Maritime and Coastguard Agency

MARINE INFORMATION NOTE

MIN 357 (M)

Navigation Safety: Guidance to the Master for Avoiding Dangerous Situations in Adverse Weather and Sea Conditions

Notice to all Shipowners, Operators, Masters and Deck Officers.

This MIN expires 31 October 2010

Summary

- This Marine Information Note (MIN) draws attention to precautionary measures which should be considered in adverse weather conditions when significantly larger waves may be encountered.
- It also aims to alert shipowners, operators, masters and deck officers regarding IMO's Maritime Safety Committee Circular MSC .1/Circ.1228 that provides guidance to the Master for avoiding dangerous situations in adverse weather and sea conditions.
- A copy of MSC Circular 1228 is reproduced as an Appendix to this Note.

1.0 Background

1.1 An incident occurred in 2008 in which two officers of a container vessel were injured, one of whom later died of his injuries, when they were struck by a large wave as the vessel proceeded in heavy weather conditions in the South China Sea.

1.2 This Information Note is intended to highlight the risk of encountering significantly larger waves at sea. Masters should consider early evasive action in the event that significantly larger waves associated with severe weather systems approach the area in which the ship is navigating.

2.0 Awareness

2.1 Masters and officers navigating in areas prone to adverse weather conditions and significantly larger waves should make full use of weather reports/ facsimiles and relevant publications including the following:

- Routeing Charts;
- Relevant Sailing Directions;
- Mariners Handbook (NP 100);
- ICS Bridge Procedures Guide;
- Ocean Passages for the World, and
- MGN 315 - Keeping a Safe Navigational Watch.

3.0 Significantly Larger Waves

3.1 The findings of the Marine Accident Investigation Branch (MAIB) investigation indicate that the phenomenon of large waves at sea has been an expected part of seagoing for a very long time, traditionally being referred to as “abnormally large” waves. A number of statistical analyses have shown that large waves are not “abnormal”, (meaning “extraordinary”), but better described as having “low probability of occurrence”. However, this **does** mean that they **will**, exceptionally, occur.

3.2 In MCA Research Project 509: HSC (High Speed Craft) – Evaluation of Existing Criteria, the *Wolfson Unit for Marine Technology and Industrial Aerodynamics* at the University of Southampton stated that:

> “The probability of encountering a wave larger than the significant height increases as the total number of encounters increases. For example, it can be shown that, approximately, 1 in 2000 waves will be twice the significant height. The expected maximum height can be calculated from the number of encounters and the significant height:
>
> Expected Maximum Height = C * Significant Height / 1.414
>
> Values for C were derived from Probabilistic Theory of Ship Dynamics, W.G.Price and R.E.D.Bishop, Chapman & Hall Ltd., 1974, and the corresponding expected maximum heights are:
>
> Maximum / Significant Height Occurrence

C	Maximum/Significant Height	Occurrence
1.708	1.21	1 in 10
2.280	1.61	1 in 100
2.738	1.94	1 in 1,000
3.130	2.21	1 in 10,000
3.478	2.46	1 in 100,000
Source: MCA Project 509: HSC – Evaluation of Existing Criteria, Wolfson Unit for Marine Technology and Industrial Aerodynamics, Southampton University”		

3.3 In practical terms, a vessel on a sheltered route, operating in a spectrum with a modal period of 4 seconds, might expect to encounter a wave of twice the significant height about once in 2½ hours. In exposed conditions, in a fully developed spectrum with a modal period of 10 seconds, one might expect to encounter a wave of twice the significant height about once in 5½ hours. It must be understood, however, that this does not mean that an encounter with a significantly larger wave will be followed by a period of 2½ or 5½ hours’ relative calm because this two thousandth wave may arrive at any time. There is also some evidence that the combination of two or more weather systems acting together may produce effects which can either reduce **or increase** the height of significantly larger waves.

