MARINE GUIDANCE NOTE

MGN 199 (M)

Dangers of interaction

Note to Owners, Masters, Pilots and Tug-Masters

This Note supersedes Marine Guidance Notice 18

Summary

This note draws attention to the effects of hydrodynamic interaction on vessel manoeuvrability and describes some incidents which illustrate the dangers.

Key Points:-

- Understand that sudden sheering may occur when passing another vessel at close range
- Appreciate the need to reduce speed in narrow channels
- Be aware of the dangerous effects on tugs when manoeuvring close to larger vessels
- Be aware that unexpected turning moments may result when stopping in shallow, confined basins
- Appreciate the need to make appropriate allowances for squat
- Note the results of laboratory work

1. Hydrodynamic interaction continues to be a major contributory factor in marine casualties and hazardous incidents. Typical situations involve larger vessels overtaking smaller ones in narrow channels where interaction has caused the vessels to collide and, in one case the capsize of the smaller vessel with loss of life.

2. Situations in which hydrodynamic interaction is involved fall into the following categories:-

   (a) Vessels which are attempting to pass one another at very close range. This is usually due to their being confined to a narrow channel.

   (b) Vessels which are manoeuvring in very close company for operational reasons, particularly when the larger vessel has a small under-keel clearance.

   (c) Vessels with a small under-keel clearance which stop rapidly, when approaching an enclosed basin, resulting in unexpected sheering. Included in this category is the reduced effect of accompanying tugs which may sometimes be experienced in these circumstances.

3. PASSING VESSELS

   When vessels are passing there are two situations: (i) overtaking and (ii) the head-on encounter.

   (i) Overtaking: Interaction is most likely to prove dangerous when two vessels are involved in an overtaking manoeuvre. One possible outcome is that the vessel being overtaken may take a sheer into the path of the other. Another possibility is that when the vessels are abeam of one another the bow of each vessel may turn away from the bow of the other causing the respective sterns to swing towards each other. This may also be accompanied by an overall strong attractive force between the two vessels due to the reduced pressure between the underwater portion of the hulls. There are other possibilities, but the effect of interaction on each vessel during the overtaking manoeuvre will depend on a number of factors including the size of one vessel relative to the other, the smaller of the two vessels feeling the greater effect.

(ii) The head-on encounter: In this situation interaction is less likely to have a dangerous effect as generally the bows of the two vessels will tend to repel each other as they approach. However, this can lead indirectly to a critical situation. It may increase any existing swing and also be complicated by secondary interaction such as bank-rejection from the edge of a channel.

In all cases it is essential to maximise the distance between the two vessels. The watchkeeper on the larger vessel should bear in mind the effect on adjacent smaller vessels and take necessary care when manoeuvring.

4. INTERACTION IN NARROW CHANNELS

When vessels intend to pass in a narrow channel, whether on the same or opposing courses, it is important that the passing be carried out at a low speed. The speed should be sufficient to maintain control adequately but below maximum for the depth of water so that in an emergency extra power is available to aid the rudder if necessary. If a reduction in speed is required it should be made in good time before the effects of interaction are felt. A low speed will lessen the increase in draught due to squat as well as the sinkage and change of trim caused by interaction itself. Depending upon the dimensions of both the vessel and the channel, speed may have to be restricted. When vessels are approaching each other at this limiting speed interaction effects will be magnified, therefore a further reduction in speed may be necessary. Those in charge of the handling of small vessels should appreciate that more action may be required on their part when passing large vessels which may be severely limited in the action they can take in a narrow channel. Regardless of the relative size of the vessels involved, an overtaking vessel should only commence an overtaking manoeuvre after the vessel to be overtaken has agreed to the manoeuvre.

5. MANOEUVRING AT CLOSE QUARTERS

When vessels are manoeuvring at close quarters for operational reasons, the greatest potential danger exists when there is a large difference in size between the two vessels and is most commonly experienced when a vessel is being attended by a tug. A dangerous situation is most likely when the tug, having been manoeuvring alongside the vessel, moves ahead to the bow to pass or take a tow-line. Due to changes in drag effect, especially in shallow water, the tug has first to exert appreciably more ahead power than she would use in open water to maintain the same speed and this effect is strongest when she is off the shoulder. At that point hydrodynamic forces also tend to deflect the tug's bow away from the vessel and attract her stern; but as she draws ahead the reverse occurs, the stern being strongly repulsed, and the increased drag largely disappears. There is thus a strong tendency to develop a sheer towards the vessel, and unless the helm (which will have been put towards the vessel to counter the previous effect) is immediately reversed and engine revolutions rapidly reduced, the tug may well drive herself under the vessel's bow. A further effect of interaction arises from the flow around the larger vessel acting on the underbody of the smaller vessel causing a consequent decrease in effective stability, and thus increasing the likelihood of capsize if the vessels come into contact with each other. Since it has been found that the strength of hydrodynamic interaction varies approximately as the square of the speed, this type of manoeuvre should always be carried out at very slow speed. If vessels of dissimilar size are to work in close company at any higher speeds then it is essential that the smaller one keeps clear of the hazardous area off the other's bow.

6. STOPPING IN SHALLOW BASINS

A vessel in very shallow water drags a volume of water astern which can be as much as 40% of the displacement. When the vessel stops this entrained water continues moving and when it reaches the vessel's stern it can produce a strong and unexpected turning moment, causing the vessel to begin to sheer unexpectedly. In such circumstances accompanying tugs towing on a short line may sometimes prove to be ineffective. The reason for this is that the tug's thrust is reduced or even cancelled by the proximity of the vessel's hull and small underkeel clearance. This causes the tug's wash to be laterally deflected reducing or even nullifying the thrust. The resultant force on the hull caused by the hydrodynamic action of the deflected flow may also act opposite to the desired direction.

