seafarers, the requirement to master one or more foreign languages for communication, and the psychological conflicts caused by different customs and interests made it more difficult to deal with each other. Due to the special circumstances of the ship, seafarers still live

a group life in their spare time. No matter how much you like or dislike the members of the group, you have to meet them every day. In this case, the importance of interpersonal relationship to every seafarer is self-evident. Different interpersonal communication status of the crew, its psychological quality and psychological endurance are not the same.

Third, quality of work and residence, the working and living places of the ship's officers are the working environment and rest of the ship's officers

If the officer's working environment is good, ship officer on duty will be more comfortable and its sustained labor intensity will be reduced on the contrary.If the ship's working environment is bad, the officer on duty's psychological feeling will be worse, the feeling of the intensity of labor will be stronger. Similarly, the quality of the living space will also have an impact on the rest of the ship's officers. The rest of the ship's officers will directly affect the extent to which they can bear the workload, and will also have an impact on the intensity of labor they feel when they are on duty.

Fourth,during the voyage of a ship at sea, an important task for the ship's officers is to avoid collision with other ships. The number of other ships around the ship, that is, the traffic density around the ship, is an important factor affecting the collision of ships. If the traffic density around the ship is large, the pressure on the ship's officers when they are on duty will be large, and the labor intensity they will feel will be strong. If the traffic density around the ship is small, the pressure on the ship's officers will be small, and the labor intensity they will feel will be weak. Therefore, the traffic density around the ship is one of the important psychological factors that influence the on-duty labor intensity of ship officers.

Fifth, the complexity of the route.

Sailing at sea when the traffic conditions are complex, such as in fishing intensity in the high seas or in and out of the, narrow waterway and harbor, may adds risk to operation, since officers need to constantly use navigation instrument on board and related auxiliary equipment to avoid the perils of the sea accidents. And the officer must highly concentrated, observe adjacent obstacles, and respond to the navigation environment changes, etc. All these cause burden to officers on duty.Therefore, there is a direct relationship between the mental labor intensity of ship officers and the complexity of the navigation waters.

Sixth, hydrometeorological conditions, ships sailing at sea often encounter bad weather and bad hydrological conditions, such as fogs, typhoons,etc.

In case of severe weather, such as strong winds and currents, officers on watch should pay more attention to the situation around them and make judgments as soon as possible. Therefore, the hydrometeorological conditions on the sea will also have an important impact on the mental labor intensity of ship officers.

Seventh, skills and experience of ship officers.

As the saying goes, "a man of skill is bold." The ship's officer encountered the same situation while on duty.

They have different levels of experience and skill, react differently to situations and experience different levels of stress. An experienced and skilled captain and a third officer who has just stepped into the position must have different psychological feelings and reactions when dealing with the same situation encountered by the ship, and the labor intensity they feel is also different.

Eighth, overall staffing level.

Generally speaking, the overall level of the crew is high, and the ship's officers will be at work and at rest.

More relaxed, the mental state when on duty is in good condition.The feel of the intensity of labor will be weaker if the overall ship manning level is lower, navigator both in work and the rest will be more nervous, will lead to the psychological state is bad when on duty, feel the intensity of labor is stronger.

Ninth, degree of ship automation.

With a high degree of automation on board, the ship's officers have less manual labor to do.

The physiological tissue will bear less pressure, and be more relaxed. With the low degree of automation of equipments on board, the ship's officers will have to do more physical labor, and the physiological tissue of the ship's officers will bear more pressure, and their psychology will be more nervous. Therefore, the degree of ship automation is closely related to the labor intensity of officer on watch on duty.

Tenth, the vessel situation.

Like the degree of ship automation, the age of the ship has an important effect on the labor intensity of the ship's officers. If the marine equipment is in good condition and the ship maneuvering performance is good, the officer can fully rely on automation of the ship's equipment. If the vessel is longer, the status of marine equipment is in poor and ship maneuvering performance is not good due to ageing state of the ship, the officers will continually use other means to make up for the drawbacks and the officer on watch in the psychological sense of the intensity of labor increases.

2.3 Relationship between labor intensity and fatigue of officer on watch

Excessive labor intensity is one of the main factors that lead to the fatigue of the crew on duty. The intensity of labor directly affects the working state of the ship's officers when they are on duty. Therefore, it is very necessary to study the relationship between the two.