3.4 Once the Master has determined that the risk of meeting significantly larger waves can be assumed to exist, he can use the following guidance from the IMO to reduce the risk to his ship.

4. Maritime Safety Committee (MSC) Circular

4.1 The International Maritime Organization's (IMO) Maritime Safety Committee (MSC), at its eighty-second session (29 November to 8 December 2006), approved the revised guidance to the Master for avoiding dangerous situations in adverse weather and sea conditions, with a view to providing a basis for decision making on ship handling in adverse weather and sea conditions, thus assisting them to avoid dangerous phenomena that they may encounter in such circumstances.

4.2 At the request of the IMO, the Government of the United Kingdom is now bringing the attached Maritime Safety Committee (MSC) circular to the attention of all concerned for information and in particular to ensure that mariners always have the safety related information available to them.

4.3 Relevant reference will be included into the latest edition of the Maritime and Coastguard Agency (MCA) publication "Safety of Navigation – Implementing SOLAS Chapter V, 2002" in due course, at which time this MIN will be cancelled.

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MSC.1/Circ.1228

11 January 2007

REVISED GUIDANCE TO THE MASTER FOR AVOIDING DANGEROUS SITUATIONS IN ADVERSE WEATHER AND SEA CONDITIONS

1 The Maritime Safety Committee, at its eighty-second session (29 November to 8 December 2006), approved the Revised Guidance to the master for avoiding dangerous situations in adverse weather and sea conditions, set out in the annex, with a view to providing masters with a basis for decision making on ship handling in adverse weather and sea conditions, thus assisting them to avoid dangerous phenomena that they may encounter in such circumstances.

2 Member Governments are invited to bring the annexed Revised Guidance to the attention of interested parties as they deem appropriate.

3 This Revised Guidance supersedes the Guidance to the master for avoiding dangerous situations in following and quartering seas (MSC/Circ.707).

REVISED GUIDANCE TO THE MASTER FOR AVOIDING DANGEROUS SITUATIONS IN ADVERSE WEATHER AND SEA CONDITIONS

1 GENERAL

1.1 Adverse weather conditions, for the purpose of the following guidelines, include wind induced waves or heavy swell. Some combinations of wave length and wave height under certain operation conditions may lead to dangerous situations for ships complying with the IS Code. However, description of adverse weather conditions below shall not preclude a ship master from taking reasonable action in less severe conditions if it appears necessary.

1.2 When sailing in adverse weather conditions, a ship is likely to encounter various kinds of dangerous phenomena, which may lead to capsizing or severe roll motions causing damage to cargo, equipment and persons on board. The sensitivity of a ship to dangerous phenomena will depend on the actual stability parameters, hull geometry, ship size and ship speed. This implies that the vulnerability to dangerous responses, including capsizing, and its probability of occurrence in a particular sea state may differ for each ship.

1.3 On ships which are equipped with an on-board computer for stability evaluations, and which use specially developed software which takes into account the main particulars, actual stability and dynamic characteristics of the individual ship in the real voyage conditions, such software should be approved by the Administration. Results derived from such calculations should only be regarded as a supporting tool during the decision making process.

1.4 Waves should be observed regularly. In particular, the wave period TW should be measured by means of a stop watch as the time span between the generation of a foam patch by a breaking wave and its reappearance after passing the wave trough. The wave length λ is determined either by visual observation in comparison with the ship length or by reading the mean distance between successive wave crests on the radar images of waves.

