REVISION OF THE TECHNICAL REGULATIONS OF THE 1966 LL CONVENTION

An assessment of the safety level for freeboard

Submitted by Japan

SUMMARY

Executive summary: This document presents an assessment of the safety level of the freeboard and corrections by means of the probability of occurrence of deck wetness.

Action to be taken: Paragraph 3

Related documents: SLF45/4/6, SLF 46/11/2 and MSC 76/23

INTRODUCTION

1. With regard to the further revision on the 1966 LL CONVENTION (ICLL 66), the Maritime Safety Committee, at its seventy-sixth session (MSC 76/23, paragraph 12.24), noted the matters for further consideration. There has been a significant change in ships since 1966, both in terms of ship types (container ships, ro-ro’s, gas carriers etc.) and the size. It is supposed that other new types of ships may also appear in the future. In addition, some of the requirements of the ICLL 66 were determined empirically owing to the technical level in those days. These facts indicate that it is necessary for the existing ships to verify the objectives and the safety level of the ICLL first of all.

2. Based on this background, the Japanese Committee for the ICLL (RR-SP3) began an examination for the review of the ICLL. The annex provides the current results of the examination. First of all, the actual situation of the freeboard of existing ship is examined. Next, the safety level, which is ensured by the freeboard, is discussed by means of the calculation of the long-term probability of occurrence of deck wetness and wave loads on the hull. As a result, some findings at the present stage are drawn.

ACTION REQUESTED OF THE SUB-COMMITTEE

3. The Sub-Committee is invited to consider these findings and take actions as appropriate.

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ANNEX

ASSESSMENT OF THE SAFETY LEVEL OF THE FREEBOARD

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1 Introduction

With regard to the further revision on the ICLL 66, the Maritime Safety Committee, at its seventy-sixth session (MSC 76/23, paragraph 12.24), noted the following matters identified by the Sub-Committee for further consideration in a future revision of the 1988 LL Protocol:

.1 evaluation of reduced type-B freeboard assignment;
.2 effect of superstructures;
.3 effect of sheer;
.4 reserve buoyancy distribution;
.5 harmonization with respect to damage stability recommendations;
.6 structural strength in damaged condition;
.7 freeboard assignment on the basis of deck wetness for conventional and novel hull forms;
.8 ships with non-conventional features, including vessels (like cable-layers), which operate with open hatches; and
.9 further refinement of hatch cover loads for all ships.

The assigned freeboard by the ICLL 66 consists of a tabular freeboard and corrections. The safety is ensured in the ICLL 66 by not only the assigned freeboard but also the condition of assignment of the freeboard. Among the above identified matters, 1, 2, 3, 4, 5 and 7 are related to the assigned freeboard and 6, 8 and 9 are related to the condition of assignment of the freeboard. The assigned freeboard and the condition of assignment of the freeboard are determined in consistency with each other. Therefore, it is necessary to verify the objectives and the safety level of the ICLL before considering of each matter.

There has been a significant change in ships since 1966, both in terms of ship types (container ships, ro-ro’s, gas carriers etc.) and the size. It is supposed that other new types of ships may also appear in the future. In addition, some of requirements of the ICLL 66 were determined empirically owing to the technical level in those days. These facts indicate that it is necessary for the existing ships to verify the objectives and the safety level of the ICLL. Such verifications are also necessary to make the ICLL be consistent with other conventions and regulations.
Based on this background, the Japanese committee for the ICLL (RR-SP3) began an examination for the review of the ICLL. Some initial results are provided below. First of all, the actual situation of the freeboard of existing ship is examined. Next, the safety level, which is ensured by the freeboard, is discussed by means of calculation of the long-term probability of occurrence of deck wetness and wave loads on the hull. As a result, the relation between the freeboard and wave loads on the hull is clarified. The effect of the sheer on the probability of occurrence of deck wetness is also examined. It is also clarified that there is a room for the revision of a standard sheer.

2 Actual situation of compliance with ICLL 66

First of all, a brief review of the actual situation of the freeboard was conducted. This review was made by means of the existing ships, which have almost the same freeboard as the one provided by the ICLL 66. The freeboard of passenger ships and ferries is limited more significantly by subdivision and damage stability than by a geometrical freeboard. Gas carriers and large container ships generally have freeboard well in excess of geometrical freeboard required by the ICLL, and will be largely unaffected by any change of the ICLL. Therefore, passenger ships, ferries, gas carriers and large cellular container ships were excluded from this review. Bulk carrier and oil/chemical tanker were dealt with.

The following table 1 shows the number and the length of ships used in this review. Ship Length (Lf) in the table 1 corresponds to the length, which is defined by the regulation 3 of the ICLL. With regard to these 23 ships, the freeboard calculation was carried out. No bulk carrier of short ship length can comply with the requirement of damage stability in the regulation 27 of the ICLL 66.