2.3.1 Definition of ship officer fatigue

Because of the complexity and multifactorial nature of fatigue production, researchers have different perspectives on, the concept of fatigue.

Lagrange (1904) : organ function decreases during overwork, accompanied by a sense of illness;

Mosso (1915) : a toxic phenomenon caused by the product of cytochemical changes;

Chailey-bert (1946) : fatigue is a phenomenon of decreased excitability of tissues and organs, which is a defensive response.

Katsumoto (1964) : fatigue is the inhibition of higher nerve centers;

The fifth international conference on exercise biochemistry (Boston 1982) defines fatigue as the physiological process by which an organism is unable to continue functioning at a particular level or the ability of its organs to function steadily.

Jane c.s. (1999) points out that the "fatigue" is caused by excessive mental and physical use of a complex physiological phenomenon, it is a kind of normal human body movement rule, the external symptoms easy to doze off, concentration, and the human body inner symptoms can make the reaction also slow the parasympathetic nerve,

sympathetic nerve activity weakened, enhancement, and so on. There is no medical definition of "fatigue," which equates fatigue with sleepiness.

Seen from the above definition of fatigue, the first five are mainly limited in the aspect of the body's physiological and physiological change that occurs fatigue or due to physiological changes caused by fatigue. However, Jane(1999) has been considering the effects of psychological factors on fatigue.It is more accord with practical situation, because in addition to physiological changes psychological factors will also produce the phenomenon of fatigue. Therefore, it can be said that fatigue is a physiological or psychological phenomenon produced by people after high intensity or long continuous activities, which is manifested as physical drowsiness, mental burnout, attention decline and work efficiency decline.

2.3.2 Relationship between the on-duty labor intensity of ship officers and ship officers' fatigue

From the definitions of the intensity of labor and fatigue, the intensity of labor for the officers on duty refers on the ship per unit time when performing a task on duty on the degree of physical loss and psychological load of ship officer fatigue is to point to is the officer work on the ship load and living environment, under the comprehensive function of human body function and decline in the ability to work, to some degree, the physiological and psychological phenomenon is reflected in the human body by excessive or strong stimulation, movement caused by the function of the cell, tissue or organ or ability to respond to abate.

It can be seen from the definitions of the two that the labor intensity of watch on duty is the physiological loss and psychological load of officer on watch on duty per unit time. When the ship officer's on-duty labor intensity accumulates continuously to a certain degree in a period of time, it will cause the ship officer fatigue.

3 Establishment of comprehensive labor intensity evaluation model for officer on watch

The evaluation model for the on-duty labor intensity of officer on watch mainly includes the following parts:

3.1 Establishment of an evaluation system for the on-duty labor intensity index of ship officers

In combination with relevant reference materials and through consulting relevant experts' opinions, this paper proposes that the "labor intensity evaluation index system for officer on watch" is mainly composed of physiological factors and psychological factors. The main evaluation indexes proposed in this paper are as follows.

Psychological factors index include sleep status, health status, working procedures of standardization, the rationality of the distribution of work, and age. Physiological psychological factors indicators include the quality of work and living space, entertainment facilities, interpersonal situation, ship traffic density, complexity of route, the hydrological and meteorological conditions, the skills and experience, the overall level of manning, automation degree, age of the ship.

In the form of consulting and issuing questionnaires to experts, a total of questionnaires were issued and received back. Through the analysis of the survey, the expert's opinion is that the standardization degree of the work procedures, the rationality of the work distribution, the quality of the work and living space, the recreational facilities on the ship and the overall level of the manning are not very important and can be ignored. At the same time, the expert suggested to add a physiological factor indicator of nutritional status, and a psychological factor indicator of responsibility and work attitude. The final evaluation indicators are as follows:

The indicators of physiological factors include: health status, sleep status, age status, nutrition status, psychological factors include interpersonal relationship status, ship traffic density, route complexity, hydrometeorological conditions, skills and experience, sense of responsibility and work attitude, ship automation degree, ship age.

3.2 Establish the evaluation set V for the on-duty labor intensity of officer on watch

The comment set established by the evaluation index for the quantitative analysis of the on-duty labor intensity of officer on watch is divided into three levels, which can be expressed as:

V=（V1，V2，V3）

The corresponding labor intensity of the ship's officer on duty is：

V=（V1，V2，V3）

=（1，2，3）

= (normal, strong, strong)

3.3 Construct pairwise comparison judgment matrix

Ship officer on duty the intensity of labor, the author of this paper the evaluation index system, set up as shown in appendix two comparative judgment matrix, calculating the weight of each evaluation index.