1.5 The wave period and the wave length λ are related as follows:

$$\lambda = 1.56 \cdot T_W^2 \text{ [m] or } T_W = 0.8\sqrt{\lambda} \text{ [s]}$$

1.6 The period of encounterTE could be either measured as the period of pitching by using stop watch or calculated by the formula:

$$T_E = \frac{3T_W^2}{3T_W + V\cos(\alpha)} \text{ [s]}$$

where V = ship's speed [knots]; and
α = angle between keel direction and wave direction (α = 0° means head sea)

1.7 The diagram in figure 1 may as well be used for the determination of the period of encounter.

1.8 The height of significant waves should also be estimated.

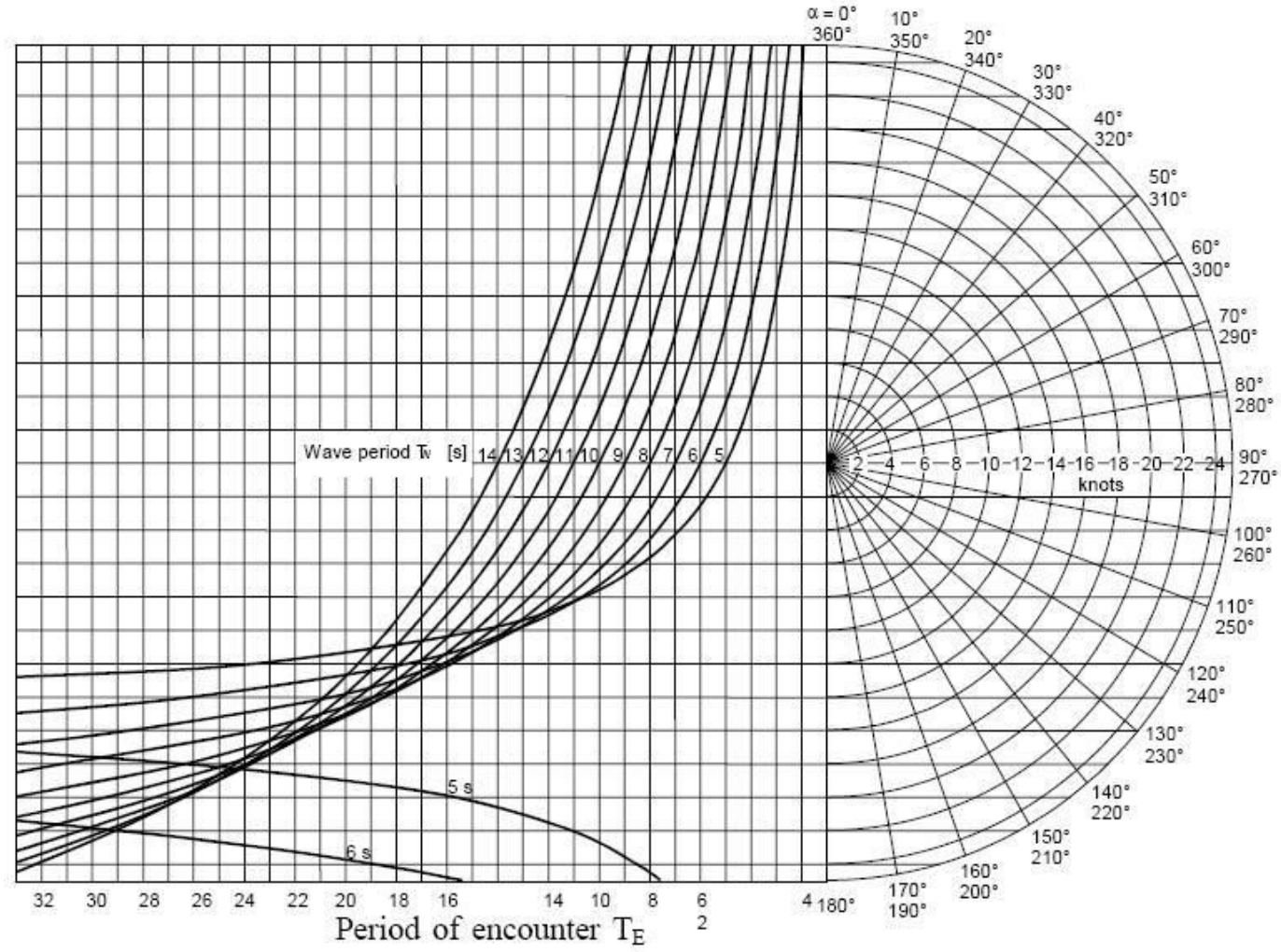

Figure 1: Determination of the period of encounter TE

2 CAUTIONS

2.1 It should be noted that this guidance to the master has been designed to accommodate for all types of merchant ships. Therefore, being of a general nature, the guidance may be too restrictive for certain ships with more favourable dynamic properties, or too generous for certain other ships. A ship could be unsafe even outside the dangerous zones defined in this guidance if the stability of the ship is insufficient. Masters are requested to use this guidance with fair observation of the particular features of the ship and her behaviour in heavy weather.

2.2 It should further be noted that this guidance is restricted to hazards in adverse weather conditions that may cause capsizing of the vessel or heavy rolling with a risk of damage. Other hazards and risks in adverse weather conditions, like damage through slamming, longitudinal or torsional stresses, special effects of waves in shallow water or current, risk of collision or stranding, are not addressed in this guidance and must be additionally considered when deciding on an appropriate course and speed in adverse weather conditions.

2.3 The master should ascertain that his ship complies with the stability criteria specified in the IS Code or an equivalent thereto. Appropriate measures should be taken to assure the ship's watertight integrity. Securing of cargo and equipment should be re-checked. The ship's natural period of roll TR should be estimated by observing roll motions in calm sea.

3 DANGEROUS PHENOMENA

3.1 Phenomena occurring in following and quartering seas

A ship sailing in following or stern quartering seas encounters the waves with a longer period than in beam, head or bow waves, and principal dangers caused in such situation are as follows:

3.1.1 Surf-riding and broaching-to

When a ship is situated on the steep forefront of a high wave in following or quartering sea conditions, the ship can be accelerated to ride on the wave. This is known as surf-riding. In this situation the so-called broaching-to phenomenon may occur, which endangers the ship to capsizing as a result of a sudden change of the ship's heading and unexpected large heeling.

