ANCHORING REQUIREMENTS FOR LARGE CONTAINER SHIPS

1 INTRODUCTION

1.1 Background

Some modern container ships are larger than most of the existing fleet, whose experience has been used as the basis of classification rules and requirements. It is therefore reasonable to question whether existing requirements are appropriate for them. One such area that has been questioned is the requirements for anchoring equipment. It has been suggested that the high stacks of above-deck containers may be inadequately represented in the existing requirements.

1.2 Objective

This note considers the adequacy of IACS requirements for anchoring of large container ships.

2 ANCHORING REQUIREMENTS

2.1 What are the Anchoring Requirements?

The requirements for ordinary "stockless" anchors are defined in IACS Unified Requirement A1, and are implemented in individual classification society requirements.

The requirements are expressed in terms of an "equipment number" defined as:

$$EN = \Delta^{2/3} + 2\ B\ H + 0.1\ A$$

Where:

- Δ = displacement
- B = beam
- H = height of uppermost deckhouse above waterline
- A = profile area above waterline of hull, superstructure and deckhouses

For each value of EN, the required anchor mass and the length and diameter of anchor chain are tabulated. The required anchor mass is directly proportional to the EN.

These requirements apply to all ship types, so they are applied to large container ships without modification. The requirements include a note stating that the height of deck cargo such as containers "may be" disregarded when determining H and A.

2.2 What Assumptions Underlie the Requirements?

The assumptions underlying the requirements are very simple and approximate:

- The environmental loading is assumed to be 25 m/s wind, 2.5 m/s current and no waves (i.e. sheltered waters).
- Wind and current are assumed to come from head-on.
- The current drag is based on displacement (the first term in the EN formula).
- The wind drag is based on the front projected area and the side profile area (the other two terms).

- The front area is in effect treated as 20 times more important than the side area.
- Average drag coefficients are used, i.e. the same for all ship types and sizes.
- The variation of wind speed with height is not explicitly represented.
- The anchor holding power is assumed to be proportional to the anchor weight.
- Holding ground is assumed to be good.

2.3 Are the Assumptions Valid for Large Container Ships?

The validity of the assumptions for large container ships is evaluated as follows:

- The assumed environmental loading can be exceeded, and in particular wave loading is likely to exist as well, but this could occur for any ship.
- Wind and current could come from different directions, but this could occur for any ship.
- The relative importance of current drag has not been independently checked, but is unlikely to be an issue for large container ships.
- The wind drag may be more significant on large container ships. Deck-stowed containers are not normally considered in the profile area, and the reasons for this are not documented. For mooring and towing equipment requirements (IACS UR A2) they are included. However, because the deckhouse is higher than container stacks, they are implicitly included in the front area, and this is much more important for the EN.
- The high weighting on front area reflects an assumption that the ship will lie mainly head to wind while anchored, which seems reasonable.
- The variation of wind speed with height may be more significant on ships with high deckhouses, such as large container ships.
- The anchor holding power is in reality more closely related to fluke area, but this is approximately proportional to anchor mass.
- The holding ground may be poor some anchoring locations.

The main concern that is specific to large container ships therefore appears to be the height of the deckhouse, which might result in higher wind pressures. In principle a more accurate formulation could be developed, but justification of this would require evidence that the inaccuracies led to inadequate requirements.

A key assumption that applies to all ships is that anchoring is in sheltered waters with no waves. An equivalent set of environmental conditions will be added to the IACS requirements, consisting of 11 m/s wind, 1.5 m/s current and 2m significant wave height. The greatly reduced wind and current speeds indicate the importance of the assumed wave height.

2.4 Are the Requirements Sufficient for Large Container Ships?

Recent IACS investigations showed that ordinary stockless anchors provide sufficient holding power for container ships up to 14000 TEU (the largest ship investigated) in the environmental conditions defined above. For blunt ships like tankers and bulk carriers, ordinary stockless anchors may provide marginal holding power, and high holding power (HHP) anchors are recommended. Additional wave loading was also investigated, and was also to be acceptable in the alternative environmental conditions (11 m/s wind, 1.5 m/s current and 2m significant wave height).