Generally speaking, each element in the factor set U has different degrees of importance in the evaluation, so it is necessary to give different weights to each element Ui according to its importance. Among them, element ai (I =1,2... , n) is the degree of factor importance, which should generally meet the normalization and non-negative conditions:

3.4 Determination of weights

In this paper, a two-tier evaluation index system has been established previously, and by means of questionnaire (see appendix B) survey, experts are invited to make pair-wise comparison of the mutual importance of evaluation indexes and construct an expert judgment matrix.

3.4.1 Hierarchical single sorting and consistency test

A total of 10 experts were sent questionnaires, 10 of which were sent out and 10 were returned.

Through sorting and relevant calculation, all experts' judgment matrices meet the consistency requirements. Due to the limitation of space, only one expert's questionnaire filling situation and the calculation result of judgment matrix are listed in this paper.

Table 1 – Judgment Matrix for Evaluation Index in the first floor

	Physical factors U1	Psychological factors U2
Physical factors U1	1	1
Psychological factors U2	1	1

Calculate the weight vector Wi= (0.5,0.5) according to the sum product method introduced previously.

Table 2 – Judgment Matrix for Evaluation Index of Psychological factors

	U11	U12	U13	U14
U11	1	1/7	1/5	1/3
U12	7	1	1/3	3
U13	5	3	1	1/3
U14	3	1/3	3	1

Also according to the previous method, the weight vector Wi=(0.053,0.344,0.319.,0.285) was calculated and the maximum characteristic root and CR were obtained for testing: λmax=4.2， CI=0.667， RI=0.90, CR=0.074＜0.1.

Table 3 – Judgment Matrix for Evaluation Index of Psychological factors

	U21	U22	U23	U24	U25	U26	U27	U28
U21	1	1/3	1	5	1	3	1	3
U22	3	1	1	3	1/3	1	1	1
U23	1	1	1	3	1	3	3	1/3
U24	1/5	1/3	1/3	1	1/3	1/3	1/3	1/3
U25	1	3	1	3	3	3	3	3
U26	1/3	1	1/3	3	1	1	1	1
U27	1	1	1/3	3	1	1	1	1
U28	1/3	1	1/3	3	1	1	1	1

Calculate the weight vector Wi=(0.171, 0.142, 0.161, 0.0404, 0.2215, 0.084, 0.095, 0.084)

The maximum characteristic root was obtained and tested: λmax=8.63， CI=0.09，RI=1.32, CR=0.068＜0.1.

The above calculation steps are used for each expert questionnaire, and the judgment matrix of all experts meets the consistency requirement after calculation. Then, take the value of average operation as the final value of weight for the weight results obtained, and the weight of each evaluation obtained is as follows:

Table 4 – Weight of each index in the first floor

Index	U1	U2
Weight	0.42	0.58

Table 5– Weight of each index in the second floor to the first floor indicator

	U1	U2
U11	0.064	0
U12	0.33	0
U13	0.321	0
U14	0.285	0
U21	0	0.164
U22	0	0.143
U23	0	0.148
U24	0	0.063
U25	0	0.208

U26	0	0.087
U27	0	0.091
U28	0	0.096

3.4.2 hierarchical total sorting and consistency test

The sorting weight of the relative importance of each level element to the overall goal of the previous level is calculated, which is called hierarchical total sorting. The synthetic sequence is calculated from top to bottom. Hierarchical single sort satisfies the consistency requirement, and its total sort can generally get more logical sort. The overall weight value and the ranking of factors are shown in the table:

Table 6– the table of the overall priority weights and factors to sort

Index	Priority	Sort
U11	0.0269	12
U12	0.1386	1
U13	0.1348	2
U14	0.1197	4
U21	0.09512	5
U22	0.08294	7
U23	0.08584	6
U24	0.03654	11
U25	0.1206	3
U26	0.0505	10
U27	0.05278	9
U28	0.05568	8

Consistency test of the total sorting:

$$CI=\sum_{i=1}^{2} CuiCIui=0.08$$

$$RI=\sum_{i=1}^{2} CuiRIui=1.1436$$

$$CR=CI/RI=0.070<0.1$$

Through the above tests, the total order of the hierarchy also has a satisfactory consistency.

