LEARNING FROM ACCIDENTS

by

Captain Henk Hensen FNI

1. Introduction

Much can be learned from day-to-day practice, but accidents do happen during the daily practice of tug operations and the challenge is to learn from these accidents to avoid repeating them.

Tug assistance is TEAMWORK. Teamwork between the tug masters and teamwork between tug masters and pilots. If one makes a mistake, whether a tug master or a pilot, it has its effect on the other team members. This effect can sometimes be disastrous, as examples will demonstrate. This is why training should not only focus on the capabilities of tug masters but also on the tug knowledge required by pilots, and on teamwork.

EXPERIENCE gained during day-to-day practice with the specific tug a tug master has under his command is essential to be able to carry out tug operations in a safe and efficient way. It will be shown what the consequences can be if this experience is lacking.

ACCIDENTS ON BOARD VESSELS also have consequences for the assisting tugs and the tug industry.

All these aspects will be reviewed and this presentation will focus on a number of essential aspects of harbor towage with particular emphasis on accidents which have occurred and how they can be prevented. In particular this paper will consider:

1. The ability to assess total tug bollard pull needed to safely handle large high sided vessels, such as large container vessels, gas carriers and car carriers, in case of strong winds.
2. The required experience and knowledge of capabilities and limitations of tugs.
3. Safety of tugs.
4. Engine and rudder failures on board ships.
5. Strength of bollards and fairleads on board ships.

These are all very practical issues. The first two items have a relationship with item 3: Safety of tugs. They show the need for proper training of pilots and of tug masters, as does item 4 to a certain extent.
The last two items have become more and more important during recent years.

2.0 Wind forces

Three aspects that require attention will be considered:

- The knowledge required by pilots.
- The effect of lack of knowledge on ship and tugs.
- The need for tug masters to show initiative in certain situations.

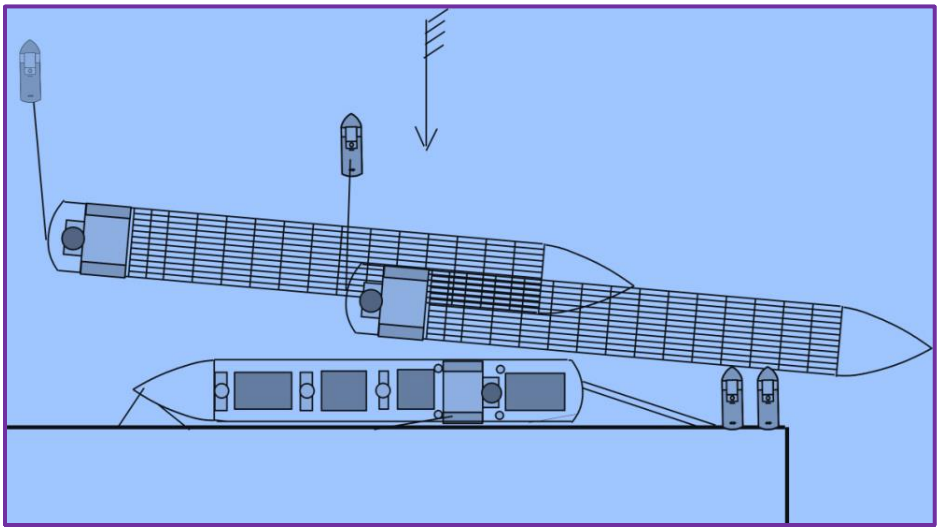

Figure 1. Accident with CMA CGM DeBussy

As an example, an accident to the container ship *CMA CGM DeBussy* will be used. The accident happened in the port of Constanta in March 2010. As a result of strong winds the ship drifted against the Turkish freighter *Haci Fatima Sari* and one of the assisting tugs was crushed between the container ship and the berth.
There was a strong beam wind blowing , so one can ask who is to blame? The wind? No! The tugs? I would not say that. The pilot? We will try to find an answer.

Wind speed and direction should be known. If the port control station or the pilot station has no wind indicator, there is one on the bridge of most ships. Knowing the wind speed, the required bollard pull for cross winds (see note 2) to keep the ship under control can be calculated. A simple formula gives a good indication of the total required bollard pull (bp) for a range of ship types:

$$\text{Total required bp} = 0.08 \times A \times V^2$$

Total required bollard pull in kgs (kgf); A is the ship's longitudinal wind area in m^2; V is wind speed in m/sec.