In principle, it would be possible to set more stringent requirements, resulting in heavier anchors and chains. This would have the advantage of providing better holding power in more severe environmental conditions, or a greater safety margin against the other assumptions in the requirements. On the other hand, the heavier equipment would be more difficult to handle in all circumstances, and may become impractical to heave if the more severe environmental conditions are exceeded. The effectiveness of heavier equipment would depend on a ship's trading patterns and anchoring locations. Owners are therefore encouraged to evaluate the need for increased anchoring equipment, especially for anchoring in deep waters [1], but this is not considered suitable as a basic class requirement for all ships.

3 ANCHOR DRAGGING CASUALTIES

3.1 Anchor Dragging on Container Ships

Events of anchor dragging on container ships have been identified from the IHS/Fairplay database for container ships world-wide during 2000-14. This is unlikely to be a complete record, but is probably a representative sample of more serious events.

Only 17 anchor dragging events were identified from this period, of which 8 led to grounding, 5 led to collisions and 4 followed engine failure. Anchor dragging in other circumstances is not normally reported in this database. All but 2 of the events resulted in serious casualties, and there were 3 total losses.

By combining with fleet data, the average frequency of container ship casualties involving anchor dragging during 2000-14 is estimated to be 2.9×10^{-4} per ship year.

There have been more events recently, but this is largely due to the growth in the fleet of container ships. The frequency per ship year for the period 2013-14 was 5.0×10^{-4}, which is 72% higher than the long-term average, but this difference is not statistically significant due to the relatively small number of events. It could also result from improvements in reporting to the database, or from more stormy weather.

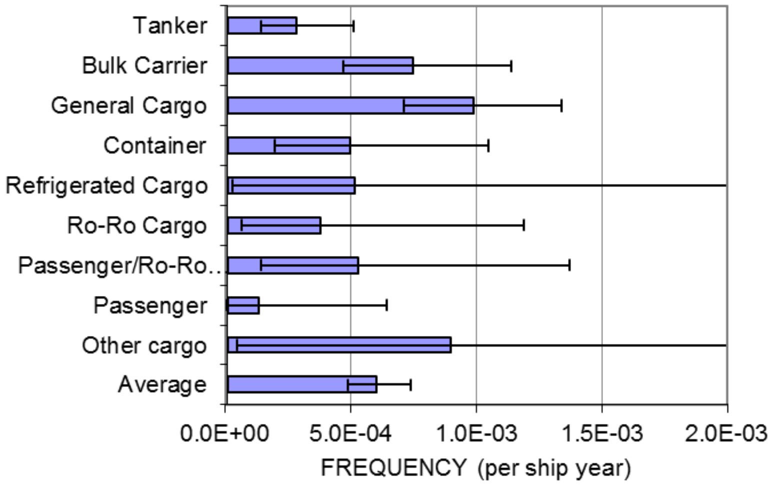
The database has little causal information, but it does indicate that 12 occurred during severe weather and only 1 in good weather. All 17 vessels appear to have been in service at the time.

There is no indication that large container ships are disproportionately involved. The average size of container ships suffering anchor dragging was 19,000GT, whereas the average size of container ships suffering grounding, collision or machinery failure in general was 29,000GT.

3.2 Anchor Dragging on Other Ships

Events of anchor dragging on other types of ships have been identified from the IHS/Fairplay database for cargo ships world-wide during 2013-14. In total 67 anchor dragging events were identified from this period. By combining with fleet data for the same period, the frequencies of casualties involving anchor dragging have been estimated for different ship types as shown in Figure 1. The I-shaped bars show the 90% confidence ranges on the estimated frequencies.

Figure 1 Frequencies of Casualties Involving Anchor Dragging, 2013-14



The average frequency is 6.0 x 10^{-4} per ship year. There is a factor of 7 variation between the ship types, but the wide confidence ranges show that most of these variations are not significant. The only ship type with a frequency that is significantly different to average is general cargo ships, whose frequency was 64% above average. The frequency on container ships is 17% below average, but this difference is not statistically significant due to the relatively small number of events.

The annual frequency of anchor dragging could be split into three components:

- The frequency of anchoring per ship year.
- The probability of anchor dragging, given that the ship is at anchor.
- The probability of the ship becoming a casualty, given that its anchor drags.

No data is available on the frequency of anchoring, although it is likely that general cargo ships anchor more frequently than container ships. Hence, it is possible that container ships have lower frequencies of casualties due to anchor dragging because they anchor less frequently than other ship types. The probability of anchor dragging may be more consistent. However, more data would be needed to confirm this.

