Tugs and wind drift

Identifying a safe means of tug approach in high winds

Capt Henk Hensen FNI

Experience remains a crucial factor for safe ship handling, even as tugs are becoming more and more capable. This includes the need for the Master and pilot of the vessel to have an insight into the circumstances under which the tug master is operating.

Proper communication and information exchange between pilot and tug master is essential for safe ship handling and for the safety of the tug and its crew. The pilot knows what information a tug master needs, and in the case that it is not provided, a well trained tug master will request it.

There are, however, a few occasions where the tug master may not get the specific information needed – or even be neglected altogether. This can lead to very risky situations for a tug, its crew, and the ship alike.

Let us take the case of a large ferry, operating in cross winds of Beaufort force 7-8. These ships do not usually use tugs, often taking them only in adverse weather conditions, so will have less experience in their use. The same considerations will to a certain extent also apply to other high windage ships, particularly those with a relatively low draft.

The vessel

Length o.a. 240m
Length p.p. 224m
Draught 6m
Two 4,000 HP bow thrusters
Estimated lateral wind area: 7000m^2
Estimated lateral underwater area: 1350m^2

Hydrodynamic conditions
Water depth: 15 metres
Underkeel clearance: 9 metres
Depth: draft ration: 2.5

Wind conditions

Wind direction: About 110° from the bow

Mean wind speed 1: 7 Bft = 15.5m/sec
30 secs gusts: 18.8m/sec

Mean wind speed 2: 8 Bft = 18.9m/sec,
30 sec gusts: 22.9m/sec.

Note: The Beaufort wind speed is given over an average of at least 10 minutes. The ferry may react to gusts of 30 secs average. A gust factor of 1.21 has therefore been applied.

Factors affecting ship behaviour

A crucial factor is how fast the ship will drift due to the wind. High windage ships with a relatively low draft will drift faster than the same ship when deep loaded. Although draft is an important factor, underkeel clearance, hull shape, bilge keels, etc, are also important parameters. For instance, ships will tend to drift aside more easily where there is a large underkeel clearance, as will ships with a less box-shaped hull.

Wind drift is largest when the wind is from about three points forward of the beam to three points aft of the beam (see figure 1). Let us assume a wind direction of about two points aft of the starboard beam, about 110° from the bow, when the ship is not yet steering a drift angle.

Even where it seems like the situation is steady, the fluctuating wind requires the ship to steer a varying course to compensate for gusts. When a cross wind gust strikes the ship, the ship may start to turn. The Master is likely to compensate for this by increasing rudder angle, and probably by increasing power too. The immediate consequence of this action is that sideways drift will increase before the intended course is achieved. This may cause additional risk for any tugs on the lee side, especially if any corrective action taken by the ship is not communicated to the tug.

To ensure the safety of tugs, it is essential that tug masters are kept continuously informed about all ship manoeuvres when approaching the bow to fasten a towline – even what may appear minor compensatory changes to maintain course and steering.

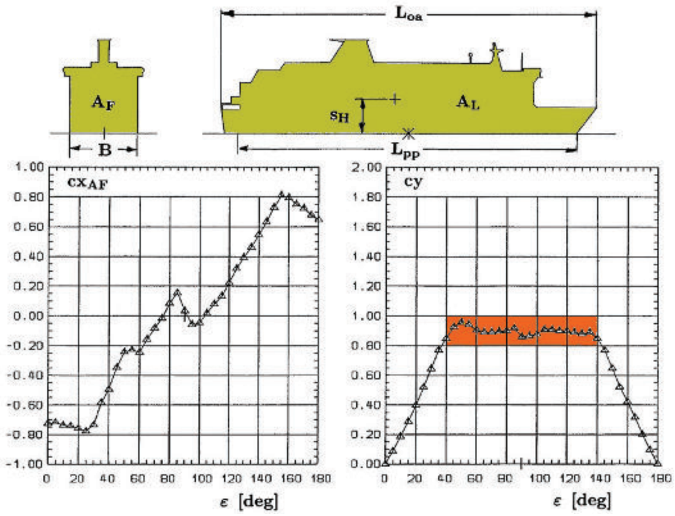


Figure 1. Wind load coefficients of a passenger/car ferry: LOA 161m; beam 29m (Blendermann, 2004)
The right hand graph shows the wind drag coefficient Cy which hardly changes between wind attack angles 40 – 140 degrees.