The wind speed is known. Longitudinal wind area can roughly be calculated:

> ship's length over all x (freeboard + height of deck cargo above maindeck) + area of superstructure above deck cargo.

Note 1

Experience has shown that for LNG carriers with spherical tanks the above mentioned formula gives a too low value for the total required bollard pull. Therefore, for gas carriers with spherical tanks 20% should be added to the outcome (and for gas carriers with prismatic tanks 5% to be added). This is due to the relatively high windforce coefficients. According to reference [10] this applies in particular to older LNG carriers of this type with semi-

cylindrical tank covers. Newer LNG carriers with spherical tanks have semi-spherical tank covers (see figure 3), the lateral wind coefficient of which is smaller. For these LNG carriers the above mentined formula can be used.

With a small pocket computer the total required bollard pull can then be calculated. This total required bollard pull includes a 25% safety margin. One of the reasons for the safety margin is that the tugs have to keep the ship under control, so if it starts drifting they have to stop the drift and bring it back to the required track. This costs extra bollard pull. The faster the tugs can react, the better, but the more bollard pull is needed to achieve this. In any event, it is just two minutes work to calculate the required bollard pull!

It is assumed the pilot *CMA CGM DeBussy* did not do that. He took the risk, or perhaps he had no idea there was any risk involved. The result was that the ship collided with a berthed ship and one of the tugs got crushed between ship and berth. Luckily, there were no casualties.

If the pilot had calculated the total required bollard pull, he could have seen that the three tugs available did not have sufficient bollard pull to keep the ship under control. The container ship probably had a working bow thruster, but as soon as a ship gathers headway the effect of the bow thruster decreases fast. This should have been taken into account. Because the pilot did not assess the required bollard pull, ships and tugs were put in danger.

Cruise vessels, container vessels and LNG carriers are becoming much larger and require specific attention during pilotage because of their large windage. Container vessels form a large part of the present world fleet. The largest container vessel at the moment is the "Emma Maersk", which was the first of a series of eight, with the following dimensions:

Length over all	398.0 m	Bow thrusters	2 x 25 tons
Length between pp	376.0 m	Stern thrusters	2 x 25 tons
Beam	56.4 m	TEU capacity (officially)	±11,000
Depth	30.2 m	Maximum TEU capacity according to press reports	13,500 – 14,876
Draught	15.5 m		
Propulsion	1 FPP		

Table 1. Main particulars of `Emma Maersk'

The longitudinal wind area, when taking into account 5 high containers (although 9 containers high is possible), will be approximately 12000 m^2 (!) at a draught of 13.5 m. This requires approximately **100 tons bollard pull** with a crosswind of Beaufort force 5 (10m/sec), not taking into account the bow and stern thrusters.

Note 2
`Crosswinds' should not be regarded as coming exactly from abeam. When the angle of attack of the wind is between abeam and approximately 30^0 each side of abeam, the bollard pull required is nearly the same as for beam winds.

Figure 2 `Emma Maersk'

Photo: Harry van den Berg, tug engineer Smit Harbour Towage, Rotterdam

Although the Emma Maersk class is the largest at the moment, many very large container ships are being built and ordered.

Other ships growing in size (and number) are the LNG carriers.

Figure 3 Large LNG carrier with spherical tanks handled by tugs

Photo: Courtesy Svitzer, Denmark

The Orderbook of LNG Carriers

(as of March 6, 2010)

Sources: Operators' and Builders' SEC Filings and Web Sites, Clarksons SIN, and many others.

Summary										
ype	***Size Bracket***	***In Service***			***Building for Delivery in***					***Totals***
		Pre-2010	2010	Total	2010	2011	2012	2013	Total	
Q-Max	> 250,000 cm	10	1	11	3	0	0	0	3	14
Q-Flex	200-250,000 cm	29	0	29	0	0	0	0	0	29
Standard	100-200,000 cm	265	3	268	19	9	3	0	31	299
Small	<100,000 cm	29	0	29	0	0	0	0	0	29
Totals		333	4	337	22	9	3	0	34	371

Table 2. Orderbook LNG carriers

A small percentage have Moss cargo systems (spherical tanks), all of the smaller size, and the rest have membrane cargo systems. An increasing number of ships have diesel engines instead of steam turbines, which improves manoeuvrability in ports and at terminals.