3.3 Anchor Loss

Data on anchor loss is more readily available than anchor dragging. The frequency of anchor loss in the DNV fleet during 2007-15 was approximately 8 x 10^{-3} per ship year [2]. This is a factor of 13 higher than the anchor drag frequencies above. In other words, relatively few anchor losses involve anchor dragging or result in casualties.

Figure 2 shows the variation with ship type [2]. This indicates a higher frequency for tankers and passenger ships, and a lower than average frequency for container ships. The frequency for general cargo ships is no higher than for container ships, suggesting that their higher casualty rate above does not result from the ship design but from the different operational standards in the non-IACS fleet.

Figure 2 Frequencies of Anchor Loss, 2010-15

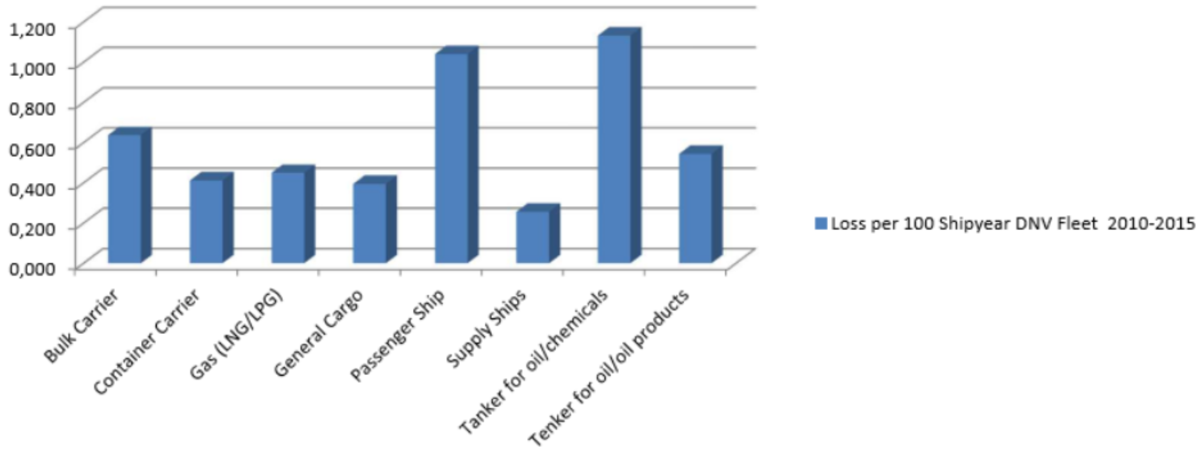
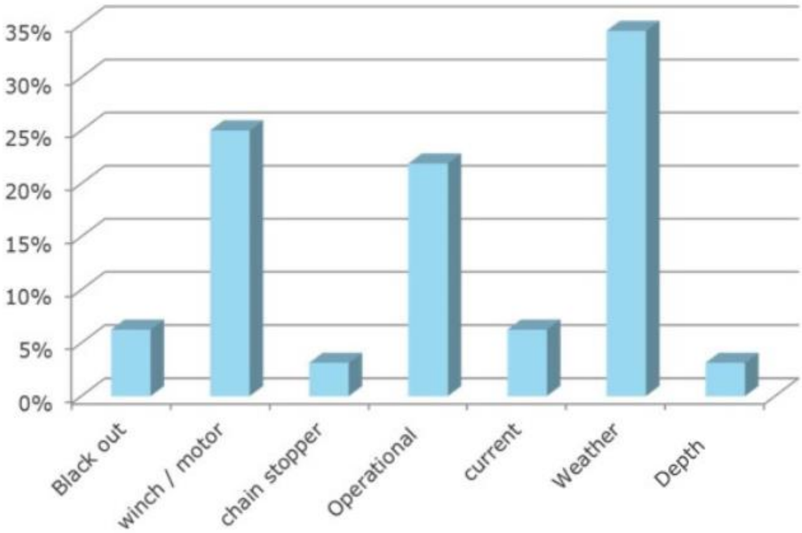


Figure 3 shows the breakdown of causes of anchor losses [1]. The main causes are weather, winch/motor failures and operational events (related to dropping, heaving and securing anchors, use of the brake, anchor watch and lack of attention to bad weather).