3.5 establishment of evaluation mathematical model

Through the previous study, the weight of relevant evaluation indexes was determined. Through the study of relevant references and combined with the actual research in this paper, the weighted average method was adopted in this paper to carry out inverse fuzzy operation, and the evaluation mathematical model of ship officers' labor intensity was established as follows:

$$V=\sum_{i=1}^{4} AiKi+\sum_{j=1}^{6} BjKj$$

Among them:

Ai refers to the index weight of the ith physiological factor;

Ki refers to the evaluation value of the ith physiological factor;

Bj refers to the index weight of the JTH psychological factor;

Kj refers to the evaluation value of the JTH psychological factor.

Among them, Ki and Kj can be determined through the membership functions of evaluation indicators determined in chapter 4 below.

4 The determination of the membership function of evaluation index

Since this article studies the content of evaluation indexes for different shipping officers have different influence, the same environment for different ship officer it considers the influence of the intensity of labor is not the same, therefore, this article will all evaluation indexes as qualitative evaluation index, according to the situation by the captain on board according to the corresponding membership function is determined. In this paper, the membership function of the evaluation index is established according to the physiological and psychological factors.

4.1 Determination of membership function of physiological factor evaluation index

Physiological factors determine the state of the seafarers' body tissue, which is the carrier for the seafarers to feel various pressures, and has a great influence on the seafarers' labor intensity. The evaluation indexes of physiological factors include sleep status, health status, age status and nutrition status.

4.1.1 Determination of comment set V of physiological factor evaluation indexes

The evaluation set V of physiological factor indicators is also divided into three levels, which can be expressed as

V is equal to V1, V2, V3.
= (normal, strong, strong)

4.1.2 The determination of physiological factor evaluation index standard

1. Sleep status

The sleep condition affects the recovery of the body tissue of the crew and has a great influence on the endurance of the crew. Specific criteria are as follows:

Strong: good sleep condition, the ship's officer can get a good sleep on board;

General: the sleep condition is general, the basic sleep of the ship's officer can be guaranteed;

Poor: poor sleep condition, ship officer can't get basic sleep on board.

2. Health status

The health status of seafarers directly affects the stress bearing and feeling of seafarers' body tissues, which is an important factor affecting the physiological factors of seafarers. Specific criteria are as follows:

Strong: in good health;

General: in general health;

Poor: in poor health, e.g., sick.

3. Age status

The physical quality of different ages of the crew is, also very different. With the increase of age, the physiological tissue of the crew also changes, and their physical state of stress bearing and feeling also changes with age. Specific criteria are as follows:

General: the crew is young and energetic;

Strong: crew age is average, crew energy is average;

Strong: the crew is older and less energetic.

4. Nutritional status

The quality of the nutritional status of the ship directly affects the health of the crew, the state of the physiological tissue of the crew, and the intensity of labor they feel. Specific criteria are as follows:

General: the nutritional status of the ship is relatively good, the diet is relatively reasonable, the crew diet is relatively rich;
Strong: the nutritional status of the ship is general, the diet is general, the crew's diet is not too rich;
Strong: poor nutrition on board, unreasonable diet, monotonous diet for the crew.

4.2 Determination of evaluation index function of psychological factors

The influence of psychological factors on the working intensity of crew on duty is as important as or even more important than the physiological factors. The evaluation indexes of psychological factors in this paper include interpersonal communication, ship traffic density, route complexity, hydrological and meteorological conditions, skills and experience, sense of responsibility and work attitude, ship automation degree and ship age.

4.2.1 Determination of comment set V of evaluation indexes of psychological factors

The evaluation set of psychological factor evaluation indicators is also divided into three levels, which are expressed as:

V is equal to V1, V2, V3.

= (normal, strong, strong)

4.2.2 Determination of evaluation criteria for psychological factors

1. Interpersonal communication

The interpersonal communication status reflects the psychological character of crew members at ordinary times. In this paper, the influence of interpersonal communication on crew members' on-duty labor intensity is divided as follows:

Strong: good interpersonal communication, good relationship between the ship's officer and most of the other crew members;

General: average interpersonal communication, average relationship between the ship's officer and most of the crew on the other ships;

Poor: poor interpersonal communication, poor relationship between the ship's officer and other crew members.

