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UNIFIED TANKER SURVEY AND INSPECTION REGIME IN TERMS OF REDUCING PSYCHOPHYSICAL STRAIN OF THE CREW

ABSTRACT

The paper focuses on analysis of the effect of various surveys and inspections on the psychophysical behaviour of the crew. After analysing the scope and the extent of each regime, the authors identified more than 60% of surveys overlapping each other. Furthermore, the results of the survey conducted among seafarers indicate that the present method of carrying out ship surveys and inspections have a negative effect on the psychophysical condition of the crew. Therefore, a new method of tanker inspections has been proposed in order to reduce the psychophysical strain of the crew. The proposed method would minimise the annual duration of the inspections up to 30% and improve inspection time coordination without compromising quality and safety of the ships.

KEY WORDS

tanker inspection; survey; workload; safety;

1. INTRODUCTION

Classification societies and other renowned organizations have started inspecting ships some times in the past. There are four basic tanker survey regimes: Port State Controls (PSC) and Flag State Controls (FSC), Annual Class Survey, P&I Club Survey and vetting inspections. Furthermore, there are additional surveys which differ in frequency and methods of conducting inspections: the shipyard inspections, machinery/equipment-related inspections, inspections by potential buyers and the crew inspections. Authors Knapp, Bijwaard and Heij (2011) investigated the potential savings in the shipping industry which resulted in implementation of inspections. The evaluation of saving included Port state inspection and Vetting, which was taken into consideration when they proposed terms

for survey regimes. [1] Hecht and XUEGAO (2004) suggest stochastic method for determining time intervals between two surveys. The suggested intervals of survey on merchant vessels are compared to navy ships where this method has already been implemented. [2] In their paper, Soliman and Frangopol (2015) suggest optimization of surveys with the objective of prolonging the exploitation life of the vessel by controlled investments in maintenance and survey of vessels. [3]

Despite indisputable contribution to ship safety, surveys may cause additional burden to the crew. For example, Karlsson (2011) describes the attitude of the crew towards vetting prior to charter. Frustration of the crew prior to vetting and the negative impact of over-inspection in certain time intervals have been detected. [4]

So far, 13 inspection regimes have been developed for tanker ships. Each of them contributes to the safety as well as to the quality of the ships. However, after analysing the scope and the extent of each regime, the authors identified more than 60% of surveys overlapping each other.

Since the crew is nowadays very busy in ports with cargo/ballast/refuelling/services operations, especially considering ever less time that ships spend in ports, elimination or at least reduction in survey overlapping would result in freeing some time, putting less pressure on the crew and contribute to crew/ship safety. Previous studies indicate that 80% of sea accidents have been caused by human error [5].

Furthermore, fatigue was identified as the most important stressor. It has been the cause of many sea accidents and severe life threatening with negative ecological and economic consequences [6]. Fatigue is often a result of a work-related stress and can depend on the complexity of the work and the number of crew

engaged in a shipboard operation. Long working hours have negative effect on one's biorhythm and can be the cause of insomnia [7]. Shift work, especially night work has been recognized as an important factor in the development of insomnia, as well as other serious diseases such as gastrointestinal and cardiovascular ones [8]. Typical symptoms of stress, such as insomnia, lack of concentration, anxiety, frustration, anger and headache affect the quality of work-related tasks [6].

Overlapping of inspection regimes could be the cause of psychophysical strain that is usually accompanied by the above-mentioned symptoms. The paper analyses inspection regimes and their overlapping, as well as the crew attitude towards them. The number of overlapping is the basis for the development of a new survey method that would try to eliminate all the negative effects of inspection regimes and increase the safety and technical quality of the ship herself.

2. INSPECTION REGIMES

There are 13 annual regimes of tanker survey: (1) Port State Control-PSC, (2) Flag State Control-FSC, (3) Annual Class Survey, (4) P&I - Protecting and Indemnity, (5) Vetting Inspection, (6) International Ship and Port Facility Security - ISPS, (7) International Safety Management - ISM AUDIT, (8) Maritime Labour Convention Audit-MLC Audit, (9) Greenward Associates Survey, (10) Superintendent's General Inspection, (11) Internal ISPS Audit, (12) Internal ISM Audit, (13) Internal Maritime Labour Convention Audit.

The authors have used the questionnaire to find out about the seafarers' attitude towards survey regimes and their effects on the crew. It has been a continuous questionnaire with the objective of analysing the influence of certain aspects of surveys, i.e. their influence on psychosocial factors that might have crucial impact on safety of navigation.

