TUG USE IN PORT

A PRACTICAL GUIDE

Captain Henk Hensen, FNI

Second Edition

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A Practical Guide

2nd edition

by
Captain Henk Hensen FNI

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Cover picture The Hellespont Metropolis arriving in Rotterdam on her maiden voyage October 2002 with Fairplay tugs in attendance. Courtesy of Port of Rotterdam; Ben Wind Fotografie, the Netherlands

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Although great care has been taken with the writing and production of this volume, neither The Nautical Institute nor the author can accept any responsibility for errors, omissions or their consequences.

This book has been prepared to address the subject of tug use in port. This should not, however, be taken to mean that this document deals comprehensively with all of the concerns which will need to be addressed or even, where a particular matter is addressed, that this document sets out the only definitive view for all situations.

The opinions expressed are those of the author only. Captain Henk Hensen was born in 1935, is a Master Mariner and was a Port of Rotterdam pilot for 23 years. During his years as a pilot he was stationed at the Pilot Office for five years. During that time he started simulator courses for harbour pilots and tug captains and participated in many port studies, including simulator research. He started a database for casualties in the Port of Rotterdam and analysed them with the object of improving safety. Following his retirement he started his own consultancy, Nautical Safety Consultancy, and works as marine consultant on the nautical aspects of port studies, tug advice and simulator training.

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2nd edition

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FOREWORD

by

Executive Director of the Port of Rotterdam

Mr. P. Struijs

Tug Use in Port, which includes escort tugs, is a valuable addition to nautical literature. Twenty years ago few would have believed that it could be possible to build in so much power and manoeuvrability into the hull form of today's tugs.

With conventional designs it was impossible to achieve this capability, but now towage companies which do not embrace this new technology are likely to find the competition overwhelming.

It is against this background, and I trained as a naval architect, that I welcome this book. It sets out to demonstrate the characteristics of the old and new and in doing so the reader can come to appreciate how to transfer and adapt towing practices to optimise the use of all tugs in a mixed fleet.

Whilst naval architects and marine engineers have concentrated on fuel economy per ton mile in deep sea vessels they remain unwieldy in confined waters. Similarly the car carrier and container ship, although generally higher powered than the bulk carriers, have special limitations imposed by windage.

Happily whilst the deep sea vessel has become larger and relatively less manoeuvrable tugs have grown in capability and so play an essential role in port economics. Indeed a port which cannot provide effective tug support becomes unviable and it is important that the towing industry recognises this.

So Captain Hensen an experienced pilot from my port has provided an essential service in demonstrating how tugs can be used to best effect. The Port of Rotterdam is pleased to have played its part as a major sponsor to this publication.

This book examines towage techniques and the reader will be constantly reminded that shiphandling with tugs is all about competent teamwork. On board the ship are the master, pilot and crew, on board the tugs are the tug masters and crew and they have to work together. To be effective all need a good knowledge of this professional area of activity particularly as ships are often attended by a mixed variety of tugs. The foundation of how best to control operations is laid out in this very practical guide.

The other chapters on tow ropes, training, bollard pull and escort work, all linked by a common thread of safe working methods makes this an ideal book for study. I believe it will favourably influence the way tugs are designed and used. This is the hallmark by which this book will be recognised and I have no hesitation in recommending this well illustrated text to towage companies, ports, tug masters, pilots and sea staff alike. Everybody will benefit from its practical guidance.

AUTHOR'S PREFACE

When ships are assisted by tugs, experience, teamwork, communication and above all insight into the capabilities and limitations of ships and attending tugs are essential for safe and efficient shiphandling. This applies to the tug captain and his crew as well as the shipmaster and pilot, particularly nowadays as older conventional tugs are increasingly being replaced by modern types with larger engine powers and increased capabilities. Reputable shipyards build good tugs, and designers can predict how well their tugs will perform. However, they do not handle ships themselves and have not experienced the tug assistance required: not in a river, channel or port approach nor in a confined harbour basin, not during a storm or in strong currents nor in the middle of a foggy night. Not even during nice, calm weather. These are the situations and conditions in which pilots and tug captains have to handle ships. So it is essential that they know what can be expected from a tug in any specific circumstance. Only when these professionals are fully aware of the capabilities and limitations of the various types of tugs in general and of an individual tug, including the effects on an assisted ship, are they able to utilise tugs in the safest and most effective way and in harmony with a ship's manoeuvring devices.

Good insight into the operational performance of different types of tugs while assisting vessels is also of major importance for tugboat companies. It allows them to determine what type of tug will provide optimum service for the port, with respect to the local situation, environmental conditions and ships calling at the port.

The increasing use of simulation for research and training purposes requires an in-depth knowledge of tug capabilities and limitations, in addition to the data required for creating a tug simulator model. Only then can results be achieved that are safely applicable to daily practice and which form a contribution to safe shiphandling.

There is a trend towards ever more powerful tugs and more manoeuvrable modern vessels. This is leading to a reduction in the number of tugs used to assist those ships, so the role of harbour tugs becomes even more crucial than before.

There are many reasons, therefore, why a book on tug assistance could be useful. The aim of this book is to improve the practical knowledge of harbour tugs and their different types, and to give a better insight into the capabilities and limitations of these tugs while rendering assistance.

Not all aspects of shiphandling with tugs are addressed in detail within this book. This work should be seen as a basic guide to the reader, whilst at the same time encouraging further increase of knowledge. The references mentioned at the end may prove useful.

The book is specifically written with the needs of maritime professionals involved in the day-to-day practice and training of shiphandling with tugs in mind, particularly pilots, tug captains and training instructors. It should also be of value to towing companies, shipmasters and mates of seagoing vessels and all other persons or organisations involved, one way or another, with tugs and shiphandling.

In the second edition several subjects have been reviewed or extended, based on experience and knowledge gained during the last five years. Items that were found to be missing have been included, ship's fittings for use with tugs have been addressed more specifically, the escort chapter has been extended, new developments in the tug world have been included, and several references used for the book have been added for those who want to read more about certain subjects.

The tug world is a fast changing world, although basic principles for tugs and tug operations do not change that much.

It is the author's earnest hope that this book will contribute to improved knowledge of harbour tugs and lead to increasing safety in tug and shiphandling operations in ports and port approaches around the world.

The author.

TUG USE IN PORT

THE OVERVIEW

The contents of this book are outlined below.

- A **general review** is presented first of factors which affect operational requirements for a harbour tug, such as the different tasks for which they are used, the particulars of a port, the environmental conditions and ships calling at the port.
- Various **types of harbour tug** are discussed in a general way, addressing the diversity of design, propulsion, steering and manoeuvring capabilities.
- After reviewing **assisting methods in use** worldwide, tug types are considered in more detail, including the performance of different types of tug resulting from the location of propulsion devices, towing point and lateral centre of pressure. Tug capabilities, limitations and effectiveness with respect to different assisting methods and operating positions relative to a ship are discussed.
- The **number of tugs required** to handle a vessel safely is frequently a topic for discussion between pilots and shipmasters. This important subject is discussed taking into account the effects of wind, current, shallow water and confined waters. The number of tugs and total bollard pull used in several ports around the world is mentioned.
- Much attention is given to **dangerous operational situations** for tugs, such as interaction and girting, and to environmental conditions such as fog.
- **Towing equipment** is dealt with, particularly in relation to safe and efficient shiphandling.
- **Escorting and escort tugs**, being a subject of specific interest nowadays, is dealt with separately.
- Proper **training** for a tug captain and crew is essential in order that they handle the tug safely and efficiently. The same applies to the pilot and/or master for shiphandling with tugs. Training is therefore an important subject in the book, including simulator training and research.

All subjects are, as far as possible, related to situations encountered in practice.

Photo: Seaspan International Ltd., Canada

Reverse-tractor tugs 'Seaspan Hawk' and 'Seaspan Falcon' (l.o.a. 25·9m, beam 9·1m, bp ahead 39 tons, bp astern 37·5 tons) ready to make fast at the forward and port quarters with a bow line

GLOSSARY OF TERMS

Assisting methods : The term used to describe the way in which harbour tugs assist seagoing vessels.

Breasted/alongside towing : A tug securely lashed alongside a ship, usually with a minimum of three lines: head line, spring line and stern line. Also called 'on the hip' or 'hipped up'.

Push-pull : A tug made fast so that it can pull as well as push at a ship's side. Depending on the type of tug, its location and the assistance required, it can be secured with one, two or three lines.

Towing on a line : A tug assisting a ship while towing on a line as is in common use in many European ports.

Box keel : An enclosed keel structure extending from the aft skeg (if fitted) to a point close to the forefoot of a tug. A box keel is sometimes installed on ASD escort tugs to provide a better course stability on astern and additional lift forces, resulting in higher towing forces, when operating as stern tug in the indirect towing mode. In addition, a box keel gives additional strength to the tug's hull and provides a better distribution of dock forces when in dry-dock.

Course stability and directional stability:
Course stability is also called dynamic stability, stability of route or dynamic stability of route (see References: Hydrodynamics in Ship Design, Vol. 1. H.E. Saunders). It is that property of a ship (which includes tugs) that, when disturbed, damps out extraneous motions set up by the disturbance and to reduce them progressively to zero. Course stability should not be confused with directional stability, which is, strictly speaking, the ability of a ship to follow a certain direction, e.g. by means of an automatic steering system. A ship closely following a selected heading has directional stability but may be course unstable (see below), which results in frequent rudder (or thruster) actions to hold the ship on its course.

Course stable ship : With a constant position of the steering systems (rudders, thrusters, etc.), a ship is defined to be course stable if, after experiencing a brief disturbance, it will resume the original manoeuvre without any use of the means of steering. Course stability on a straight course, with the rudder in the equilibrium position, is mostly only considered. A turn initiated by a brief disturbance of a course stable ship will thus not continue. However, after the disturbance has vanished, the actual course of the ship will generally be altered. A course stable ship needs relatively large rudder angles for course changing. A course stable ship has good yaw checking ability.

Course unstable ship : A ship is called course unstable, if, after it is disturbed, it will immediately start to turn. Course changing, with relatively high rates of turn, can be achieved with relatively small rudder angles. A course unstable ship therefore generally has poor yaw checking ability.

Cross lines/gate lines : Separate lines from either side of the tow to the opposite quarter of the tug or the opposite side of the tug's H-towing bitt.

Dead ship : A ship which cannot use her own propulsion.

Density of air as used : 1.28 kg/m^3

Density of sea water as used : 1025 kg/m^3

Escort tugs : Tugs specifically built for escorting at high speeds.

Escorting tug : Any type of tug escorting a ship underway.

F(P)SO : Floating (Production) Storage and Offloading Unit.

Free sailing : A tug sailing independently.

Girting : Risk of capsizing, especially with conventional tugs, due to high athwartships tow line forces. Also known as girding, girthing or tripping.

Gob rope / gog line : A rope or steel wire used on conventional tugs to shift the towing point.

HMPE	:	High-modulus polyethylene fibre under the trade names 'Spectra' and 'Dyneema' used for high performance ropes.
Hockle	:	Kinking or twisting of a strand in a rope which makes it unfit for use.
IMO	:	International Maritime Organization.
Lbp	:	Length between perpendiculars.
Loa	:	Length overall.
LWL	:	Length at the waterline.
MBL	:	Minimum Breaking Load (of a rope).
MG	:	Initial Metacentric Height.
Messenger	:	A light rope attached to the tow line in order to heave the tow line on board a ship.
Norman pins	:	Short iron bars fitted in the gunwales of the transom to prevent the tow line from slipping over the side gunwales. Sometimes called 'King Pins'.
Nozzle	:	A tube around the propeller to increase propeller performance. The nozzle can be fixed or steerable.
OCIMF	:	Oil Companies International Marine Forum.
PIANC	:	Permanent International Association of Navigation Congresses.
Pendant/pennant	:	A separate part at the final part of a tow line which is most liable to wear on board an assisted ship, at ship's fairleads, etc. The pendant can be of different construction to the tow line.
Propulsion:		
Azimuth propellers	:	360° steerable propellers, which can deliver thrust in any direction. Also called: 'Z-pellers', 'Rexpellers', 'Duckpellers' (azimuth propellers in nozzles).
CPP	:	Controllable pitch propeller(s).
FPP	:	Fixed pitch propeller(s).
VS	:	Voith Schneider propulsion: propulsion system with vertical propeller blades, also called cycloidal propulsion system.
PRT	:	Prevention and Response Tug.
Significant wave height	:	The approximate wave height as seen by an experienced observer when estimating the height visually.
Snag resistance	:	Resistance of a rope to single yarns being pulled out of the rope when it slides along a surface, such as over a deck or through a fairlead. A snag is a loop of a yarn.
SPM	:	Single Point Moorings.
Sponson	:	A strongly flared section in the side of a tug, commencing at or just below the waterline, which results in substantial increase in deck area and reserve buoyancy without increasing the beam at the waterline.
Stemming	:	A tug coming under the bow of a ship at speed.
Stretcher	:	That part of a tow line, between the original tow line and pennant, which absorbs the dynamic forces in the tow line. Also called a spring and often made of nylon, polyester or a polyester/polypropylene combination.
Towing point	:	Point of application of the tow line force. It is the point from where the tow line goes in a straight line towards the ship.
Towline	:	A flexible hawser used for towing purposes.
Tripping	:	A tug towing on a line swinging around and coming alongside a ship's hull due to excessive speed by the ship in relation to a tug's capabilities and towing angle. The expression 'tripping' is also used for girting.

Tug/engine power:

BHP	:	Brake Horse Power: power delivered by the engine.
SHP	:	Shaft Horse Power: power delivered to the propeller shaft (approximately 97% of BHP).
BP	:	Bollard Pull, which in this book is expressed in the practical units of tons, equal to 1000 kgf (= 9·80665 kN).
MCR	:	Maximum Continuous Rating (of tug engine).
Ton	:	The practical unit used in this book for force, e.g. for bollard pull, equal to 1000 kg force, and for 'weight', equal to 1000 kg.

Tug simulation:

Interactive tug	:	A tug simulated on a bridge manoeuvring simulator, able to interact with other bridge manoeuvring simulators, which are simulating other tugs and/or the assisted ship.
Vector tugs	:	Tugs simulated by just a force vector.
UHMW polyethylene (UHMW PE)	:	Ultra High Molecular Weight polyethylene. Material used for dock fendering and for fenders of tug boats at places where a low friction coefficient is required.
VS-tug	:	A tug with VS propulsion.

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Photo: Smit International

Three different tug types towing on a line. The tugs port side forward and starboard side aft are VS tugs of 35 tons bollard pull. The tug starboard side forward is a twin screw conventional tug of 37·5 tons bollard pull and the port tug aft is an ASD-tug of 62 tons bollard pull.
When the tanker has to berth starboard side alongside the jetty, the ASD-tug and the VS tug port side forward can, when near the berth, easily change to a pushing position or push-pull without releasing the towline

Chapter ONE

TUG DESIGN FACTORS

1.1 Differences in tug design and assisting methods

METHODS OF ASSISTANCE PROVIDED BY TUGS in ports and port approaches around the world differ due to local conditions and specific situations and have often grown from long standing customs and traditions. These differences in assistance methods and practices are often reflected in the requirements for the tugs and hence in the development of a range of tug types.

Over the past few years rapid development has been observed amongst harbour tugs. New types have been designed with high manoeuvrability and considerably increased engine power. Modern steering devices, new towing appliances and new materials for towlines, to name a few, have been fitted. These developments affect methods of tug assistance and the number of tugs used. Following the *Exxon Valdez* disaster, the requirement to escort tankers in certain port approaches has resulted in the development of specially built escort tugs.

As a result of the improved manoeuvring capabilities of modern ships on the one hand and the improved towing performance of modern tugs on the other hand, the number of tugs required for assistance in port areas is decreasing. Due to economic factors shipping companies are facing, captains and pilots are often under pressure to use the minimum number of tugs.

This reduction in the number of assisting tugs per ship places the individual tug in a more crucial role. It requires a high level of operational safety and reliability from the tug and a high level of suitability for the job to be carried out.

In order to keep a port's tug services up to date and to ensure safe, smooth shiphandling it is essential to keep abreast of developments in harbour towage and shipping, to have the most suitable tugs available and to have well trained crews for the specific situation in the port. This is all the more important when the investment required for new tugs is so very high. It may be necessary to reconsider the traditional approach.

It requires extensive research and knowledge of tugs before an answer to the question "which type of tug or which working method is the best for a certain port" can be given. It requires a profound knowledge of the different tug types, their capabilities and limitations, and a good insight into the local situation.

The capabilities and limitations of different tug types are dealt with in the following paragraphs.

The operational requirements that harbour tugs must conform to with respect to ship assistance are mainly determined by the following factors:–

- The kind of port or harbour and approaches, foreseeable future developments and the existing geographical environmental conditions.
- The type of ships calling at the port.
- The services required in and around the port and, if relevant, at offshore locations, e.g. SPMs, F(P)SOs or oil rigs.

Photo: Port of Antwerp / Guido Coolens

Figure 1.1 Port of Antwerp. Zandvlietsluizen. Tugs should be able to assist ships through the locks and bridges.

In addition, the following considerations should be taken into account:

- The tug assistance methods already in use.
- The present tugs and available experience.
- The required safety factors.

A number of other factors play a role in tug choice, not least the budget available. The larger the budget available the higher the tug requirements can be. Not every port can afford the most ideal harbour tug. The fact that spare parts and technical support for a certain type of propulsion are readily available within a short distance is well worth consideration. Damage resistance, mechanical reliability, maintainability, simplicity of control and ease of training are also factors of influence on tug choice.

1.2 Factors influencing tug type and tug assistance

1.2.1 Categories of port and their approaches

Ports can, in general, be divided into three categories:

a. Conventional ports

These ports represent the majority of ports around the world, often with a long history as such. Ships are berthed in harbour basins or docks, along river berths and often have to pass locks and/or bridges. This leads to specific requirements for tugs and tug assistance. The development of these ports has taken place hand in hand with that of shipping and this applies to the tugs as well. Ports such as Rotterdam, Le Havre and Hong Kong have a good, short connection with the open sea. Other ports like Antwerp, Calcutta and New Orleans have a long and sometimes complicated connection with the open sea. In all these ports tugs should not only be suitable for assistance in the harbour areas, but for assistance outside the harbour as well, i.e. on the river or at sea. Development of conventional ports does not always keep abreast of the increase in dimensions of ships that call at the ports. This can result in increasingly complicated manoeuvres on arrival or departure, and hence in additional requirements for the harbour tugs with regard to engine power, manoeuvrability and dimensions.

b. Ports with mainly terminals

The location of ports with terminals is often such that there is plenty of room available for manoeuvring and manoeuvres can be more standardized. Such terminals are very well suited for the so-called 'push-pull' method and tugs are specifically designed for this type of operation.

c. Ports with mainly piers and jetties

Jetties can be divided into those in the open sea and those in protected waters. A major difference between a jetty and a normal harbour or terminal is the method of mooring and unmooring. With jetties, mooring is mostly done on dolphins or on a finger- or T-pier, allowing tugs to operate on both sides of the vessel assisted. In harbour basins and at terminals, however, mooring is done alongside a quay where assistance is, in most cases, restricted to one side.

Jetties in the open sea can be found, for example, in Australia. Ships there are often made fast under windy circumstances and in high seas. This demands special requirements of the tugs such as good stability, sturdy fendering, a towing winch and high engine power.

Photo: Port & Harbour Bureau, City of Osaka

Figure 1.2 Push-pull tugs operating in the Port of Osaka. Large manoeuvring area near the berth.

Ports under development

In many ports, developments take place such as new berths or harbour basins and new ports are still being designed. At an early stage it is desirable that tugboat companies and pilots should participate in design studies for these new ports, harbour basins, terminals, etc. In this way tugboat companies and pilots can give advice based on their experience of shiphandling with the available harbour tugs. Moreover, tug companies can take account of these new developments when ordering new tugs which are suitable for the new situation. Regular consultation between port authorities, port designers, tugboat companies and pilots will favourably affect the accessibility of ports and harbours.

In container ports, especially where space is limited, the requirement for large land space to stack containers may not correspond with the minimum manoeuvring area required for ships and tugs. Specific requirements for tug assistance may be necessary, such as the type of tug, engine power, towing equipment and assisting method.

Port approaches

Port approaches are under the influence of the open sea and can be wide or narrow, with sandy or rocky banks, winding or straight entrances. Depending on the local situation, tugs may be used in the port approaches and should be capable of working in more open sea conditions with waves and/or swell. Following the *Exxon Valdez* disaster there is a growing tendency to require an escort for oil and gas tankers in port approaches. Tugs used for escorting must comply with very specific requirements.

Photo: Author

Figure 1.4 Tug assisting in open sea close to port entrance

1.2.2 Environmental conditions

Geographical environmental conditions are very important from a tugboat company's point of view. The majority of older ports are situated in river estuaries and are particularly subject to the influence of tides or seasonal effects. Fairways and rivers are constantly subject to changes. Differences in water depth, bridge passages and lock entries may require the adoption of time windows. The accessibility of these ports, therefore, can be rather complicated. Tugs have to handle ships safely and efficiently. Especially in these ports, therefore, the requirements to which a tug must conform may change continuously from the entrance or approach up to the berth and the final mooring. In some ports this problem is solved by using different types of tugs for the various parts of the route.

As already mentioned, ports close to the sea may be influenced by waves and swell, leading to additional requirements for tugs. The same applies to tugs that have to operate at offshore locations or in ports in colder areas where ice may be encountered. Limited water depths in port areas where harbour tugs have to operate will give rise to special requirements with regard to a tug's maximum draft.

Photo: Shetland Islands Council

Figure 1.3 M.T. 'Capitol' berthing at Jetty 4 at Sullom Voe Oil Terminal

Photo: Port of Montreal

Figure 1.5 In colder areas tugs should be able to operate in ice conditions

Tugs used should, as long as safety permits, always be capable of working effectively under the environmental conditions in and around the port and, if relevant, in the port approaches or at offshore locations, whether during strong winds, currents or ice, waves and/or swell. When water depth is restricted, manoeuvring space is limited, or locks or bridges have to be passed, the type of harbour tug used should obviously be such that it is capable of performing well in these situations.

1.2.3 The ships concerned

Another important factor is the type of ships to be assisted, such as large LNG or LPG tankers, bulk carriers, oil tankers, container ships, car carriers, ro-ro ships and so on. Different types of ship give rise to specific requirements on the assisting tug such as with regard to engine power, towing equipment, fendering, manoeuvrability and superstructure.

For example, in a port where only tankers moor alongside an oil jetty, it is not too difficult to determine what kind of tug and what power is required. However, if there is a large variety of types and sizes of ships, the requirements of tugs will vary too.

1.2.4 Services required in and around the harbour

The most important activities of harbour tugs have been mentioned above. In many ports these activities also include assisting at dock yards.

Harbour tugs are often used for activities other than assisting seagoing vessels, such as:

- Towing offshore material, such as oil rigs and crane barges.
- Towing inland barges, elevators, floating cranes.
- Assisting push-tow barges.
- Firefighting and pollution control duties.

Photo: KOTUG / Fotografie Voets & van Leeuwen

Figure 1.6 Car carrier passing Calandbridge in the Port of Rotterdam. The stern tug is an azimuth tractor tug. The types of ship calling at a port is a factor to be taken into account in choosing tugs.