2. Ship traffic density

The ship traffic density in navigable environment has different influence on the crew's labor intensity. The specific criteria for its influence on labor intensity are as follows:

Strong: ship traffic density is small, officer on watch should keep some attention;
General: ship traffic density is large, officer on watch should pay enough attention;
Strong: ship traffic density, ship officers to maintain high vigilance.

3. The complexity of the route

The complicated situation of the route directly affects the psychological state of the crew when they are on duty, and the psychological pressure of the crew when they are sailing the complicated route is much greater than that when the situation of the route is normal. In this paper, the degree of its influence on the on-duty labor intensity of crew members is divided as follows:

General: good condition of route waters;
More complex: the condition of the route water is general, there may be some shoals, reefs, etc.;
Complex: the condition of the route water is not good, surrounding shoals, reefs and other obstacles to navigation more.

4. Hydrometeorological conditions

Hydrometeorological conditions such as the accuracy and safety of ship navigation of the role is very big, the crew's psychology

The degree of labor intensity affected by it is divided as follows:
Strong: good weather conditions, low sea wind and visibility, small water flow;
General: meteorological conditions are general, the sea wind is small, visibility condition is general, water flow is general;
Poor: weather conditions are poor, the sea wind or visibility is poor or water flow.

5.Skills and experience

The seafarers' skills and experience determine their ability to deal with emergencies and also influence them.

Based on the psychological pressure of the crew, this paper divides its influence on the on-duty labor intensity of the crew as follows:

Strong: rich in skills and experience, high skill level of ship officers, ship officers have rich working experience on board;
General: average skills and experience, average skill level of ship officers, not working experience on board
Very rich;
Poor: poor skills and experience, poor skill level of ship officers, lack of work experience on board.

6. Responsibility and work attitude

The crew's responsibility and work attitude have great influence on the ship officer's performance on duty

The specific classification criteria for the influence of labor intensity are as follows:
Strong: ship officers have a strong sense of responsibility and a serious work attitude;
Genenral: officer on watch have general sense of responsibility and general working attitude;
Poor: officer on watch have poor sense of responsibility and poor working attitude.

7. Degree of ship automation

The influence of ship automation degree on crew's psychological endurance is divided as follows:
General: the ship automation degree is good, most of the time basically do not need the ship operator to operate;
Strong: the ship automation degree is general, sometimes also need the ship officer to carry out some small operations;
Strong: the ship automation degree is poor, need the ship officer to carry out a lot of

operations.

8．Vessel

The age of the ship will also have an impact on the psychology of the officers on duty. The specific classification criteria are as follows:

General: the ship is relatively new, the equipment on board is good, the ship handling performance is good

Strong: the ship has been in operation for a period of time, the equipment on board is general, the ship's handling performance is general

Strong: the ship has been in operation for a long time, the equipment on board is aging, and the ship's handling performance is poor.

4.3 Subjection function of the ship's on-duty labor intensity evaluation index

This paper takes into account the grade of the evaluation index of the ship's officer's on-duty intensity, which is divided into three levels, respectively shown in the table

Indicating that the ship's on-duty labor intensity is general, the ship's on-duty labor intensity is strong, the ship's on-duty labor intensity is strong.

In this paper, the evaluation index are qualitative evaluation index."good, better, general" or "good, general," such as the evaluation of expressions, and according to its influence on strength of ship officer on duty, respectively by the evaluation score 1, 2, 3, and the matching index level at each phase in the level standard between evaluation score, separately for each.

The values 1.5 and 2.5 between the integer levels correspond to them.

According to the above analysis, the scoring standard of the evaluation index of ship officers' on-duty labor intensity can be integrated.

5 Watch arrangement based on labor intensity of officer on watch

5.1 Current regulations governing the on-duty of ship officers

5.1.1 Relevant provisions of the international maritime organization

The stcw78/95 convention, formulated by the international maritime organization, is an international convention on certification, training and watchkeeping of seafarers. For The crew scheduling rules in the rule stipulated in A - VIII / 1 is as follows: the crew on duty within 24 hours should be have at least 10 hours of rest; Breaks can be divided into no more than two periods, one of which should be at least six hours long. The minimum time of 10 hours may be reduced to no less than 6 consecutive hours, provided that the reduction shall not exceed 2 days and that the rest time provided within 7 days shall not be less than 70 hours in case of emergencies, exercises or other exceptional work.