For the purpose of easier dissemination the questionnaire was done online and sent to 10 tanker shipping companies. The overall number of questionnaires was 500.

To make the results clearer, all the answers were turned into percent and numbers displayed without decimals, and some answers were grouped and put into categories.

There were 104 deck and engineer officers, aged 18 to 65 who participated in the research. Some 40% of them were with more than 20 years of experience in the maritime industry.

By comparing the proportions of the two independent samples, the hypothesis that the proportions of the two main groups are equal or not significantly different, has been tested.

A null hypothesis is $H_0: P_1 = P_2$, and an alternative hypothesis is $H_1: P_1 \neq P_2$. Using the data on sample

units, the sample proportions p_1 and p_2 , standard error and the z value are calculated. If $z < t$, H_0 is accepted, otherwise H_0 is rejected in favour of the alternative hypothesis that the proportions of the two main groups are not equal.

Steps in hypothesis testing procedure:

$$H_0: P_1 = P_2$$

$$H_1 = P_1 \neq P_2$$

$$z = \frac{|p_1 - p_2|}{S_{p_1 - p_2}}$$

H_0 - null hypothesis; H_1 - alternative hypothesis; P_1 - first group proportion (sample proportion); P_2 - second group proportion; z - test statistics; p_1 - first group sample proportion; p_2 - second group sample proportion

$$\text{If } z \leq t \rightarrow H_0$$

$$z > t \rightarrow H_1$$

$$S_{p_1 - p_2} = \sqrt{\bar{p} \cdot \bar{q} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

$$\bar{p} = \frac{p_1 n_1 + p_2 n_2}{n_1 + n_2} = \frac{m_1 + m_2}{n_1 + n_2}$$

z - test statistics; p_1 - first group sample proportion; p_2 - second group sample proportion; t - reliability coefficient; \bar{q} - average proportion; $\bar{q} = 1 - \bar{p}$; m_1 - number of units from the first sample with the specific property; m_2 - number of units from the second sample with the specific property

The comparison of respondents according to their occupation (engine and deck crew):

- 1) Based on the 99% confidence interval, examine whether the proportion of engine and deck crew who find vessel survey stressful is equal or significantly different. In a group sample of 57 engine crew members, there are 39% of those who find vessel survey stressful. In a group sample of 47 deck crew members, there are 66% of those who find vessel survey stressful. On the 1% level $z = 2.74$ which is greater than $t_{0,01} (2.58)$ which is in favour of that proportions of engine and deck crew who find vessel survey stressful are significantly different.

Simultaneously, other hypotheses were tested:

- 2) Is the proportion of engine and deck crew who find vessel survey stressful equal (null hypothesis) or significantly different (alternative hypothesis)?
- 3) Is the proportion of engine and deck crew who do not suffer from insomnia prior to vessel survey equal or significantly different?
- 4) Is the proportion of engine and deck crew feeling anxious prior to vessel survey equal or significantly different?
- 5) Is the proportion of engine and deck crew who find social interaction somewhat difficult prior to vessel survey equal or significantly different?

- 6) Is the proportion of engine and deck crew who suffer from loss of appetite prior to vessel survey equal or significantly different?
- 7) Is the proportion of engine and deck crew who think there is an overlapping in survey regimes equal or significantly different?
- 8) Is the proportion of engine and deck crew who think their colleagues are more/less motivated for work after the inspection equal or significantly different?
- 9) Is the proportion of engine and deck crew who think their colleagues are more motivated until signing off equal or significantly different?
- 10) Is the proportion of engine and deck crew who think their colleagues are more motivated during the month after the survey equal or significantly different?
- 11) Is the proportion of engine and deck crew who think that frequency of vessel surveys influences the equipment status equal or significantly different?

For hypotheses 2, 3 and 4 the results were as follows: Testing based on the 99% confidence interval suggests that the proportion of engine and deck crew is equal, while 95% confidence interval rejects the null hypothesis in favour of alternative hypothesis that they are significantly different.

Hypothesis number 5: The proportion of engine and deck crew who find social interaction somewhat difficult prior to vessel survey is equal, but it should be emphasized that this proportion is less than 40%.

Hypothesis number 6: The proportion of engine and deck crew who do not have appetite problems prior to vessel survey is significantly different, being much larger among the engine crew members (79%) than among the deck crew members (49%).