An indication of the increase in size of LNG carriers is shown in the table below:

Capacity	**125,000 m^3**	**145,000 m^3**	**215,000 m^3**	**265,000 m^3**
Cargo system	spherical	membrane	membrane	membrane
Length o.a.	288 m	289 m	315 m	345 m
Breadth	44.0 m	43.4 m	50 m	53.8 m
Depth	25 m	26 m	27 m	27 m
Draught loaded	11.0 m	11.5 m	12 m	12 m
Draught ballasted	9.0 m	9.7 m	10.3 m	10.3 m
Side wind area loaded	6600 m^2	6000 m^2	7800 m^2	
Side wind area ballasted	7100 m^2	6500 m^2	8500 m^2	

Table 3. Indication of dimensions and side wind areas of LNG carriers

Other ship types, such as car carriers, ro-ro vessels, ferries, and the earlier-mentioned cruise vessels are also increasing in size. For all these ships, and in particular for the growing number of large and very large container vessels and LNG carriers, it becomes necessary to calculate for day-to-day operations, and in the most accurate way possible, the required tug force to handle the ships safely in varying conditions of wind, current and sometimes waves, and/ or to determine the limits of safe operations. This should be done for all ports and for remote locations for LNG carriers.

Actual current, wind and wave information as well as reliable forecasts should therefore be available. Studies and training programs on ship bridge simulators, which is strongly recommended for all large vessels, give good insight into the required tug assistance, tug placement and safe manoeuvres, as well as into the limiting conditions. Nevertheless, during day-to-day operations and particularly for these very large vessels, port authorities, terminal managers and pilots should be able to assess the tug assistance needed in all cases of strong winds, taking into account wind gusts. Towing companies should have the required tugs available. Margins with these large ships are generally very small.

In the approach channels to a port or terminal, wind, current and waves may all play a role. However, ships can often sail at higher speeds in these areas, while compensating for the drift forces by steering at a drift angle. When coming closer to the berth, ship's speed decreases and steering capability is reduced, so wind forces generally become the predominant factor and tugs have to operate to their full capabilities.

Required total bollard pull for wind and current forces can be approximated with the formulas and graphs shown in reference [1]. MARIN (Marine Research Institute Netherlands) has recently developed a simulator program, called TAT (Tug Assist Tool), which calculates for a certain ship and certain wind and current speeds and directions, the required tug bollard pull forward and aft for mooring and unmooring operations. In both systems mentioned, additional bollard pull for controlling the dynamics of ship movements is included in the calculations, although in an approximate manner.

Consequences and recommendations

What can we learn from this:

- Pilots should be trained to calculate the required bollard in case of strong winds. Some ports already do this, but many do not. All simulator training courses train pilots in how to handle a ship safely, but at least the simple calculation method outlined above should be included in the training.
- It is strongly recommended that in ports where pilots have to handle large container ships, gas carriers and car carriers, they are equipped with a simple tool that can calculate the required bollard pull.
- In case of emergency, tug masters should be trained to take the initiative to prevent the tug from becoming crushed (see note below).

Note 3

There is one more lesson which can be learned from the accident to the `CMA CGM DeBussy':
If the forward tugs had been pulling *instead of* pushing, *the accident would not have had such serious consequences. The tugs could keep pulling up to the last moment, no tug would have been damaged and the damage to the ship alongside would have been less. In such critical cases it is better that the tugs are pulling as the stern tug did. In several other cases tugs have been crushed between ship and berth, and all these accidents could have been avoided.*