Wind forces

For ferries, wind drag coefficient for a wind angle of 90° varies between Cyw = 1.0 and 0.9. We will assume a wind drag coefficient of 1.0. Although the wind direction may differ, the wind drag coefficient itself hardly changes between rather large angles forward and aft of the beam as shown in Figure 1.

The calculated wind forces on the ferry for the two wind speeds are then:

- For wind speed 1 (7 Bft): 162 metric tons
- For wind speed 2 (8 Bft): 240 metric tons

Drift speeds

To calculate the drift speeds, the drag coefficients for cross currents are needed.

Given a current angle of 90° and a water depth/draft ratio of 2.5, a Cyc = 1.2 is taken into account. The underwater area is Draft x Lpp = approximately 1350m^2.

This gives the following drift speeds:

- Wind force 7 Bft: Drift speed: 1.38m/sec = 2.8kn
- Wind force 8 Bft: Drift speed: 1.68m/sec = 3.4kn

In other words, in five seconds, the ship will drift:
7 metres in 7 Bft winds;
8.5 metres in 8 Bft winds.

Effects on the ship

What do these conditions mean, for the ship, and for the tug?

The drift angle which the ship steers will depend on its speed. The maximum safe speed for passing a towline near the bow of a ship having headway is 6 knots. However, because a speed of 6 knots could be too low for the ship to maintain its course in high winds, we will also look at the effects of the less safe speeds of 7 and 8 knots. The various drift angles are shown below.

Ship speed	Wind speed 7 Bft Sideways drift 2.8 knots	Wind speed 8 Bft Sideways drift 3.4 knots
	Drift angle to steer	
6 knots	27°	32°
7 knots	23°	28°
8 knots	20°	24°

The higher the ship speed, the smaller the drift angle to steer. Note that as the ship speed increases, so do the risks for the tug near the bow, due to the interaction effects between tug and ship.

Use of the bow thruster and stern propellers can to some extent compensate for sideways drift, although the effectiveness of the bow thruster decreases as the ship speed increases. The ship's pilot or master should inform the tug master that the bow thrusters are running as this may affect the flow pattern around the bulbous bow.

What is the effect of the bow thruster? Assume an effect of 30% at 6 knots speed. Two bow thrusters of 4000 hp each give a total cross force forward of about 80 tons. 30% of this is 24 tons. If both stern propellers could deliver this in addition to the power needed for the forward speed, a total cross force of about 50 tons could be generated to compensate for the wind force.

For 8 Bft wind this is 20% of the total cross force. This reduction in cross force still results in a drift speed of 1.34m/sec or 2.7 knots.

With 7 Bft wind it is 30% of the cross force. This reduction in cross force results in a drift of 0.97m/sec or almost 2 knots.

In short, bow thrusters in combination with propellers will reduce the drift speed, but will not eliminate it entirely. A rather large drift speed still remains.

It is questionable whether bow thrusters can keep running with full power over a period of 30 minutes or more, and whether the Master would be able to continuously carry out the manouevres given the fluctuating wind. Further, when bow thrusters are overloaded due to too much sideways speed and/or insufficient water inflow, they may suffer sudden thrust break down, with implications for drift speed and steering angle.

For these reasons, the effect of the bow thruster will not be taken into account in the following discussion.

Effects on the forward tug

A high sided ship in strong side winds preparing to fasten tugs will usually be doing so outside the narrower port areas. The lack of visual cues can make it difficult for the tugs to observe or estimate the ship's drift, particularly in darkness, rain or snow.

Two approach procedures will be considered:

1. The approach procedure normally followed by conventional tugs, which also applies to Azimuth Stern Drive (ASD) when operating over the stern, and
2. The procedure followed by tractor tugs, and ASD tugs when operating bow-to-bow.

Bear in mind that in these scenarios the tugmaster has not been informed of the ship's drift. An approach that crosses directly ahead of the ship might give the tug master some indication of the ship's drift – but neither of these methods allow for that possibility.