5.1.2 Relevant provisions of the international labor organization

ILO Convention No.180 (convention on seafarers' working hours and manning of ships), as well as the 1996 protocol to ILO Convention No. 147, provide reference for seamen's watch arrangements.

According to ILO Convention No.180, the maximum working hours shall not exceed 14 hours per 24 hours, no more than 72 hours per day, and the minimum rest time shall not be less than 10 hours per 24 hours and no less than 77 hours per 7 days. The rest time can be divided into two periods at most, one of which should be at least 6 hours, and the interval of continuous rest should not exceed 14 hours. Fire fighting, launching exercises and other prescribed exercises shall interfere with rest periods as little as possible and shall not cause fatigue. In case of emergency, the master shall not be bound

by working hours and rest periods until normal conditions are restored, after which the master shall give the crew members performing their duties during rest periods sufficient rest periods.

5.1.3 Relevant provisions of China

The crew on duty in China also attaches great attention. In order to strengthen the crew on duty management, prevent crew fatigue operation, security and property safety of life at sea, protect marine environment , the maritime traffic safety law of the People's Republic of China, the Law of the People's Republic of China on Marine environmental protection law and other relevant laws and regulations, are put forward,and the international maritime organization in correction of the certification of seafarers' training, and duty standard international convention and the international telecommunication union "radio regulations requirement, in order to standardize the boat crew on duty in our country has established the law of the People's Republic of China for Marine officers on duty regulations hereinafter referred to as the rules of sea-going ships crew on duty.

In addition to standardizing some basic requirements for seafarers on duty, the rules have also made some specific requirements. The rules of watch are divided into officer watch, engineer watch and radio watch respectively. As for the specific regulations on duty hours, the regulations on duty rules for seagoing crew are as follows:

Article 136 says the master shall take effective measures to prevent fatigue operation. All crew members on duty must have at least 10 hours' rest during a 24-hour period. Breaks may be separated, but not more than two periods, one of which should be at least six hours.

Article 137 mentions the 10-hour minimum rest period prescribed in Article 136 of these rules may be reduced to no less than 6 hours, provided that such reduction does

not exceed 2 days per week and that no less than 70 hours of rest are provided per week.

Article 138 says in case of emergency, performance or special circumstances, the requirements for rest time set forth in article 137 of the rules may not be maintained.

Article 139 mentions the maximum average working hours in a given period of time shall not exceed 12 hours per day. The general rule for working hours does not include necessary routine work, such as meals, substitute work, or the extra time required for a normal shift.

5.2 Current situation of marine ship watch

At present, there is no mandatory law on the arrangement of crew members of maritime ships, and different duty arrangements of ships are also different. The following is a description of several kinds of bridge duty arrangements on ships. One is to divide four hours into one duty period. The corresponding duty period is chief officer: 04-08/16-20, second officer: 00-04/12-16, and third officer: 08-12/20-24. For example, the container ship "GDYNIA" whose port of registry is Cyprus has a crew of 11 and a officer of 3. The bridge watch arrangement is as follows: chief officer: 18-24 hours; Second mate: 12-18 hours.

5.3 Flexible on-duty arrangement

In this paper, the comment set established for the evaluation index of the on-duty labor intensity of officer on watch is divided into three levels, which can be expressed as below:

V is equal to V1, V2, V3.

The corresponding labor intensity of on-duty ship officers is:

V is equal to V1, V2, V3.
= (normal, strong, strong)

When the calculation result is 0-1, the labor intensity is average; when the calculation result is 1-2, the corresponding labor intensity is relatively strong; when the calculation result is 2-3, the corresponding labor intensity is strong.

For the watchkeeping intensity of the ship's officers, the corresponding watchkeeping time shall be arranged, that is:
1. For officer on watch, the labor intensity of on-duty is generally based on the current on-duty arrangement adopted by officer on watch, that is, the on-duty arrangement is changed every 4 hours;

2. For officer on watch whose on-duty labor intensity is relatively strong, the new on-duty arrangement shall be adopted.

Namely every 3 hours a shift on duty arrangement;

3. For officer on watch whose on-duty labor intensity is strong, the new on-duty arrangement is also adopted, that is, the shift arrangement is adopted every 2 hours.
In addition, for officer on watch on duty labor intensity is relatively strong, strong above the ship in the arrangement of the ship's officer on duty, the captain should also participate in the watch in addition to some ordinary crew members can be arranged to participate in the watch, carry out some auxiliary work, to assist the officer on watch so as, to reduce their labor intensity.

