

5. SHIP-TUG INTERACTION

5.1 Ship-tug cooperation

The ship-tug interaction is a function of many factors and depends mainly on:

- Type of tug co-operating with a ship, where the main difference results from the location of tug's propulsion and towing point. The choice is between conventional single or twin-screw tugs very often fitted with nozzles and tractor type tugs. The ASD (azimuth stern drive) tugs are the compromise linking some of the benefits of conventional and tractor tugs type.

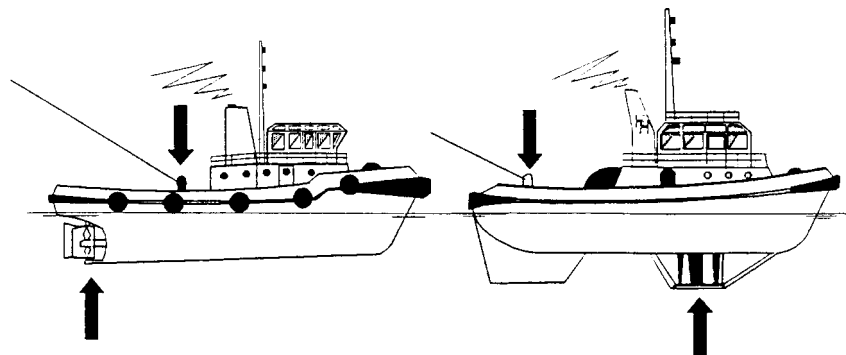


Fig. 5-1 Conventional and tractor type tugs – difference in location of tug's propulsion and towing point is shown (from “Tug Use In Port”, The Nautical Institute, 1997).

- Assisting methods are mainly used: tugs towing on a line and tugs assisting at the ship's side.

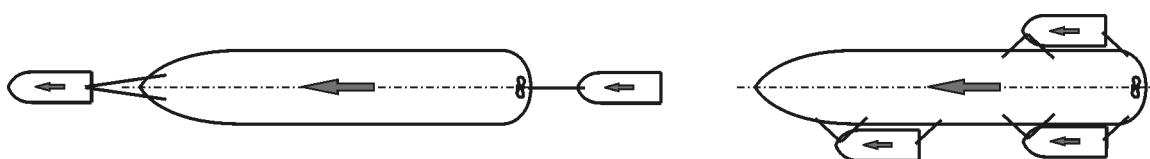


Fig. 5-2 Schematic presentation of towing on a line and assisting at the ship's side (from “Tug Use in Port”, The Nautical Institute, 1997)

5.2 Dangers related to ship-tug cooperation

When assisting a ship, tugs operate in her close proximity in disturbed water pressure regions surrounding a ship's hull. This is the source of interaction phenomenon, especially dangerous for relatively small tugs when comparing with the size of assisted ships.

Consecutive positions of a tug when approaching a ship to be assisted are shown in fig. 5-3. When the tug approaches the aft part of the ship (position 1), an increase of her speed

may occur due the incoming flow velocity. In the close proximity of ship's hull, a low pressure starts to move the tug towards the hull. For ships in ballast condition or for ships having particular overhanging stern, the tug can easily come to position 2, which creates danger of damages to the tug's hull and superstructure.

Proceeding further along the hull (position 3), the tug is under important suction force oriented towards the ship's hull and outward turning moment due to tug bow-cushion. Once sucked alongside it is very difficult to get off again and to continue the way.

Tug in position 4 enters the high-pressure area. Arising outward turning moment must be eliminated by appropriate use of rudder and engine. When arriving to position 5 close to the bow, very strong "out force" acting on the stern tries to bring the tug to position 6 broadside under the bow with risk of capsizing. Immediate action of rudder and use of available power (full astern) can correct the position. Tractors type tugs are less vulnerable in such a situation.