3.1.2 Reduction of intact stability when riding a wave crest amidships

When a ship is riding on the wave crest, the intact stability can be decreased substantially according to changes of the submerged hull form. This stability reduction may become critical for wave lengths within the range of 0.6 L up to 2.3 L, where L is the ship's length in metres. Within this range the amount of stability reduction is nearly proportional to the wave height. This situation is particularly dangerous in following and quartering seas, because the duration of riding on the wave crest, which corresponds to the time interval of reduced stability, becomes longer.

3.2 Synchronous rolling motion

Large rolling motions may be excited when the natural rolling period of a ship coincides with the encounter wave period. In case of navigation in following and quartering seas this may happen when the transverse stability of the ship is marginal and therefore the natural roll period becomes longer.

3.3 Parametric roll motions

3.3.1 Parametric roll motions with large and dangerous roll amplitudes in waves are due to the variation of stability between the position on the wave crest and the position in the wave trough. Parametric rolling may occur in two different situations:

.1 The stability varies with an encounter period TE that is about equal to the roll period TR of the ship (encounter ratio 1:1). The stability attains a minimum once during each roll period. This situation is characterized by asymmetric rolling, i.e. the amplitude with the wave crest amidships is much greater than the amplitude to the other side. Due to the tendency of retarded up-righting from the large amplitude, the roll period TR may adapt to the encounter period to a certain extent, so that this kind of parametric rolling may occur with a wide bandwidth of encounter periods. In quartering seas a transition to harmonic resonance may become noticeable.

.2 The stability varies with an encounter period TE that is approximately equal to half the roll period TR of the ship (encounter ratio 1:0.5). The stability attains a minimum twice during each roll period. In following or quartering seas, where the encounter period becomes larger than the wave period, this may only occur with very large roll periods TR, indicating a marginal intact stability. The result is symmetric rolling with large amplitudes, again with the tendency of adapting the ship response to the period of encounter due to reduction of stability on the wave crest. Parametric rolling with encounter ratio 1:0.5 may also occur in head and bow seas.