For hypotheses 7-11, the null hypothesis that the proportions are equal for every question has been accepted.

The scope of the questionnaire was to investigate the effects of some of the elements of ship inspections on the crew, especially their effects on psychosocial factors that can have the key role in the safety of ship operations.

Is there any overlapping of survey regimes?

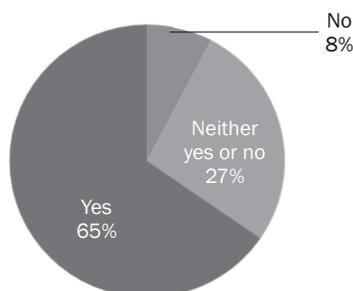


Figure 1 – Overlapping of inspection regimes

The results show that 65% of respondents think that there is overlapping present, whereas only 8% of them think the opposite.

3. EFFECTS OF THE SURVEYS ON THE CREW

A high overlapping percentage of inspection regimes is the basis for further analysis of their effects on the crew. Apart from the excessive overlapping between the regimes, the questionnaire has revealed the negative attitude of the crew towards them.

The effects of the survey have been analysed through several questions:

- Does the upcoming survey make the crew nervous?
- Do the members of the crew feel that their colleagues are nervous before the survey?
- Does the survey have a negative effect on social relations?
- Is the survey the cause of insomnia?

Does the survey make you nervous?

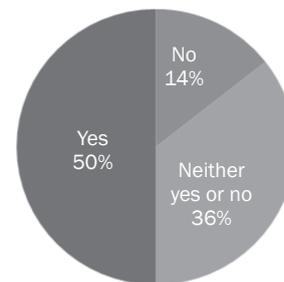


Figure 2 – Possibility of nervousness or stress caused by the survey

The results show that 50% of seafarers feel nervous or stressed during the survey, whereas only 14% of them are not stressed at all. On the other hand, 71% of respondents think that the survey makes their colleagues nervous. That is, only 3% of them think that there is no nervousness among the colleagues caused by the survey.

Relatively high percentage of respondents who notice higher stress levels among themselves, is not surprising at all, since we are talking about situations with longer working hours.

Relatively high percentage of respondents who notice higher stress levels among themselves is not surprising at all, considering the often prolonged working hours and excessive psychophysical pressure due to "multitasking" (performing multiple job operations at the same time).

Working hours are the universal source of stress. When comparing weekly working hours (67-70) of an average seafarer to the ones of other workers, it can be noticed that they are much longer [9].

The logic of such a working strain can be explained by the fact that seafarers spend several months at home with no or with significantly reduced working hours (used for personal development and other activities). However, it does not diminish the fact that on-board seafarers' working hours are too long. Perhaps the working hours are not the best example of work-related strain, but they are certainly highly correlated. A higher level of working strain combined with the level of wakefulness can lead to the reduced working efficiency and loss of situational awareness, which is recognised as the primary factor of marine accidents. Furthermore, if taking into consideration all the negative consequences of the prolonged, overlapping and unsynchronized surveys, it can be concluded that the figures referring to the level of nervousness are as expected [9].

Does the survey make your colleagues nervous?

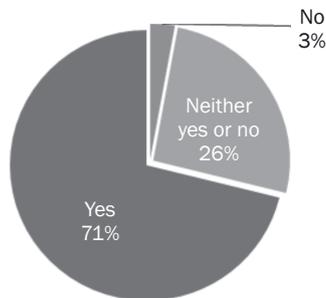


Figure 3 – The effects of the survey on the colleagues

The results of the questionnaire show that 21% of respondents suffer from insomnia just before the survey. That is, only 40% of them do not have sleeping problems.

Do you suffer of insomnia before the survey?

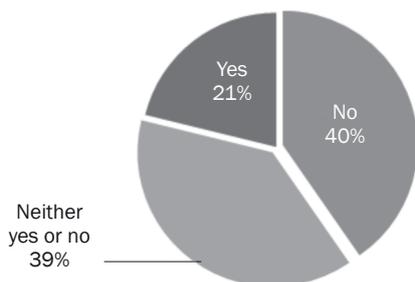


Figure 4 – The effects of the survey on the sleeping habits of the crew

It can be noticed that the results referring to insomnia are far lower than those related to nervousness. Such an outcome is logical, considering that nervousness or anxiety can be expressed in many terms, insomnia being just one of the terms. However, the fact that one fifth of respondents have insomnia-related problems is not negligible.

The wakefulness-sleeping cycle is a very complex physiological function, and, regardless of the fact that sleeping is an everyday phenomenon, modern science still does not have the answer to as why we sleep. Consequently, there have been many sleep-related theories developed. Some studies show that working in shifts (as seafarers do) can be related to bad quality of sleeping [10].

When it comes to the lack of sleep in terms of weaker performance and efficiency, the researchers have shown that sleep deprivation is actually perceived more negatively than it really is, according to the results of the objective tests [11].

I am stressed and strained before the survey?

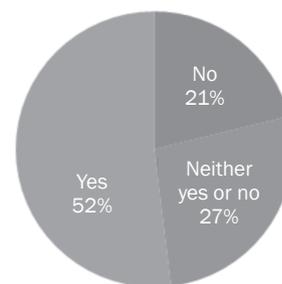


Figure 5 – Stress and strain during the survey

No less than 52% of respondents feel stressed and strained before the survey (Figure 5). At the moment, it is not possible to discuss the qualitative reasons for such a strain, but it is possible that they affect human relations among the crew since 29% of them think that they worsen before the survey. In other words, only 38% of respondents think that the survey does not have a negative effect on human relations (Figure 6).

Human relations worsen before the survey.

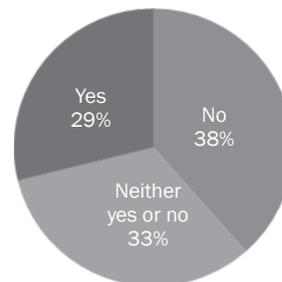


Figure 6 – The effects of the survey on human relations

As can be noticed, “Neither yes or no” has been answered frequently. That is, depending on the question, the respondents cannot give categorical “yes” or “no” answer. It probably means that there are some problems that cannot be solved by a simple questionnaire. They require a qualitative research since we cannot presume whether the distinction is made between

various survey regimes that are more or less stressful than the others, etc. Nevertheless, it is indisputable that surveys are the cause of stress that can interfere with everyday work, safety of navigation and even lead to other mistakes caused by human factor. Since the questionnaire has shown the negative attitude of the crew towards surveys, especially in regards to psychophysical strain of the crew, the authors have proposed a new inspection method.

4. UNIFIED INSPECTION METHOD

The unified method has to meet three major criteria:

- Maintain the safety level or increase it.
- Shorten the annual survey times.
- Establish the precise number of surveys as well as their annual intensity.

The basis of the unified inspection method is the analysis of all the components of each inspection regime. Actually, it unites their components. According to the proposed method, the total number of 1,685 components could be reduced to 529 (Table 1).

A high number of survey overlapping has led to psychophysical strain of the crew. The scope of the inspection regimes is to improve the safety and quality of a ship. In order to maintain the safety level, the unified method must not reduce the annual number of surveyed components. Thus, to improve the safety and the quality of the ship, the unified method proposes

that the number of surveyed components is larger than the current number:

$$\frac{12}{T} \cdot 529 > 1,685 \tag{1}$$

where T is the time between surveys.

Therefore, as far as safety is concerned, the optimal number of surveys is four per year. In this way, the number of surveyed components would be 2,116, which is 30% higher than today's 1,685. Furthermore, psychophysical strain occurs largely because of unevenly scheduled or unsynchronised surveys. Surveys in the unified inspection regime should be carried out in regular time intervals, that is, every three months.

The method has 529 components that have to be surveyed. In order to estimate the proposed survey duration we compared this number with the number of components of the vetting inspection. Since the Surveyor needs 10 hours to carry out the vetting inspection, which includes 282 components, the estimated time for survey of 529 components is 16 hours.

Duration of the surveys performed in all regimes currently is presented in Table 3.

If we compare the length of time required for surveys performed currently (89 h) with estimated time to perform surveys according to the proposed method (64 h), we can notice that significant time-saving (28%) will be achieved.

The surveys are proposed to be carried out by a two-member team. The team, consisting of a Marine and an Engineering Surveyor, should eliminate

Table 1 – Components of tanker survey

Number of chapters	Chapter name	Number of components of all regimes	Number of components of unified method	Difference	Overlapping percentage [%]
1	Ship certificates	95	21	74	78
2	Crew certificates	57	20	37	65
3	Lifesaving appliances	75	13	62	83
4	Fire safety	112	27	85	76
5	Navigation	234	56	178	76
6	Ship's procedures	192	55	137	71
7	Bridge publication	49	32	17	35
8	Ship's records	195	74	121	62
9	Mooring/anchoring	58	23	35	60
10	Structural condition – hull&deck	82	24	58	71
11	Structural condition – ballast&void spaces	20	12	8	40
12	Health & hygiene	92	26	66	72
13	Machinery space operations	149	50	99	66
14	Steering gear system	40	10	30	75
15	Environmental protection	64	24	40	63
16	Cargo worthiness, tanker	158	50	108	68
17	Cargo control room	13	12	1	8
Total		1,685	529	1,156	69

Table 2 – Total annual number of surveyed components

Number of chapters	Chapter name	Total annual number of surveyed components (all regimes)	Number of components of unified method	Annual intensity	Total annual number of surveyed components (unified method)
1	Ship certificates	95	21	4	84
2	Crew certificates	57	20	4	80
3	Lifesaving appliances	75	13	4	52
4	Fire safety	112	27	4	108
5	Navigation	234	56	4	224
6	Ship's procedures	192	55	4	220
7	Bridge publication	49	32	4	128
8	Ship's records	195	74	4	296
9	Mooring/anchoring	58	23	4	92
10	Structural condition - hull&deck	82	24	4	96
11	Structural condition - ballast&void spaces	20	12	4	48
12	Health & hygiene	92	26	4	104
13	Machinery space operations	149	50	4	200
14	Steering gear system	40	10	4	40
15	Environmental protection	64	24	4	96
16	Cargo worthiness, tanker	158	50	4	200
17	Cargo control room	13	12	4	48
Total		1,685	529	1,156	2,116

Table 3 – Overall duration of annual surveys

	Survey regimes	Annual intensity	Survey hours	Annual hours
1	Port state control - PSC	2	5	10
2	Flag state control - FSC	1	8	8
3	Annual class survey	1	10	10
4	International safety management - ISM audit	0.5	6	3
5	International ship and port facility security - ISPS	0.5	6	3
6	Protecting and indemnity - P&I	0.5	8	4
7	Vetting inspection	2	10	20
8	Superintendent's general inspection	1	8	8
9	Greenward associates survey	1	8	8
10	Maritime labour convention audit - MLC audit	0.5	6	3
11	Internal maritime labour convention audit	1	4	4
12	Internal ISM audit	1	4	4
13	Internal ISPS audit	1	4	4
Total annual number of survey hours				89

possible oversights of the survey. The Marine Surveyor would be in charge of the deck, whereas the Engineering one would survey the engine room and related items. The related department crew would accompany them during the surveys.

This way, momentary physical strain of the crew would be eliminated during very crucial ship operations whereas efficiency and working results would be improved.

5. CONCLUSION

After thorough analysis of tanker survey regimes, overlapping was identified, which was confirmed, among others, by the crew members. Overlapping has two major negative effects on the safety of a ship. The first one refers to the time needed to carry out and to prepare the survey as well as prolonged time stay in the "zone of multitasking". The second one refers to the lack of coordination among regimes, which, consequently, has negative psychological effect on the crew.

In order to reduce and finally to eliminate both of them, the authors propose a new, unified tanker inspection method that would integrate components of all inspection regimes. Thus, the annual number of components surveyed would increase up to 30%, which would ultimately increase the safety of a ship. Besides, the annual number, the survey dates would be defined as well. The duration of annual surveys would be reduced up to 30% which would lessen the psychophysical strain of the crew and at the same time improve the safety and quality of the ships.

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OBJEDINJENI PREGLED I INSPEKCIJSKI REŽIM TANKERA SA SVRHOM SMANJIVANJA PSIHOFIZIČKOG NAPORA POSADE

SAŽETAK

Rad se usredotočuje na analizu učinka različitih inspekcijских režima na psihofizičko ponašanje posade. Nakon

analize cilja i opsega svakog režima, autori su uočili preklapanja u 60 % stavki za preglede. Nadalje, rezultati ankete provedene među pomorcima pokazuju da sadašnji način provođenja inspekcijских pregleda negativno utječe na psihofizičko stanje posade. Stoga je predložena nova metoda inspekcija tankera kako bi se smanjio psihofizički napor posade. Predložena metoda bi smanjila godišnje trajanje inspekcija do 30% i poboljšala koordinaciju termina inspekcije bez ugrožavanja kvalitete i sigurnosti brodova.

KLJUČNE RIJEČI

inspekcija broda; pregled; opterećenje posade; sigurnost;

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