Figures 2A and 2B represent the situation with a wind force of 7 and 8 Bft respectively.

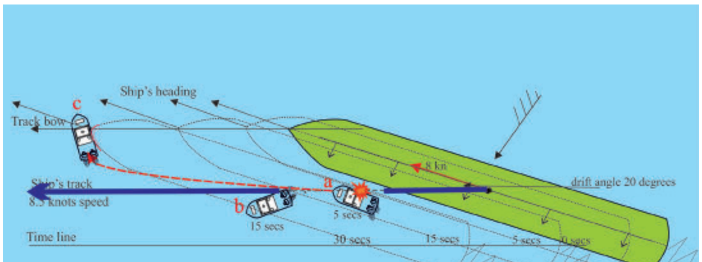
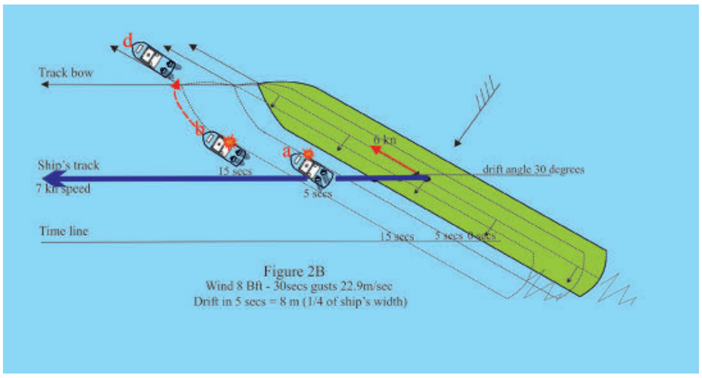


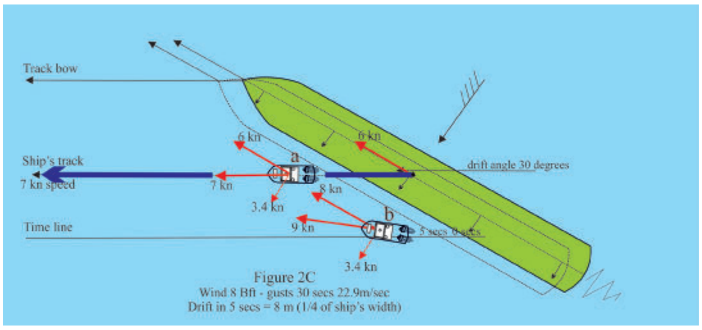
Figure 2A
Wind 7 Bft - 30 secs gusts 18.8m/sec
Drift in 5 secs = 7m

Figure 2A, above, shows the better situation, relatively speaking, with wind force 7 Bft, but with a ship speed of 8 knots – too high. The tug has approached the ship on the lee side to try to make a connection at the bow. It intends to travel forward along the ship at 5-10m distance off (position a). As the tug master cannot see that the ship is drifting, they steer the tug parallel with the ship. Within just a few seconds, the ship drifts against the tug. What can the tug master do? An instinctive reaction is to try to get free from the hull with engines full ahead and with port rudder, or thrusters set to port for an ASD tug. However, in doing so, the tug is pushing itself even harder towards the ship's hull. The result is that the tug will move forward along the ship's hull, finally coming under the bow and on the bulb with a great risk of capsizing. If the tug master does succeed in getting the tug free from the ship's hull, the tug should then get away at full speed because the ship is coming rapidly closer (position b). A tractor tug would have better ability to get free due to the forward position of the propulsion units.



The situation shown in figure 2B, above, with wind force 8 Bft, is even worse. The ship speed is now 6 knots, and the vessel is steering a drift angle of 30 degrees. Everything that has been said about the tug positioning with wind force 7 Bft applies with even more urgency here.

In both situations, the tug master could give astern on the engines/ thrusters to get away from the vessel, instead of increasing speed with port rudder or port thruster angles. However, does that make any sense here? Would the tug get free from the drifting ship? An ASD tug might manage it, but with the conventional type of tug it becomes very problematic.