3.3.2 Other than in following or quartering seas, where the variation of stability is solely effected by the waves passing along the vessel, the frequently heavy heaving and/or pitching in head or bow seas may contribute to the magnitude of the stability variation, in particular due to the periodical immersion and emersion of the flared stern frames and bow flare of modern ships. This may lead to severe parametric roll motions even with small wave induced stability variations.

3.3.3 The ship's pitching and heaving periods usually equals the encounter period with the waves. How much the pitching motion contributes to the parametric roll motion depends on the timing (coupling) between the pitching and rolling motion.

3.4 Combination of various dangerous phenomena

The dynamic behaviour of a ship in following and quartering seas is very complex. Ship motion is three-dimensional and various detrimental factors or dangerous phenomena like additional heeling moments due to deck-edge submerging, water shipping and trapping on deck or cargo shift due to large roll motions may occur in combination with the above mentioned phenomena, simultaneously or consecutively. This may create extremely dangerous combinations, which may cause ship capsize.

4 OPERATIONAL GUIDANCE

The shipmaster is recommended to take the following procedures of ship handling to avoid the dangerous situations when navigating in severe weather conditions.

4.1 Ship condition

This guidance is applicable to all types of conventional ships navigating in rough seas, provided the stability criteria specified in resolution A.749(18), as amended by resolution MSC.75(69), are satisfied.

4.2 How to avoid dangerous conditions

4.2.1 For surf-riding and broaching-to

Surf-riding and broaching-to may occur when the angle of encounter is in the range $135° < \alpha < 225°$ and the ship speed is higher than $(1.8\sqrt{L})\cos(180 - \alpha)$ (knots). To avoid surf riding, and possible broaching the ship speed, the course or both should be taken outside the dangerous region reported in figure 2.