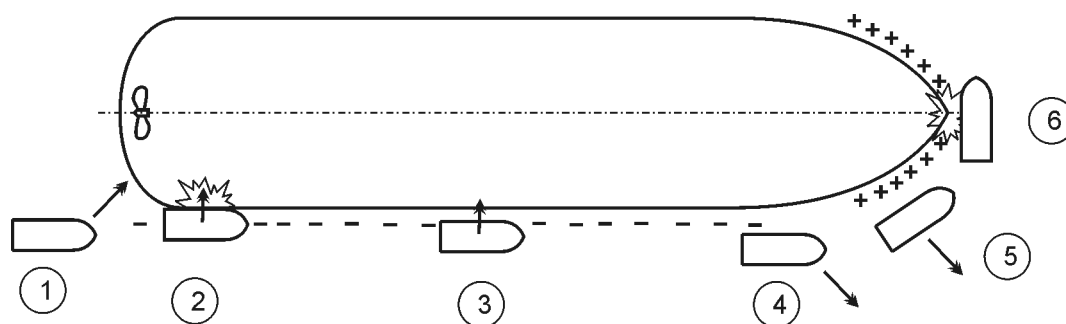


Fig. 5-3 Schematic representation of possible tug ship interactions when preparing passing or taking a towline

The main source of danger for a tug when assisting a ship is ship's too high speed. Classical tug accidents (so-called "girting") are presented in next three figures. In fig. 5-4, a tug working on a line is assisting a ship making a turn to starboard (position 1). Ship is suddenly accelerating for example to improve turning abilities in order to realise the turn correctly. The speed after few moments becomes too high and the consecutive tug positions are more and more aft with high tension in the towline (positions 2 and 3). The danger of capsizing is then real.

The above-described situation is less dangerous for tractor tugs because their towing point lies at the aft. So-called "gob rope" (fig. 5-5) for conventional tugs can improve much the situation by shifting the towing point more to the stern, but on other hand it limits the manoeuvrability of the towing tug.

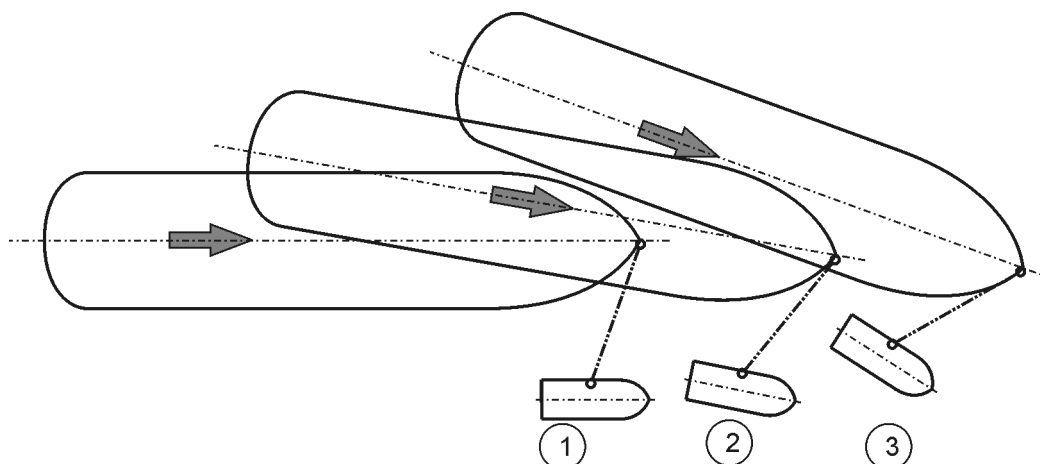


Fig. 5-4 an example of girting due to excessive ship's speed, tug is working on a line.

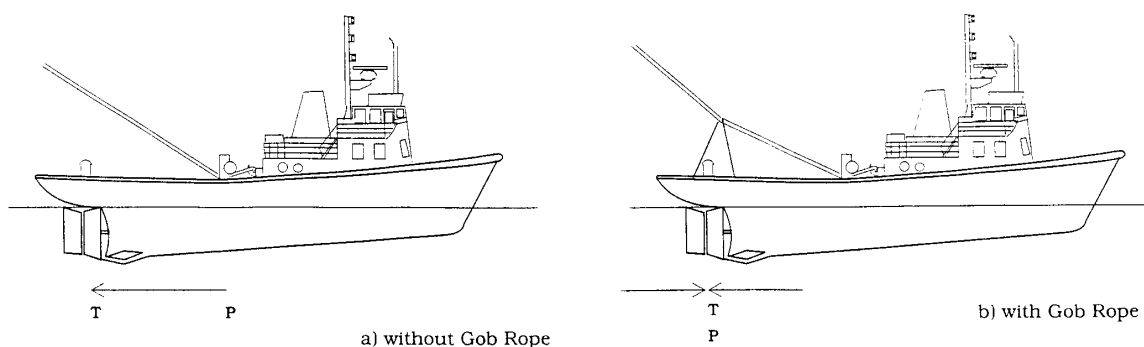


Fig. 5-5 the gob rope – principle of use (“ The ship handler’s guide”, The Nautical Institute, 1997)