7. EFFECT ON THE RUDDER

It should be noted that in dealing with an interaction situation the control of the vessel depends on the rudder which in turn depends on the flow of water round it. The effectiveness of the rudder is therefore reduced if the engine is stopped, and putting the engine astern when a vessel is moving ahead can render the rudder ineffective at a critical time. In many cases a momentary increase of propeller revolutions when going ahead can materially improve control.

8. GENERAL

Situations involving hydrodynamic interaction between vessels vary. In dealing with a particular situation it should be appreciated that when a vessel is moving through the water there is a positive pressure field created at the bow, a smaller positive pressure field at the stern and a negative pressure field amidships. The effects of these pressure fields can be significantly increased where the flow of water round the vessel is influenced by the boundaries of a narrow or shallow channel and by sudden local constrictions (e.g. shoals), by the presence of another vessel or by an increase in vessel speed. An awareness of the nature of the pressure fields round a vessel moving through the water and an appreciation of the effect of speed and the importance of rudder action should enable a vessel handler to foresee the possibility of an interaction situation arising and to be in a better position to deal with it when it does arise. During passage planning depth contours and channel dimensions should be examined to identify areas where interaction may be experienced.

9. SQUAT

Squat is a serious problem for vessels which have to operate with small under-keel clearances, particularly when in a shallow channel confined by sandbanks or by the sides of a canal or river. The "Mariners' Handbook" (NP 100) contains further information on squat. The Admiralty Sailing Directions also give specific advice for squat allowances for deep draught vessels in critical areas of the Dover Strait.

EXAMPLES OF ACCIDENTS CAUSED BY HYDRODYNAMIC EFFECTS

1. OVERTAKING IN A NARROW CHANNEL

This casualty concerns a fully loaded coaster of 500 GT which was being overtaken by a larger cargo vessel of about 13,500 GT. The channel in the area where the casualty occurred was about 150 metres wide and the lateral distance between the two vessels as the overtaking manoeuvre commenced was about 30 metres. The speeds of the two vessels were initially about 8 and 11 knots respectively. When the stem of the larger vessel was level with the stern of the smaller vessel the speed of the latter vessel was reduced. When the bow of the smaller vessel was level with the midlength point of the larger vessel the bow started to swing towards the larger vessel. The helm of the smaller vessel was put hard to starboard and speed further reduced. The rate of swing to port decreased and the engine was then put to full ahead but a few seconds later the port side of the smaller vessel, in way of the break of the foc'sle head, made contact with the starboard side of the larger vessel. The angle of impact was about 25° and the smaller vessel remained at about this angle to the larger vessel as she first heeled to an angle of about 20° to starboard and shortly afterwards rolled over and capsized, possibly also affected by the large stern wave carried by the larger vessel into which the smaller one entered, beam on, as she dropped back.

2. MANOEUVRING WITH TUGS

The second category is illustrated by a casualty involving a 1,600 GT cargo vessel in ballast and a harbour tug which was to assist her to berth. The mean draughts of the vessel and the tug were 3 and 2 metres respectively. The tug was instructed to make fast on the starboard bow as the vessel was proceeding inwards, and to do this she first paralleled her course and then gradually drew ahead so that her towing deck was about 6 metres off, abeam of the vessel's forecastle. The speed of the two vessels was about 4 knots through the water, the vessel manoeuvring at slow speed and the tug, in order to counteract drag, at $^3/_4$ speed. As the tow line was being passed the tug took a sheer to port and before this could be countered the two vessels touched, the vessel's stern striking the tug's port quarter. The impact was no more than a bump but even so the tug took an immediate starboard list, and within seconds capsized. One man was drowned.

3. STOPPING IN A SHALLOW BASIN

In the third category a VLCC was nearing an oil berth in an enclosed basin which was approached by a narrow channel. The VLCC stopped dead in the water off the berth while tugs made fast fore and aft. An appreciable time after stopping the VLCC began to turn to starboard without making any headway. The efforts of the tugs to prevent the swing proved fruitless and the starboard bow of the tanker struck the oil berth, totally demolishing it.

RESULTS OF LABORATORY WORK

1. Extensive laboratory work has been carried out on the combined effects of hydrodynamic interaction and shallow water (i.e. depth of water less than about twice the draught) and the following conclusions, which have been borne out by practical experience, are among those reached:

(a) The effects of interaction (and also of bank suction and rejection) are amplified in shallow water.

(b) The effectiveness of the rudder is reduced in shallow water, and depends very much on adequate propeller speed when going ahead. The minimum revolutions needed to maintain steerage way may therefore be higher than are required in deep water.

(c) However, relatively high speeds in very shallow water must be avoided due to the danger of grounding because of squat. An increase in draught of well over 10% has been observed at speeds of about 10 knots, but when speed is reduced squat rapidly diminishes. It has also been found that additional squat due to interaction can occur when two vessels are passing each other.

(d) The transverse thrust of the propeller changes in strength and may even act in the reverse sense to the normal in shallow water.

(e) Vessels may therefore experience quite marked changes in their manoeuvring characteristics as the depth of water under the keel changes. In particular, when the under-keel clearance is very small a marked loss of turning ability is likely.

(f) A large vessel with small under-keel clearance which stops in an enclosed basin can experience strong turning forces caused by the mass of entrained water following it up the approach channel.

(g) The towing power of a tug can be reduced or even cancelled when assisting a larger vessel with small under-keel clearance on a short towline.

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April 2002

MNA 53/43/001

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