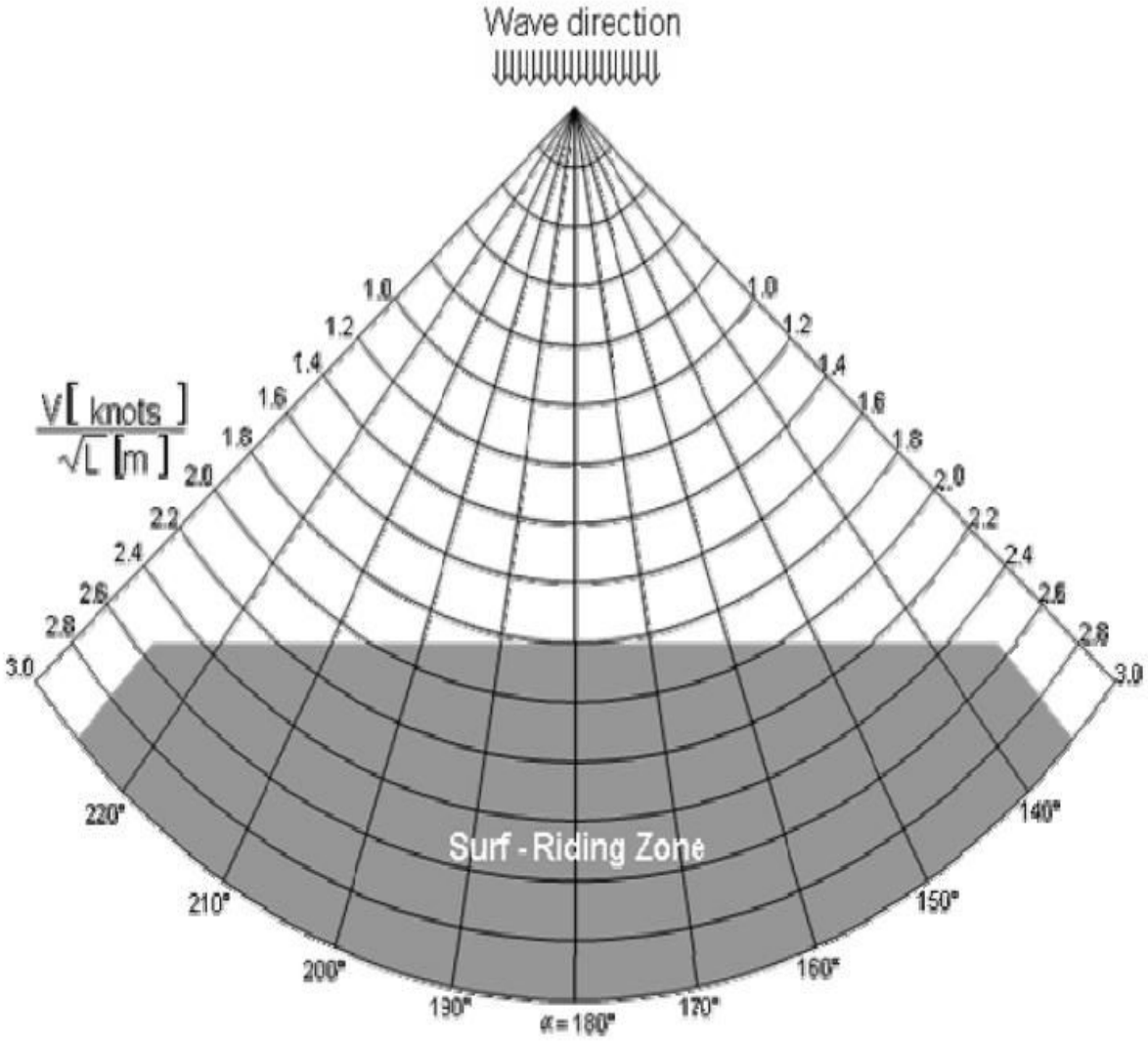

Figure 2: Risk of surf-riding in following or quartering seas

4.2.2 For successive high-wave attack

4.2.2.1 When the average wave length is larger than 0.8 L and the significant wave height is larger than 0.04 L, and at the same time some indices of dangerous behaviour of the ship can be clearly seen, the master should pay attention not to enter in the dangerous zone as indicated in figure 3. When the ship is situated in this dangerous zone, the ship speed should be reduced or the ship course should be changed to prevent successive attack of high waves, which could induce the danger due to the reduction of intact stability, synchronous rolling motions, parametric rolling motions or combination of various phenomena.

4.2.2.2 The dangerous zone indicated in figure 3 corresponds to such conditions for which the encounter wave period (TE) is nearly equal to double (i.e., about 1.8-3.0 times) of the wave period (TW) (according to figure 1 or paragraph 1.4).

4.2.3 For synchronous rolling and parametric rolling motions

4.2.3.1 The master should prevent a synchronous rolling motion which will occur when the encounter wave period TE is nearly equal to the natural rolling period of ship TR.

4.2.3.2 For avoiding parametric rolling in following, quartering, head, bow or beam seas the course and speed of the ship should be selected in a way to avoid conditions for which the

encounter period is close to the ship roll period ($T_E \approx T_R$) or the encounter period is close to one half of the ship roll period($T_E \approx 0.5 \cdot T_R$).

4.2.3.3 The period of encounter TE may be determined from figure 1 by entering with the ship's speed in knots, the encounter angle α and the wave period TW.