The requirements of segregated ballast tanks and double hulls have been introduced by the other mandatory instruments after the ICLL 66 was adopted. In accordance with these requirements, tankers have been required a substantial increase in an enclosed volume. As a result, it is not necessary for large tankers to have a type-A freeboard although small tankers have a type-A freeboard. Therefore, there are some large tankers, which have a type-B freeboard, in these 23 ships.

Relation between a tabular freeboard and corrections was examined. This relation is shown in table 2. In the table, a tabular freeboard has been normalized to 100%, and the corrections are shown as a percentage of the tabular freeboard (minus sign indicates decrease). The assigned freeboard in table 2 indicates the sum of a tabular freeboard and corrections. These values are mean values of the ships of each type of freeboard respectively. The value of each ship is almost the same as the corresponding mean value shown in table 2.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>A list of ships</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type A</strong></td>
<td><strong>Type B</strong></td>
</tr>
<tr>
<td>Lf(m)</td>
<td>Number of ship</td>
</tr>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>150</td>
<td>175</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
</tr>
<tr>
<td>320</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 2  Relation between tabular freeboard and correction of tabular freeboard

<table>
<thead>
<tr>
<th></th>
<th>Type A</th>
<th>Type B</th>
<th>Reduced freeboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cb correction</td>
<td>10.6%</td>
<td>8.3%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Depth correction</td>
<td>51.5%</td>
<td>45.2%</td>
<td>37.6%</td>
</tr>
<tr>
<td>Super structure</td>
<td>-3.2%</td>
<td>-7.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>correction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheer correction</td>
<td>26.2%</td>
<td>17.7%</td>
<td>21.5%</td>
</tr>
<tr>
<td>Assigned Freeboard</td>
<td>185.1%</td>
<td>179.6%</td>
<td>171.9%</td>
</tr>
</tbody>
</table>

The assigned freeboard varies from 172% for reduced freeboard ships up to over 185% for type-A ships owing to the corrections to be made mainly for the depth and the sheer. For most ships, the superstructure correction appears minimal. The ratio of the depth and length of most ship is about 1/11. In addition, there are few differences in the block coefficient among these ships. Therefore, the ship length has much effect on these corrections in the table 2.

3  Assessment of the safety of the freeboard

3.1 Verification of safety level by the calculation of the long term probability

According to the record of a technical background of the ICLL 66 (Reference 1), majority of delegates who attended the technical committee for the ICLL 66 concluded that objectives of the ICLL 66 are

(a) prevention of the entry of water into hull,
(b) adequate reserve buoyancy,
(c) protection of the crew,
(d) adequate structural strength of the hull, and
(e) limitation of deck wetness.

Deck wetness can be limited simply by the increase of the freeboard. In addition, reserve buoyancy, which improves the performance of stability and prevents the occurrence of deck wetness, is also ensured by an adequate freeboard. It is found that a limitation of deck wetness is a basic safety factor. However, it is not realistic to determine a freeboard in a way that deck wetness never happen. Therefore, requirements for the prevention of the entry of water into hull and the protection of the crew are introduced on a premise that deck wetness occurs in a certain limited probability. Furthermore, a requirement for the protection of the deck fittings should be introduced.

Based on the philosophy described in the above paragraph, freeboard should be determined to control the probability of occurrence of deck wetness. The Netherlands, Germany and Japan carried out calculations of the long-term probability of occurrence of deck wetness to determine the minimum bow height as a part of previous revision of the ICLL 66 (SLF45/4/6). In the light of the former examination, the freeboard should be determined by the calculation of the long-term probability of occurrence of deck wetness. Requirements for the prevention of the entry of water into hull, the protection of the crew and the protection of the deck fittings also should be determined to be consistent with the probability of occurrence of deck wetness.
In accordance with this procedure, the probability of occurrence of deck wetness was estimated to assess the safety level of the freeboard. Ships, which are the same ships shown in table 1, were used for this estimation. First of all, relative motion between ship and wave was calculated by means of strip method, which is one of reliable estimation methods of seakeeping performance. Next, long term probability of relative motion was calculated. The probability of occurrence of deck wetness was determined by the probability of the relative motion when it becomes the same as the magnitude of freeboard. In the present calculations, ship speed is defined as zero on the premise that a ship loses its handling ability completely. Wave diagram of winter north Atlantic, which is the same diagram as the one of IACS Recommendation No.34, was used. Directional distribution of waves was assumed as a distribution of cosine square. Encountering angle with waves is assumed to be uniformly distributed.

An example of results is shown as a function of ship length (L_f) in figure 1. Probability in the vertical axis is described as a logarithmic value. It is found that the probability of occurrence of deck wetness decreases as ship length increases.