If the tug master has been informed of the drift angle, track speed and direction, the tug master could use this knowledge to anticipate the ship's movements, as shown in figure 2C, below left. Here, the arrows at position a shows the direction and speed required to keep pace with the ship. The smaller red arrows in situation b show how the tug can move forward along the ship without coming close. In theory this looks feasible, but in practice it will be a very risky manoeuvre to keep the tug in a safe position on the leeside of the fast drifting ship.

Picking up the towline on the windward side of the ship is not an option.

A better solution

If the tug master is well informed, then there are better ways to approach the bow. These are discussed below, and illustrated in Figure 3, below. All these options are suitable for ASD tugs operating over the bow and tractor tugs, but also for highly manouverable conventional tugs and ASD tugs operating over the stern.

One possibility is for the tug to approach the ship from the windward side, coming in at position A. From here it can pass the bow of the ship at a safe distance. The course to steer is roughly parallel to the ship's track (see dotted blue line inidicating tug's course to steer and solid blue arrow indicating ship's track).

The tug master may choose to alter the course somewhat to port or starboard to pass the ship's bow at a closer or wider distance. Tug's speed should be higher than 7 knots.

Having passed the ship's bow (position C), speed can be decreased and tug's heading can be changed somewhat to port. This allows the ship to approach the tug, which controls its position relative to the ship's bow by heading and speed settings. The tug therefore comes into the lee of the bow. A heaving line can then be thrown from the ship's bow to the tug.

Alternatively, the tug may approach from position B, at a safe distance from the ship, or from position D. In each case, the tug should manoeuvre towards position C and then follow the same procedure as above.

A tractor tug can follow the same procedure.