Figure 3 Causes of Anchor Loss



Source: The Swedish Club

4 OPERATIONAL ASPECTS

4.1 Where and How to Anchor?

In general, anchoring takes place in approved anchorages, following principles of good seamanship and the ship's anchoring procedures. Since many anchor losses result from operational causes, it is appropriate to emphasise key issues such as [3]:

- The crew should know the limitations of the anchoring system and plan the anchoring operation appropriately with respect to the weather forecast. The anchor should be weighed as soon as environmental conditions come close to these limits (see below).
- The position of the ship should be monitored to identify dragging as early as possible.

- The holding ground is important as dragging may occur earlier if the anchor holding power is impaired by bad holding ground.
- Sufficient anchor chain should be horizontal on the sea bed in order to achieve the required holding power. Class guidance is that the length of chain paid out should be 6 to 10 times the water depth.
- The anchor winch motor is typically designed to lift the anchor and three lengths of chain (82.5m). Hence for ships with a large freeboard, the maximum anchoring depth is typically 60m. This is apparently not common knowledge among seafarers.

4.2 When is the Weather Unsuitable for Anchoring?

The environmental conditions assumed in the anchoring requirements imply that even in sheltered waters with good holding ground the anchor may drag in conditions worse than 25 m/s wind and 2.5 m/s current. The calculated equivalent conditions imply that these figures are very sensitive to the wave height. At present there is no consistent practical guidance available on whether specific environmental conditions are suitable for anchoring. The ship's Master is advised to define criteria for aborting anchoring, but these are inevitably based on judgement.

The weather limits of the anchoring system are apparently not common knowledge among seafarers, as indicated by the high proportion of weather-induced anchor losses. DNV GL has therefore included these limits in recent awareness campaigns [3]. In order to provide a formal link between the classification requirements and the ship's operations, two further steps could be considered:

- Include the assumed environmental conditions on the ship's Class Certificate. However, it is doubtful whether this is really an effective communication tool for this information.
- Provide a tool to indicate whether specific conditions of wind, current and wave height exceed the assumed loading in the classification requirements.

4.3 What if Weather Limits are Exceeded?

Because the weather is difficult to predict, and because a need for emergency anchoring can arise at any time, even rigorous weather limits may sometimes be exceeded.

The conditions in which a securely anchored ship may start to drift cannot be predicted with confidence. Although there is a growing probability of anchor dragging as the weather worsens, it is possible that an anchor will continue to hold even in conditions much worse than the weather limits. Therefore, if the consequences of anchor dragging are judged to be acceptable, it may be prudent to remain at anchor, possibly deploying a second anchor or additional chain. Alternatively, if the operational hazards of weighing anchor in adverse weather are judged to be acceptable, it may be preferable to leave the anchorage for the open sea or more sheltered waters.

The mass of anchor and chain needed to stop a drifting ship is much greater than that needed to hold a stopped ship in position. Therefore, the anchor equipment may be insufficient for emergency braking, even in the environmental loading assumed by the classification requirements, and especially if they are exceeded. However, although the anchor equipment is not designed for this, it may be able to reduce or prevent drifting in some cases, depending on the holding ground, water depth, length of chain paid out and the environmental loading.

5 CONCLUSIONS

In summary, while there are a few reasons to suspect that the assumptions underlying the anchoring requirements may be less accurate for large container ships, there is no evidence from theoretical investigations or the casualty record to suggest that anchoring requirements are insufficient for them. Hence there is no incentive to develop a more accurate formulation.

Available data indicates that for every 1000 ship-years there are on average about 8 cases of anchor loss and 0.6 casualties due to anchor dragging. Experience on container ships has been better than average, possibly because they anchor less frequently than other ship types. There is no indication that large container ships are disproportionately involved.

The main causes of anchor dragging and anchor loss are poor anchoring practices and severe weather. A key reason seems to be that the limits of the anchoring system (weather and water depth) that are assumed in the requirements are not common knowledge among seafarers. While these have been included in recent awareness campaigns, better links between the classification requirements and the ship's operations could be considered.

6 REFERENCES

[1] DNV GL, "Most anchor losses are avoidable", Technical and Regulatory News No.15/2016

[2] DNV GL, Gard and The Swedish Club "Anchor loss - technical and operational challenges and recommendations", March 2016

[3] "Most anchor losses are avoidable", TANKEROperator, March 2016

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