Conclusion

This paper makes a systematic analysis of the content of the on-duty labor intensity of ship officers, establishes the evaluation index system of the on-duty labor intensity of ship officers, determines the weight of each index by using the analytic hierarchy process, and carries out a comprehensive evaluation of the on-duty labor intensity of ship officers by using the fuzzy comprehensive evaluation method.

On the basis of the study on the labor intensity of ship's officers on duty, the flexible arrangement of ship's officers on duty based on the labor intensity of ship's officers on duty is proposed by referring to the current relevant regulations and the current situation of the arrangement of ship's officers on duty.

In this paper, based on the officer put forward by the officer on the intensity of labor ship flexible scheduling to reduce officer on watch at a high labor intensity on the physical and mental pressure has a great effect, at the same time to prevent the ship officer on duty to appear fatigue phenomenon also has a lot of help, and for preventing ship officer suffer from occupational disease aspect also to have certain reference value.

However, due to the limitation of my personal ability and effort, this paper cannot give a comprehensive index system of the intensity of labor, when determining the weights and the intervention of human factors. In addition, the proposed ship officer flexible scheduling cannot achieve real-time judgment of ship the officer's fatigue state, and the evaluation index of membership function is not very perfect. These should be further perfected and improved in the future.

REFERENCES

Acejo, I., Sampson, H., Turgo, N., Ellis, N., & Tang, L. (2018). The causes of maritime accidents in the period 2002-2016.

Analysis of the cause of the fatigue of the crew and the countermeasures, Wang Bin,2017.

Berg, H. P. (2013). Human factors and safety culture in maritime safety. Marine Navigation and Safety of Sea Transportation: STCW, Maritime Education and Training (MET), Human Resources and Crew Manning, Maritime Policy, Logistics and Economic Matters, 107.

Chen Yi. Comprehensive evaluation of fatigue factors and safety of ship manning.

Cheng，Haitao，Li Chunsheng（2017）, Fatigue management from the ISM rules, World shipping, DOI:10.16176/j.cnki.21-1284.2017.05.005.

Chen Guoxiong, Xie Zonghui. China ranks first in seafarers' training scale in the world. China water transport daily, April 18, 2008, page 005 Zhu Wushou, Lu Weihua.

Deng Xiulan. Analysis and control of ship safety factors. Basic management, 4th issue, 2007: p65-66.

Fatigue for safety?Supply chain occupational health and safety initiatives in shipping,Document 4,Li juntang,2012.

Fatigue can be fatal,Michael Grey,2015.

How to prevent seafarers from fatigue duty under the background of the new convention, Huang Junbo, 2013.

Grech, M. (2016). Fatigue risk management: A maritime framework. International journal of environmental research and public health, 13(2), 175.

Guangxi communications technology, December 1998 Chen Weijiong. The harm of crew fatigue to maritime safety and its control. Proceedings of the second national conference on safety science and technology academic exchange. November 2002.

Houtman, I., Miedema, M., Jettinghoff, K., Starren, A., Heinrich, J., Gort, J., & Wubbolts, S. (2005). Fatigue in the shipping industry. Hoofddorp: TNO.

How to prevent seafarers from fatigue duty under the background of the new

convention, Huang Junbo, 2013

Huang Canhuang, Liao Kunjing, Wu Zhanjia, analysis of human factors in collision accidents [J]. Marine technology, 2006: p1-17.

International Maritime Organization. (2006). Guidelines on the basic elements of a shipboard occupational health and safety programme. London, UK: IMO. Retrieved from https://docs.imo.org/

International Labour Organization. (2006). MARITIME LABOUR CONVENTION, 2006, as amended. Genève, Switzerland: ILO. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/normativeinstrument/wcms_554767.pdf

International Maritime Organization. (2010). The Manila Amendments to the Seafarers' Training, Certification and Watchkeeping (STCW) Code. London, UK: IMO. Retrieved from https://docs.imo.org/

International Labour Organization. (2014). Guidelines for implementing the occupational safety and health provisions of the Maritime Labour Convention, 2006. Genève, Switzerland: ILO. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/normativeinstrument/wcms_325319.pdf

International Maritime Organization. (2019). Guidelines on Fatigue. London, UK: IMO. Retrieved from https://docs.imo.org/

IMO.Res.A.772(18) Fatigue Factors in Manning and Safety,1993.