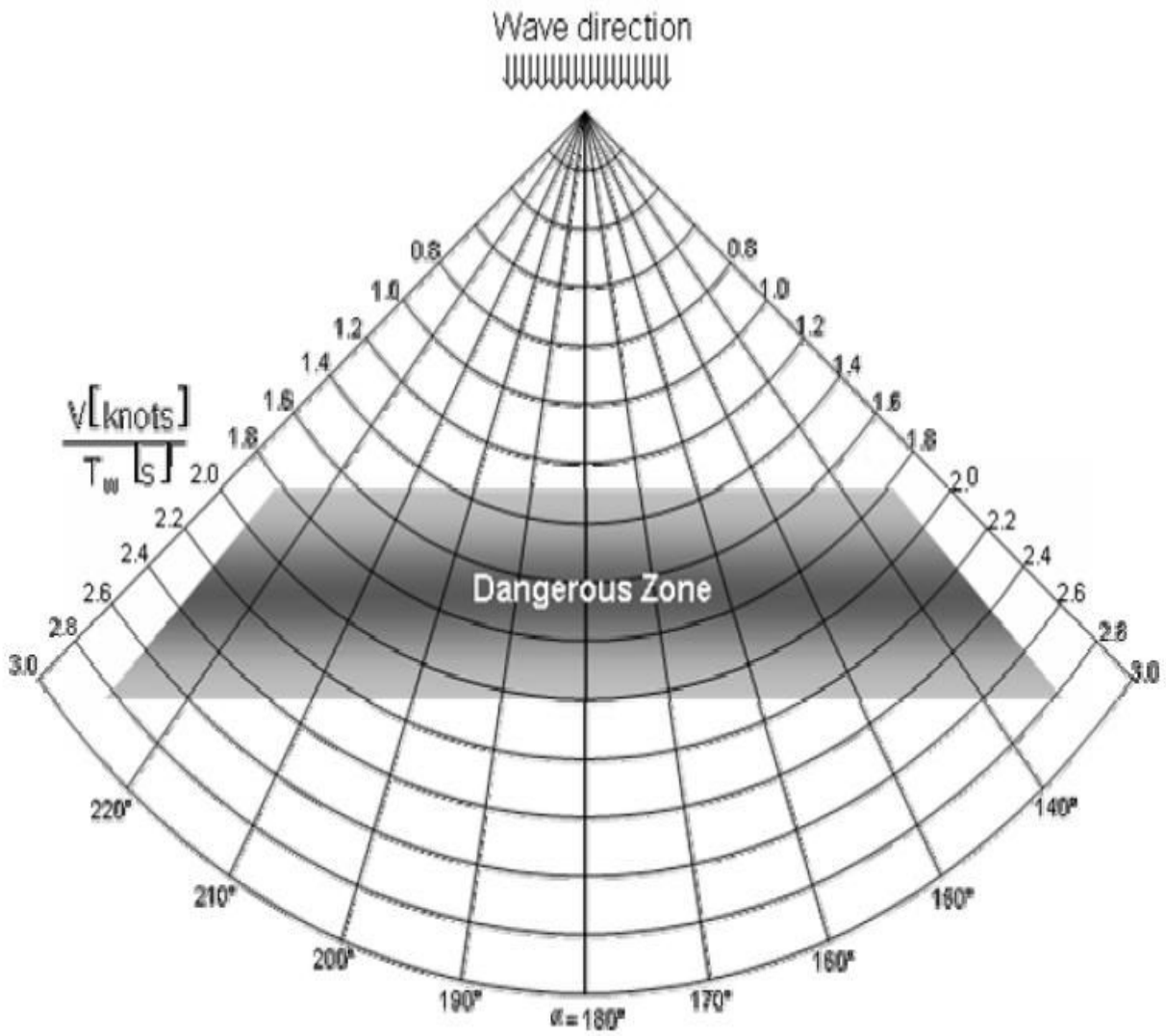

Figure 3: Risk of successive high wave attack in following and quartering seas

Abbreviations and symbols

Symbols	Explanation	Units
TW	wave period	s
λ	wave length	m
TE	encounter period with waves	s
α	angle of encounter (α = 0° in head sea, α = 90° for sea from starboard side)	degrees
V	ship's speed	knots
TR	natural period of roll of ship	s
L	length of ship (between perpendiculars)	m