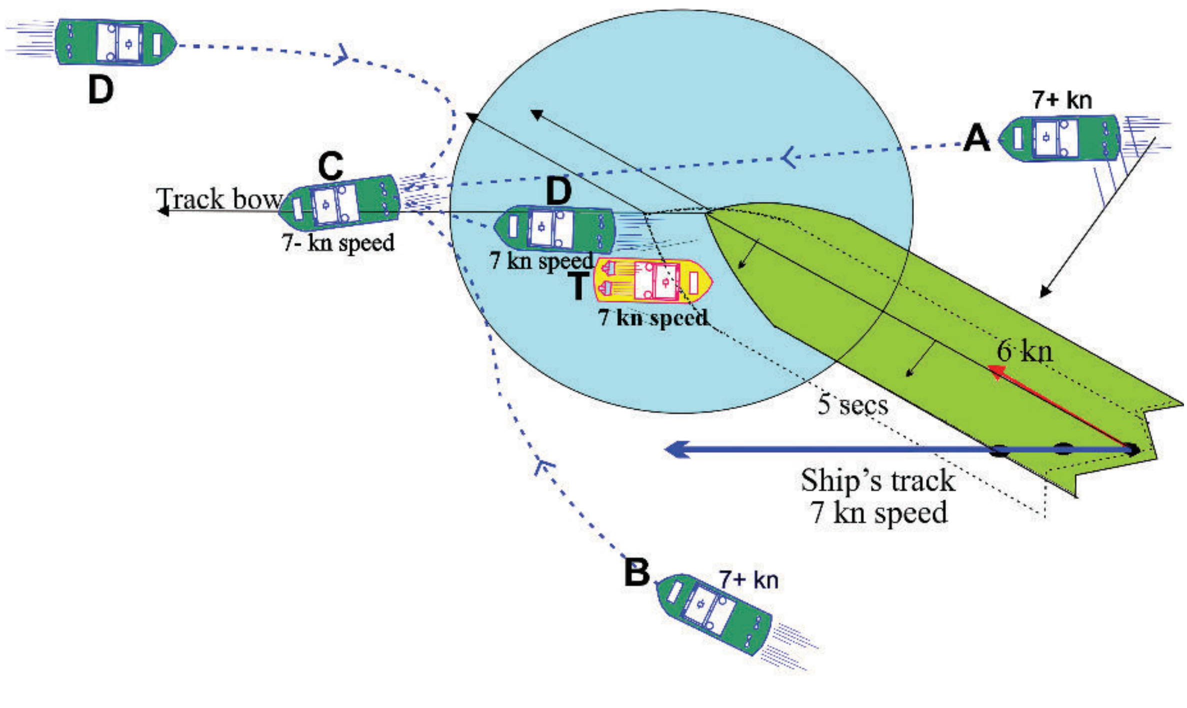


Figure 3. Tugs approaching bow
Wind 8 Bft with 30 secs gusts of 22.9m/sec

An ASD tug operating over the bow in order to assist bow-to-bow (tug T, in yellow) should preferably start from position A, sailing stern first across the vessel's bow towards position C and then reducing the speed and regulating the heading to let the leeside of the ship's bow approach the tug. Once the tug has come close enough to the bow, the speed should be regulated to ensure that it stays at a safe distance from the bow.

Which to choose?

The key difference between options A, B and D is that approaching from position A gives a better insight into the ship's movements, such as drift and speed. The ship's heading may change during a tug approach due to the fluctuating wind. Therefore, although the tug master should be informed of any changes, a tug approaching from position A will have a better view of ship movements as it passes rather close to the bow, regardless of any information given, and can better anticipate and control the tug's position in relation to the ship.

It would be good to test and train these manoeuvres on a ship bridge simulator. If doing so, please be aware that the close hydrodynamic ship – tug interaction may not be accurately modeled in the simulator and a nearby position may seem safer in the simulator than it is in real life.

Note:

It has been shown that approaching the ship on the leeside to pass a heaving line poses risks for the tug and its crew. This is potentially a very stressful situation for a tug master, and the risks may be increased by the following instinctive reactions:

1. A tendency to quickly turn the thrusters. No problem with that. However, a combination of quickly turning the thrusters while proceeding at a rather high speed may cause a large angle of attack of the nozzle openings versus the direction of the inflowing water.

   This may result in thrust reduction and consequently in speed reduction.

2. A tendency to oversteer, meaning that a larger angle than necessary is selected. This is often afterwards followed by a smaller angle as the tug starts to react. Both oversteering and understeering have an adverse effect on thrust.

   When positioned close to the ship, any thrust reductions may have a disastrous outcome when the tug master tries to keep sufficient distance and may so collide with the ship.

At a glance

This discussion and the following conclusions apply specifically to crosswinds – that is, from about 30 degrees before the beam to 30 degrees aft of the beam.

Most importantly, it is essential that the ship's pilot, Master or mate informs the tug master of ship's speed, drift angle steered and the direction and speed of the ship.

The best way for an ASD tug or tractor tug is to approach the ship from the windward side, cross the bow and manoeuvre the tug into a position where the ship will approach the tug with its leeside, as shown in Figure 3. A heaving line can then be sent over from the ship's bow. The tug's position can be precisely controlled, and the tug can easily enlarge the distance if the ship comes too close. A good manoeuvrable conventional tug could also follow this procedure.

Other lessons to be learned include:

- The drift angle to be steered depends on ship size and draft, etc, but also on the safe speed for working with tugs, particulary bow tugs. This safe speed is in general about 6 knots. In strong cross winds, it can become very difficult to control a large high windage vessel at such a low speed and speeds may rise to 7 knots or more.
- It is difficult for the tug master to see drift speed and drift angle steered, particularly when there are few visible cues and in darkness, rain or snow.
- Not being aware that the ship is steering a drift angle due to high winds includes risks for the attending tugs, tug crew and the ship to be assisted.
- Ship's pilot or master should inform the tug master if the bow thrusters are running as this may affect the flow pattern around the bulbous bow.
- Conventional tug types and ASD tugs operating over the stern should not approach a drifting ship from the lee side. If drift speed is not more than about 1 knot, tractor tugs may be able to operate at the leeside, although utmost care is needed.

It is strongly recommended to test, and if necessary, to train the above manoeuvres on a ship bridge simulator with pilots and tug masters for the high windage ships that call at the port, particularly for those ships that do not normally use tugs.

References:

1 Ship may encounter high wind loads – a statistical assessment. Blendermann, 2004.

Handling a high-sided ship in calm conditions – matters are very different in high winds