Jane C.Stutts，Jean W.Wilkins，Bradley V.Vaughn.Why do people have drowsy driving crashes? [A].AAA Foundation for Traffic Safety[C], Washington,1999.

Jin Xiaoning, Ma Chunxiang. Fuzzy measurement of labor intensity. Industrial engineering and management. Second issue, 2007: p107-110.

Ji Hongguang, Chen Yaozhong, Zhang Lin et al. Relationship between sleep quality and supervisor fatigue and neurobehavioral response in seafarers. Chinese journal of mental health, vol. 13, no. 5, 1999: P295.

Ji Hongguang, Wang Haiming, Chen Yaozhong et al. A survey on sleep behavior and fatigue status of shipboard crew. Chinese journal of occupational medicine. Oct.2002, vol. 29, no. 5: p57-58.

Li Wenping. Fatigue - the safety of navigation [J]. Marine technology, 2003: p77-78

Li Jianming. Effects of fatigue on crew behavior [J]. Marine technology, May 1996: p77-78.

Liu Lingyan, Wu Xiaoping, Ye Qing. Quantitative analysis of crew fatigue factors based on unascertained AHP. Ship electronic engineering, 2006, 1st issue.

Liu Changyong. Quantitative analysis of labor intensity. Productivity research, 2009 NO.1: p24-25.

Liao Kunjing, Wu Zhanjia. Analysis of driving fatigue factor of seafarers based on analytic hierarchy process. Chinese journal of safety science, April 2007.

Liu changyong. Exploration of labor intensity theory. Dissertation of graduate student of xinjian university, June 2002: P18.

MAIB Report No 14/2006-Report on the investigation into the grounding of MV LERRIX off the Darss Peninsular, Baltic Sea, Germany,10 October 2005,pages 23-24,http:www.maib.gov.uk/publications/investigation reports/2006/lerrix.cfm.

Marc B.Mandler Coast Guard Probes Human Factor Proceedings of the Marine Safety Council,May-June,1995:P18-21.

MCCALLUM M C,RABY M,ROTHBLUM A Procedures for Investigating and Reporting Human Factors and Fatigue Contributions to Marine Casualties[R].Washington DC：US Coast Guard Research &Development Center，1996.

Minimum manning and safeare fatigue,Document 3,2015.

Review of labor intensity research at home and abroad, journal of Beijing sport university, November 2007: p691-692.

Shipowners face increase in fatigue claims in court,David osler,2011.

Sun Jianhua, Li Zhen. Analysis and research on fatigue types. Journal of guangxi university for nationalities (natural science edition). February 1998: p72-74.

The harm of crew fatigue to Maritime Safety and its Countermeasures, Han li,2019.

Wang, Q,&Zhang, S, J,&Zhang, G, Risk Control Analysis of Super Low Speed Navigation and Combustion of Super High-Viscosity Fuel, Qingdao Ocean Shipping Mariners College, vol.37 no.3 2016.

Wang Zihai,(2009) Reasons and Countermeasures for the Fatigue of Seafarers,China Water Transport,Vol.9 No.1 1006-7973（2009）01-0035-02.

Wang Wanliang. A study on individual physical labor intensity. Graduate thesis of shandong university.

Wang Meng. Study on driving fatigue of operating officers. Institute of highway science, ministry of communications (master's thesis), June 2006; P33.

Yin Chaozhong. Factors affecting crew fatigue and preventive measures. Journal of wuhan shipbuilding vocational and technical college, 2008, no.4: p12-16.

Zeng Huaran. Fuzzy comprehensive evaluation of seafarers' overall safety level. Journal of dalian maritime university, 2001.

Zhao, Q, B,(2017) Optimization of Sailing Speed of Operating Ship in Fixed Routes by Considering Fuel Consumption and Economy, Harbin Engineering University.

Zhang Rongzhong. Crew fatigue on duty is a cause for alarm. Basic management. Issue 9, 2007, P64.

Zheng Zhongyi, wu zhaolin. Ship safety manning [M]. Dalian: dalian maritime university press, 2002.

Zhu Guofeng. Construction of physical and mental quality evaluation index for sea-going officer on watch. Psychological science, vol. 24, no. 6, 2004.

Zhu Guofeng. Manifestations and causes of adverse psychological factors in seafarers. Journal of dalian maritime university, August 2001: p45-48.