Girting may occur not only when ship is making turn, as it was shown previously. In the case of straightforward motion with too high speed for a given tug, her master starts to steer out towards the position more aside to avoid contact with ship's bow. If ship's speed will not be quickly reduced, in next few instants a girting may occur.

In figure 5-6, another example of girting situation discussed in many manuals is shown. Due to misunderstandings between a pilot and a tug master, a tug continues the straightforward motion (position 1), even when the ship starts to swing starboard. As the result of it, the dangerous situation to the tug may develop (positions 2 and 3). To avoid this, the tug master always should be informed about ship's intention.

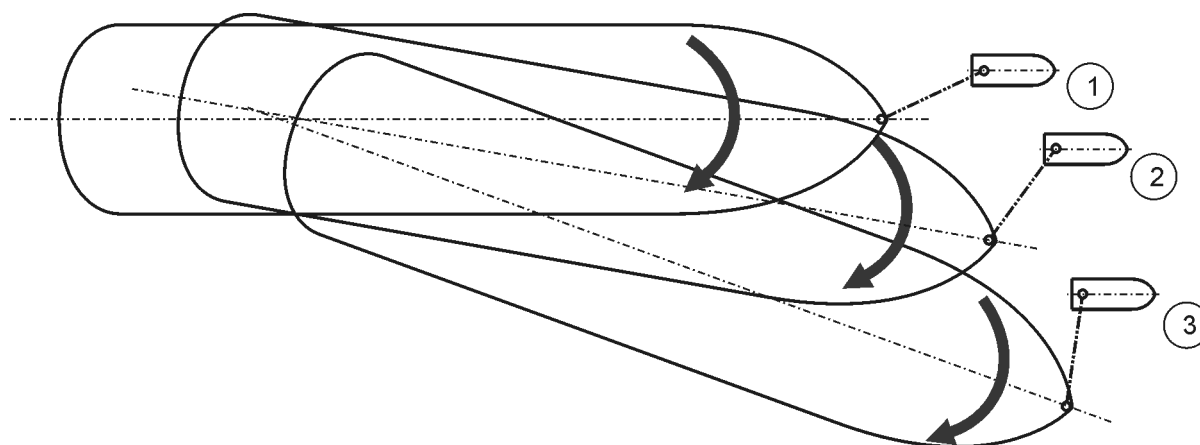


Fig. 5-6 An example of girting due to misunderstanding between manoeuvring ship and a tug, tug is working on a line.

Of course, girting phenomenon occurs also in the case of stern tugs, as it is shown in fig. 5-7. Too high ship's speed being often result of sudden increasing of propeller revolutions makes working positions 1 and 2 difficult to keep, and the tug moves more and more towards position 3, where it will be exposed to a risk of girting.

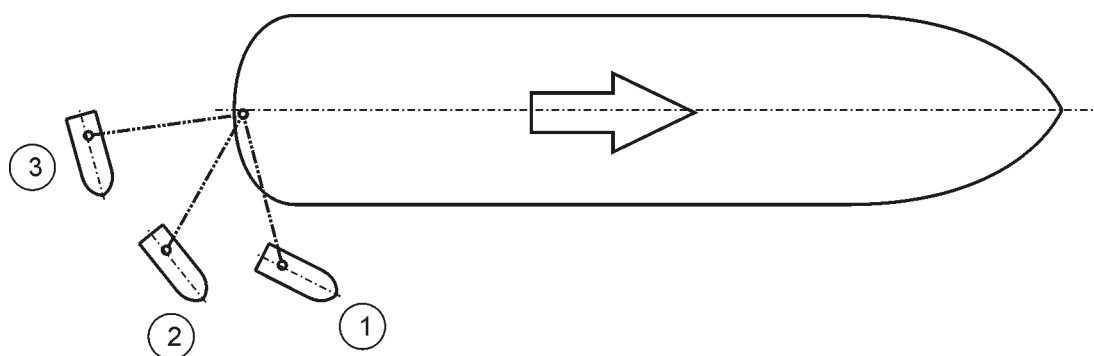


Fig. 5-7 Girting a conventional tug being in aft position

Some other dangers affecting frequently tug's safety are listed below:

- Bulbous bows are not visible when they are underwater and because of their important dimensions the stern of the tug may touch the bow when passing or taking a towline. Short towlines can also create similar danger for tugs. This situation is especially dangerous in the case of excessive forward speed of ships to be assisted.
- An inexperienced ship's crew may not be able to release tug's towline when needed. After slacking off the towline by a tug, when ship's speed increases, the tension simultaneously increases in the towline dragged through the water. The releasing of the towline becomes very difficult, if not impossible.

- When the bollard pull of assisting tugs is not sufficient to counteract all external forces acting on a ship (underestimation of wind force, current velocity increases), tugs can be jammed between the ship and the berth as the result of drifting ship's motion.
- When passing or taking a towline, the ship's speed and heading must be constant. Any change in values of the above parameters creates additional danger to the tug. If such a situation will occur, the assisting tug must be immediately informed to anticipate expected manoeuvres.

5.3 Required number and total bollard pull of tugs

There is no general rule describing relationship between ship's size and required tug's number and bollard pull. Each harbour has its own calculations based on port layout, berth construction, local environmental conditions, available tug characteristics and method of assistance, parameters and equipment of a ship to be assisted, and experience of local authorities.

For a given port layout and berth construction and for a given ship, the required bollard pull is a function of wind, current and eventual waves. The resulting force acting on a given ship must be compensated by bollard pull of assisting tugs.

To the above assessment of required bollard pull, special allowance should be added. It takes into account special power reserve:

- For pushing or pulling a ship up against wind and current;
- For elimination the eventual longitudinal motion when berthing without use of propeller;
- For elimination undesirable interaction effects (for example Coanda effect);
- For taking into account true power actually available which can differ from original bollard pull tests.

Equal forward and aft tug power is not always the case. The ship is very often under the influence of wind and current yaw moment due to specific ship's profile above the water and to the form of underwater part of the hull. Actual loading conditions are very important factor in planning of number of tugs and the tug position along the hull.

An example of calculation of required bollard pull and number of tugs for different ship types based on their length and deadweight is given below ("Tug Use In Port", The Nautical Institute, 1997).

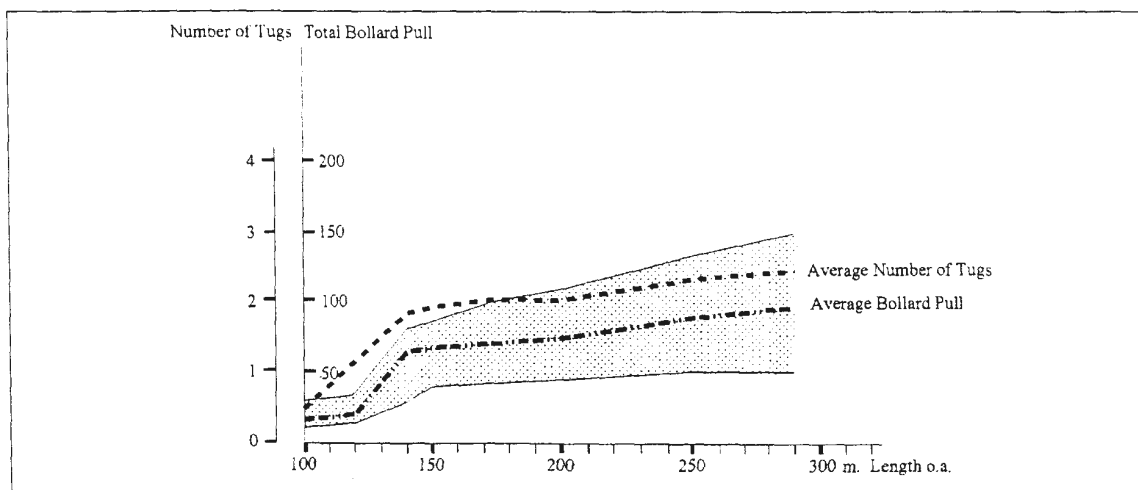


Fig. 5-8 Total bollard pull and average number of tugs for container and general cargo vessel in function of ship's length

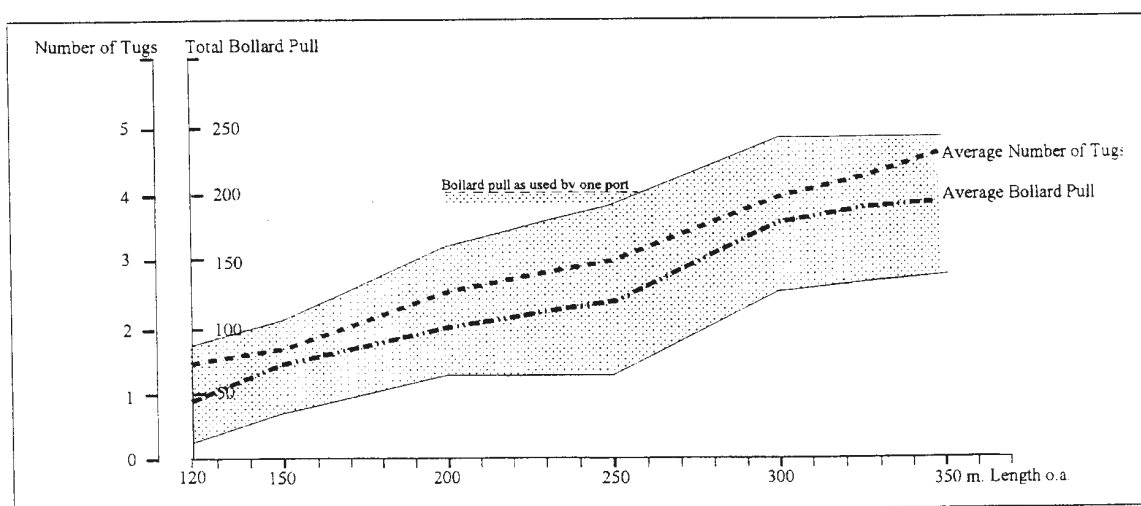


Fig. 5-9 Total bollard pull and average number of tugs for tankers and bulk carriers in function of ship's length

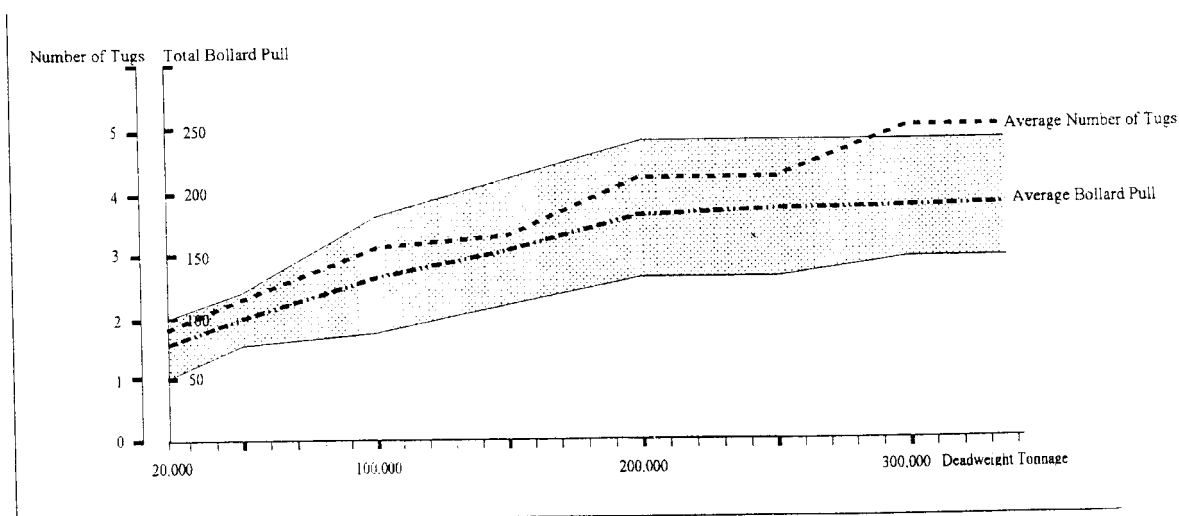


Fig. 5-10 Total bollard pull and average number of tugs for tankers and bulk carriers in function of ship's deadweight

5.4 Tug effectiveness

5.4.1 Ship dead in the water

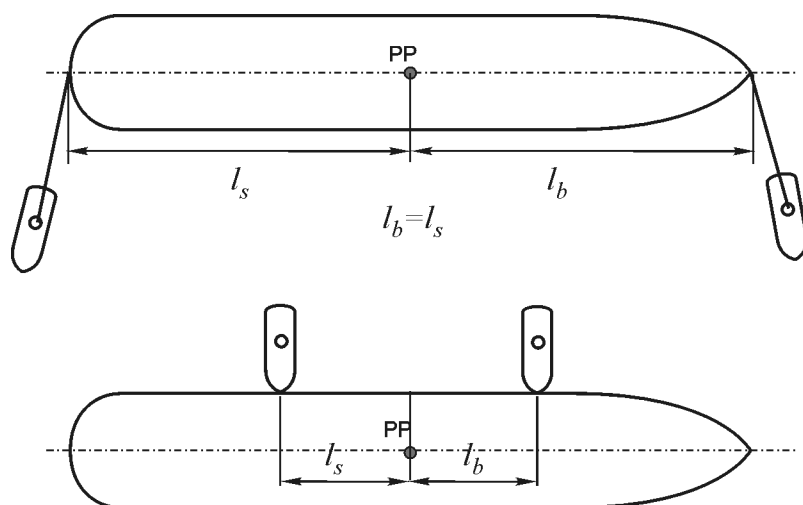


Fig. 5-11

Pivot point at midship.

Two tugs pulling or pushing sideways.

Ship is shifting to one side without swing if both tugs develop equal pulling or pushing forces and levers are the same.

5.4.2 Ship making headway

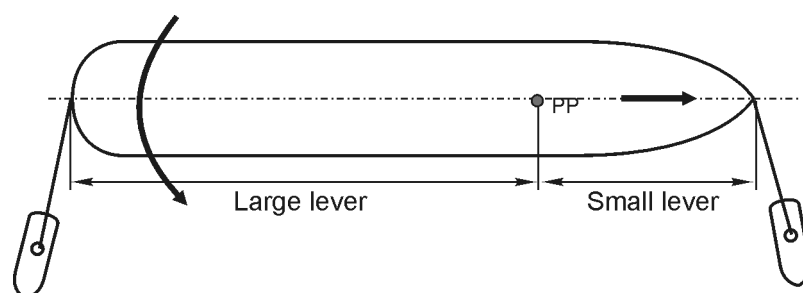


Fig. 5-12

Pivot point shifts forward.

Stern tug working on large lever is more effective.

Ship has a tendency to swing to port.

5.4.3 Ship making sternway

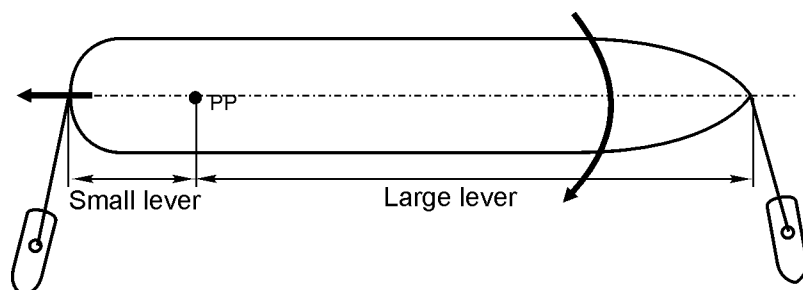


Fig. 5-13

Pivot point shifts aft.

Stern tug working on small lever (less effective).

Bow tug working on large lever.

Ship has a tendency to swing to starboard