2. Required knowledge of tug capabilities and lack of experience

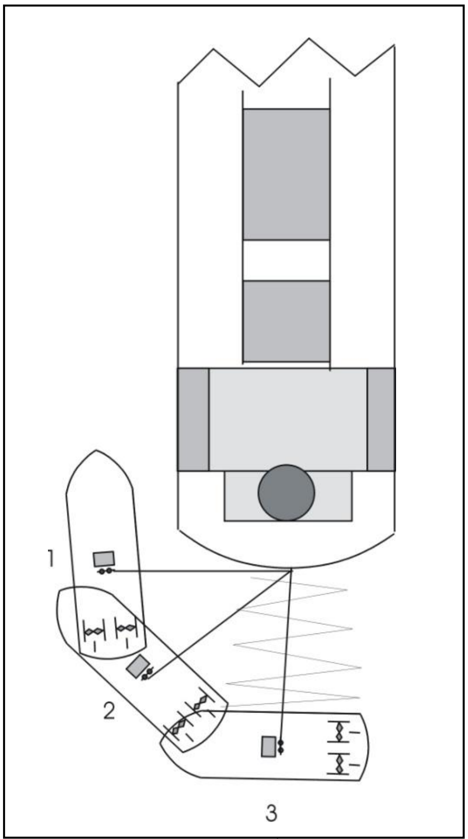

Figure 4a

Three other accidents. Lack of knowledge of tug capabilities has caused serious accidents, sometimes with fatal consequences.

An example: A pilot brought a bulk carrier into port. He asked for one ASD-tug as stern tug, but was told he would get the brand new conventional tug. Not aware of the limitations of the conventional tug, he instructed it to go from position 1to a postion astern of the vessel to assist in braking the ship's speed. The speed of the vessel at that time was at least about 5 knots and the engine was still on Dead Slow Ahead. The result was that the tug started to capsize in position 2 and was pulled by the ship, while capsized in position 3, for several minutes. The pilot was not aware this was happening. When approaching the berth, the ship's engine was stopped, so the force on the towline decreased and the tug came upright again. There were no fatalities.

A thoughtless attitude by a pilot which had serious consequences.

It must be said that the tug master in this case, although very experienced, had no experience of the particular manoeuvre he wanted to carry out. Such manoeuvres should only be carried out at speeds below 3 knots and with the ship's propeller stopped! Accidents such as this one have resulted several times in serious consequences for the tug crew. The quick release system should have been activated, but does not always work in such circumstances. Sometimes the tug and crew are only saved by a breaking towline.

A comparable accident took place recently with the twin-screw tug *IJsselstroom* in the Port of Peterhead on 14 June 2009 (MAIB report of 8 April 2010; ref. 2). Please, see figure 4b. The tug was a steering tug, with engines turning ahead to keep the tug in line with the tow. The risk with such a manoeuvre is that if with increasing speed (say up to 3 – 4 knots) the tug veers away, it will become impossible to bring it back in line with the tow. The towline under high tension will then come near right angles to the tug, which will result in capsizing. This is what happened.

The tug had no gob rope system, which COULD have prevented capsizing, IF speed through the water would have been less than about 3 knots, but bearing in mind the small heeling angle at which tug's deck edge submerges, this was by no means guaranteed. The rather old system of a gob rope winch, which can pull the towline down and shift the towing point to the after end of the tug, would have prevented the tug veering off and consequently capsizing. The tug was not equipped with such a system, which is compulsory on, for instance, German conventional tugs.

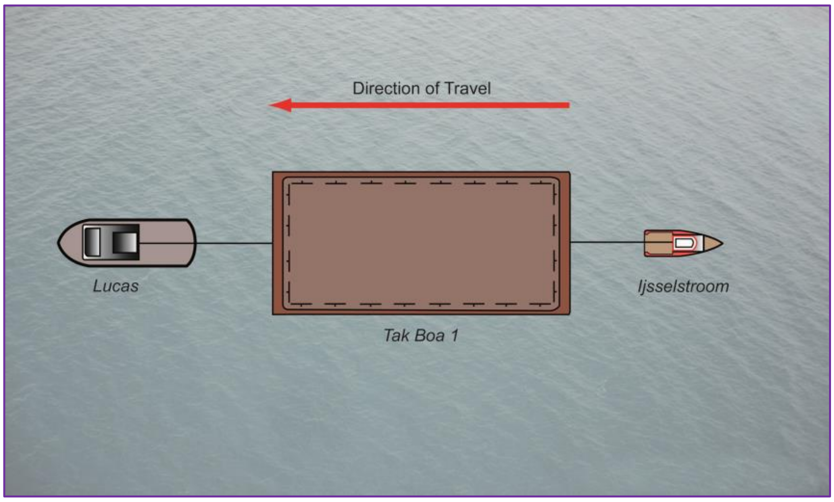

Figure 4b
Courtesy: MAIB

A radial system could also have prevented this accident, but the tug did not have such a system. The new Dynamic Oval Towing System (DOTS) which is fitted on the small tug *Ugie Runner*, or the Caroussel System, could have prevented capsizing as well. These systems are all basically the same. When the towline is coming under an angle with the tug's centerline, these systems shift the towing point away from the tug's centreline more to the ship's side, so preventing large heeling angles.

The major factor in these accidents is a failure to appreciate the limitations of the tug, by both the tug master and the pilot. And such accidents still happen much too often!

Figure 5

Figure 6

Figure 5 and 6 show another kind of serious accident. Such an accident do happen more than once with ASD-tugs operating bow-to-bow and are caused by a too high ship's speed and/or insufficient experience of the tug master with the specific ASD-tug. If ship's speed is the cause, then the pilot plays a role in it as well.

Operating bow-to-bow with an ASD-tug is a rather risky operation and needs a lot of experience and a thorough knowledge of the tug's capabilities and limitations particularly with respect to speed [ref. 3]. The tug shown swung around and came under the bow of the attended ship.

The accidents shown also demonstrate the importance of proper safety measures on board tugs. During tug operations doors, deck openings, etc. should be closed to prevent flooding of the tug with large angles of heel.

Consequences and recommendations

The former examples show again:

- The importance of experience with a specific tug type and knowledge of the capabilities and limitations of the assisting tugs, which applies to tug masters as well as to pilots.
- Most situations can be taught on a simulator, although in the case of bow-to-bow operations the tug model should carefully reproduce the capabilities of the ASD-tug when operating bow-to-bow. It should be recognized that there is a large difference between various ASD-tug designs.
- Careless thoughtless attitudes can be modified after a simulator training course.
- The importance of proper safety measures.

3. Engine/rudder failures on board ships

Engine and steering failures on ships manoeuvring in port areas are getting more and more attention internationally. Pilots will be aware of such failures in their own port or area, but they may not be aware of how prevalent such cases are on a global scale.

In the book `Compendium on Seamanship & Sea Accidents" [4] one can read on page 305:

"During the last years shipping experienced an astonishing number of incidents caused by the failure of the main engine or other vital equipment in the engine room."

Many of these accidents took place in ports, port approaches and pilotage waters, and their number is increasing.

The `Safe Transit Program. A Guide for Preventing Engine and Steering Failures' of 2003 [5] stated:

"Since the mid-1990's, the number of propulsion casualties experienced within San Francisco Bay area has been on the rise. In the last five years, the number of propulsion casualties has steadily increased as follows: 21 in 1996, 28 in 1997, 39 in 1998, 35 in 1999; and 44 in 2000."

What could be the reason for these propulsion casualties in port areas? Reference [4] again:

"Most of the casualties can be attributed to improper maintenance of the inboard systems. Additionally, it appears that the required precautionary testing of the propulsion and steering systems prior to entry into the port may not be occurring."

In the CESMA (Confederation of European Ship Masters' Associations) paper "Blackouts and other Deficiencies." [6] a number of causes are mentioned, including the ones sited above:

"For economic reasons changing of power supply from sea condition (in many cases with shaft generator) to harbour conditions with generators too late (or for same reasons a late change from heavy oil to light oil), poor education and training, fatigue, culture and language barriers, while lack of familiarisation with the vessel and its systems is also mentioned as being an important cause."

Furthermore the authors conclude that the STCW 95 Convention has not brought what the international community expected. It was in fact a downgrading of education and training standards. The result is that overall competence is declining, causing an increasing number of accidents and incidents.

With respect to several of the items mentioned above as causes for engine and/or steering failures, the reader is also referred to the MAIB investigation report regarding the engine failure on board the new container vessel S*avannah Express* and her subsequent contact with a linkspan at Southampton Docks [7].

It can be concluded that there are a significant number of engine and/or rudder failures on board ships in port areas and other piloted waters and, for a variety of reasons the number is increasing. CESMA even concluded in their paper [6]: **"Safety in harbour areas is in danger".**

It is for this reason the author includes the topic. Engine, steering, or human failures on board tankers and gas carriers have resulted in vessels being escorted in the approaches to several ports, particularly in the USA and Europe. However, such failures should be a matter of concern for all port and pilotage areas, and all pilots should be aware of the risks.
It is something to keep in mind when arranging tugs for handling large vessels in confined areas and when positioning the tugs forward and aft. A proper tug made fast at the stern, which can deliver braking and steering forces (such as a tug with azimuth propellers or Voith propulsion, and powerful enough for the size of ship) will be of great help if there is a failure. For the same reason, failures should be a primary concern of port authorities and towing companies. The latter should always have suitable tugs available.

Consequences and recommendations

- Port authorities and pilots should be aware of the relatively large number of engine and steering failures on board vessels entering and leaving ports.
- It is recommended that the risk of engine or steering failures on board a ship to be assisted by tugs is taken into account with respect to tug types to be used, the bollard pull of the tugs and tug placement.
- Training of pilots and tugmasters should include tug reponse to ship engine and/or rudder failures.

4. Strength of bollards and fairleads on board ships

Modern tugs are increasingly powerful, and the towage forces generated, particularly during indirect towing, are far greater than ever before. Nowadays, bollards, bollard foundations and fairleads on seagoing vessels may not be strong enough to withstand the towline forces generated.

This is a real problem. Recently a working group consisting of EMPA (European Maritime Pilots Association) and ETA (European Tugowners Association) representatives has been established. The target of this working group is:
"to define 'Best Practice' for both pilotage and harbor towage services and operations in view of the ever growing ships and tugboat-sizes."

A letter was recently sent by the EMPA-ETA working group to European ship owners, shipyards, naval architects, engine manufacturers, classification societies, marine surveyors and others to raise awareness of the following safety issues:

1. High bollard pull of tugboats vs strength of ships' bollards and fairleads.
2. Position of ships' bollards, fairleads and winches.
3. Possible strength problems of ships "Push Points".
4. High minimum speed of ships.

The letter included a Position Paper with objectives, concerns and suggestions.

In the Rotterdam area this paper has been discussed with towing companies, pilots , and the author. They have sent their comments to the EMPA-ETA working group, including several recommendations for actions to be taken now and in the future.

It is a very good initiative. The EMPA-ETA working group has been advised to further improve their position paper with respect to certain aspects. To achieve a good cooperation from IACS and its members, ship owners and ship builders, and IMO, a representative position paper is needed.

Courtesy: Smit Harbour Towage Rotterdam

Figuur 7

Causes of the problems

The Rotterdam comments include the following causes of the problems:

A. Some thirty years ago tugs' maximum power was low compared to the present situation. In addition, there were large variations in tug power. The most powerful tugs were used for the large ships and the smaller tugs for the smaller ships. At a certain stage the smaller tugs disappeared and the more powerful tugs had to assist the smaller ships as well. At that time the problem with unsuitable bollards and fairleads started.
B. In cases where more power was needed for certain large ships, more tugs were ordered. It was not uncommon to have up to to 6 tugs assisting a ship. Ship owners,

aware of the fact that more tugs meant higher tug charges, actually forced tug owners to provide modern tugs with more power. Over the same period, ship sizes gradually increased, particular those ships with high windage, such as container ships, LNG carriers and car carriers. Tug owners kept pace with the developments in ship size and anticipated the growth in size by building more powerful tugs. During the past two decades the average bollard pull of harbour tugs has increased from a maximum of 35 tons bollard pull (bp) to 60 or even 80 tons bp nowadays, while harbour tugs of 100 ton bp are already operational.

Naval architects and classification societies did not take into account the requirements of these stronger tugs needed. Deck equipment on these large ships was not upgraded to withstand the high towline forces of the new generation tugs. In addition, older and smaller ships were not required to strengthen their fittings to cope with the increasing forces being generated. A new and serious problem developed.

C. Strength of deck equipment on ships is related to the minimum breaking strength of the *ship's ropes!* See, for instance, the OCIMF publication `Mooring Equipment Guidelines' which tell us: "Industry practice has not been consistent." and "Numerous national standards for mooring fittings exist, …" ; furthermore: "Listed `load' differences between two fittings of equal size may be as much as a ratio of 1 to 10, most of which can be due to different definitions of 'load', safety factor and load application."

D. Even the most recent publications of IMO and IACS do not refer to the strength of tug towlines, but to towlines that ships may have on board, which is a quite different subject.

E. Safe Working Loads in use on board ships refer to the strength of bollards and fairleads and not to the supporting foundations (even if they are there)! This is an oversight in the requirements, and a cause for many of the present problems.

The situation now is that container ships have grown in size and tug power has increased considerably, but deck equipment and supporting foundations of these ships lack sufficient strength, so the powerful tugs needed in adverse weather conditions have to limit their power! This results in unsafe conditions! Ironically, to overcome the problem, more tugs might be needed to handle a ship safely and efficiently, so we are back where we were in the old days.

It can be concluded that the cause of present problems lies to a great extent with IACS and its members, although IMO, ship builders and ship owners could be doing more to resolve the situation!

How to solve the problem. Recommendations.

The Rotterdam Joint Nautical Service Providers came with a large number of recommendations, such as with regard to:

- Size, strength, locations and construction of bollards and fairleads.
- Strength of the necessary supporting foundations.
- Recommended type and position of fairleads.
- Towline force monitoring on tugs of more than a certain bollard.
- Availability of messenger lines on board ships.

- Location and marking of pushing points with maximum pressure per m^2.
- Limiting Dead Slow Ahead speed on ships.
- Better marking of bulbous bows, with special attention to bulbous bows protruding beyond the utmost visible part of the ship's bow.
- Standard guidelines for securing and releasing tugs, as mentioned in several OCIMF publications and in the publication "Tug Use in Port. A Practical Guide".
- The use of a (standardised) `Towing and Mooring Arrangement Plan'.

Courtesy: KOTUG, Rotterdam

Top eye on bollard will damage the towline

Figuur 8

Summary and Recommendations

Most recommendations are for the long term, for new buildings to have fittings and mooring arrangements which are truly fit for purpose. There are, however, recommendations that can be carried out immediately with respect to:

- Pushing points: number, location and marking with safe pushing loads.
- Better marking of bulbous bows.
- The use of a `Towing and Mooring Arrangement Plans'.
- Standard guidelines for securing and releasing tugs, including the use of safety leaflets as is done by URS and Smit Harbour Towage.
- The availability of ready to use messenger lines on board ships where distance to the ship's winch is too large.
- Providing tugs with a system that gives the tug master information about the actual forces in the towline.

5. Conclusion and Recommendations

Accidents do happen and will happen in the future. However, one should learn from accidents. What can be learned from the type of accidents discussed in this paper is:

- Team work between tug masters and between tug masters and pilots and the right attitude is essential for safe ship handling with tugs.
- Proper experience in handling a specific tug type is indispensible.
- Training is an absolute requirement, particularly for operating a specific tug.
- Training should include lessons learned from accidents, which applies to training of tug masters and of pilots.
- Training should also include how to deal with emergencies, such as engine/rudder failures on board vessels.
- With respect to tug type, tug bollard pull and tug placement one should keep in mind the relatively large number of accidents happening on board vessels calling at a port.
- Pilots should know the capabilities and limitations of the attending tugs.
- In case of strong winds it is necessary to know the bollard pull required to handle high sided vessels safely and efficiently. This should be included in pilot training. A tool for pilots to calculate the required bollard pull is strongly recommended.
- The lack of strength of deck equipment on board many ships is a matter of concern and indicates that action is needed to improve the situation so tugs can handle ships safely in ports and port approaches.

Many aspects mentioned above are well known. However, it should be emphasized again and again that proper training is a necessity. Through proper training, the safety of tugs and ships in ports and port approaches will be improved.

Captain Henk Hensen FNI
For BTA. April 2010

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