Ship motion (e.g. pitching) is generally the largest in the waves of which length is similar to the ship length. According to the wave statistics, the probability of occurrence of the longer waves is relatively lower than the one of the shorter waves. Therefore, the probability of the occurrence of deck wetness in the longer waves becomes lower than the one in the shorter waves.

It is found that there are differences between the probabilities of type-A ships, reduced freeboard ships and type-B ships although such differences are relatively smaller than the one owing to the difference of ship length. As a matter of course, the level of safety must be the same irrespective of the type of freeboard. In accordance with the objective of the ICLL, these differences should be compensated by the compliance with the requirement for the prevention of the entry of water into the hull, for the protection of the crew and the deck fittings.

A determination of the adequate probability of occurrence of deck wetness is required for the determination of the freeboard. For the verification of the adequate probability of occurrence of deck wetness, it is important to examine the relation between the freeboard and requirements for the assignment of freeboard. In this examination, the relation between freeboard and the wave loads, which is one of the factors of the structural strength, is discussed.

A Long-term probability of wave vertical bending moment, which is one of the wave loads on the hull, was calculated. A typical example of results is shown in figure 2. The wave vertical bending moment of each direction of wave is shown as a function of the probability of it. For the assessment of the magnitude of it, a threshold value of the IACS unified requirements S11 (UR-S11) is also shown in figure 2. It is found that wave vertical bending moment corresponding to the once in 20 years ($Q=10^{-8}$) is smaller than the one of UR-S11. It is clarified that structural strength of ship is adequate for the draught, which corresponds to the assigned freeboard.
3.2 The effect of sheer on the deck wetness

With regard to the examination of the effect of the sheer on the probability of occurrence of deck wetness, the probability was calculated by means of two kinds of freeboard. One is the assigned freeboard, which consists of the tabular freeboard and corrections of the ICLL 66. Another is the freeboard in which the standard sheer is used in place of a sheer correction of the assigned freeboard. In this examination, minimum bow height and reserve buoyancy are not included in the freeboard at stem. The probability of occurrence of deck wetness was calculated at five longitudinal positions (F.P., S.S.8, S.S.5, S.S.2 and A.P.) of each ship.

Longitudinal distribution of the probability of occurrence of deck wetness by means of the assigned freeboard is shown in figures 3, 4 and 5, respectively. The horizontal axis indicates the longitudinal position of each ship. Longitudinal distribution of the probability of occurrence of deck wetness by means of the standard sheer is shown in figures 6, 7 and 8, respectively.

From calculations by means of the assigned freeboard, it is found that the probability of occurrence of deck wetness at fore part (i.e., from the stem to the midship) of each ship is almost the same irrespective of the longitudinal position of ship. It is also found that the probability of occurrence of deck wetness at aft part (i.e., from the midship to the stern) is relatively lower than the one at fore part. On the other hand, from the calculation by means of the standard sheer, it is found that the probability of occurrence of deck wetness at stem and stern are remarkably lower than the one at the midship. It is clarified that the assigned freeboard limits the probability of occurrence of deck wetness adequately. It is also clarified that the standard sheer is inconsistent with the probability of occurrence of deck wetness.

It is confirmed that sheer contributes to ensure reserve buoyancy. It is also confirmed that reserve buoyancy improves the performance of stability and prevents the occurrence of deck wetness. With regard to the improvement of stability, it is more effective to increase the freeboard at the midship than the one at the stem and the stern. Therefore, it is concluded that a sheer mainly contributes to the prevention of deck wetness. In the light of these findings, requirements relating the standard sheer in the ICLL 66 should be removed first of all. New tabular freeboard for ships that have no sheer and the correction for ships that have a sheer should be made.
4 Conclusions at this stage of examination

(1) Ship length has much effect on the probability of occurrence of deck wetness.

(2) Structural strength of ship is adequate for the draught correspond to the assigned freeboard.

(3) Requirements relating the standard sheer in the ICLL 66 should be removed.

New tabular freeboard for ships that have no sheer and the correction for ships that have a sheer should be introduced.

Acknowledgements

A part of the present study was carried out as the part of the Japanese project for the ICLL (RR-SP3) with the Shipbuilding Research Association of Japan that is supported by the Nippon Foundation.

Figure 3: Longitudinal distribution of the probability of deck wetness (Assigned freeboard, Type-A ships)

Figure 6: Longitudinal distribution of the probability of deck wetness (Standard sheer, Type-A ships)

Figure 4: Longitudinal distribution of the probability of deck wetness (Assigned freeboard, Type-B ships)

Figure 7: Longitudinal distribution of the probability of deck wetness (Standard sheer, Type-B ships)
Reference: