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


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 \( H_0: P_1 \neq P_2 \). 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:

\[ H_0: P_1 = P_2 \]

where \( H_0 \) - 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

\[ z = \frac{|p_1 - p_2|}{\sqrt{\frac{p(1-p)}{n_1} + \frac{p(1-p)}{n_2}}} \]

\[ t = \frac{q}{\sqrt{\frac{P_1(1-P_1)}{n_1} + \frac{P_2(1-P_2)}{n_2}}} \]

\[ P_1 = \frac{m_1}{n_1 + n_2} \]

\[ P_2 = \frac{m_2}{n_1 + n_2} \]

\[ z = t < H_0 \]

\[ P_1 = p_1 n_1 + p_2 n_2 \]

\[ P_2 = \frac{n_1 + n_2}{m_1 + m_2} \]

\[ z \text{ test statistics; } p_1 \text{ - first group sample proportion; } P_2 \text{ - second group sample proportion; } t \text{ - reliability coefficient; } q \text{ - average proportion; } q = 1 - p \text{ - number of } \]

Simultaneously, other hypotheses were tested:

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.

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

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?
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?

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.
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 how 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].

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 onboard 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].

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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:

\[
\frac{12}{T} \cdot 529 > 1,685 \quad (1)
\]

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 2 – Total annual number of surveyed components

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

### Table 3 – Overall duration of annual surveys

<table>
<thead>
<tr>
<th>Survey regimes</th>
<th>Annual intensity</th>
<th>Survey hours</th>
<th>Annual hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Port state control – PSC</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2 Flag state control – FSC</td>
<td>1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>3 Annual class survey</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4 International safety management – ISM audit</td>
<td>0.5</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>5 International ship and port facility security – ISPS</td>
<td>0.5</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>6 Protecting and indemnity - P&amp;I</td>
<td>0.5</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>7 Vetting inspection</td>
<td>2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>8 Superintendent’s general inspection</td>
<td>1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9 Greenward associates survey</td>
<td>1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>10 Maritime labour convention audit - MLC audit</td>
<td>0.5</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>11 Internal maritime labour convention audit</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>12 Internal ISM audit</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>13 Internal ISPS audit</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total annual number of survey hours</strong></td>
<td></td>
<td><strong>89</strong></td>
<td></td>
</tr>
</tbody>
</table>
possible oversights of the survey. The Marine Survey- or would be in charge of the deck, whereas the Engi- neering 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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