Due to the low lateral resistance of the tug, compact tug 1 can push effectively. Experience with such a compact tug shows that the tug can remain pushing square to the ship up to eight knots. For the same reason tugs 2, 3 and 4 can apply pulling or steering forces more effectively than with a high underwater resistance. A small forward skeg may increase performance of tugs 2, 3 and 4, and improve safety of operations at the bow. A forward skeg also increases performance of tug 4 at higher speeds in the indirect mode.

As already mentioned, at speeds higher than approximately six knots performance of tug no 3 reduces. Tug 5 is a compact tug of the ASD type, capable of working over the stern and is more effective at such speeds, which can further be improved by an appropriate skeg. For berthing, tugs 3 and 4 can easily change over to the push–pull mode. Response times of the tugs for changing positions are very low.

Note: When pulling astern with full power on a very steep towline, which sometimes might be necessary with high ships in narrow areas, the high power of the relatively light tugs will result in a large stern trim.

Vs compact tug

A compact tug with VS propulsion has been built for the Port of Napier, New Zealand. The tug, named *Ahuriri.* with a new type of VS propulsion units of enhanced efficiency, has a length over all of 23.8m, a width of 11.0m, a draft of 5.0 m and a bollard pull of 69 tons. Naval architects of Conan Wu & Associates, Singapore, designed the tug. For the difference in performance between VS tugs and other tug types, see chapter 4 and in particular paragraph 4.3.

10.2 Developments in general

There have been four areas of real development during the last few decades: in normal harbour tugs, escort tugs, research and tug simulation. With harbour tugs there has been a steady development towards higher capabilities providing safer and more efficient shiphandling. Harbour tugs have developed from being slender and low-powered to wide beam, high-powered units. Slender harbour tugs were conventional tugs and much use was made of the hull form to generate hydrodynamic forces for ship assistance.

In more recent years, often together with the increased use of azimuth thrusters, tugs have been built with much higher power and, as a consequence, with larger beams. More use is made of the tug's power than of the tug's hull, although optimum hull form, which includes different skeg types, remains subject of continuous research to improve a harbour tug's performance. With VS tractor tugs the hydrodynamic forces, particularly those generated by the skeg, remain essential over the years, particularly for the indirect assisting method, although installed power has in general also increased.

Development as indicated refers not only to tugs towing on a line. In ports where tugs operate at the ship's side, such as the push-pull or similar assisting methods, tugs with omnidirectional propulsion have often been in use for many years, of which capabilities have been increased as well.

Tugs with omnidirectional propulsion systems are gradually replacing a growing number of ordinary conventional tugs, although conventional tugs will still be built in the coming years, because of their generally greater simplicity in construction, handling or maintenance, specific performance characteristics, or for other reasons. New developments have been signalled, particularly in the USA and Canada, where a growing number of tugs with azimuth propulsion are entering service or conventional tugs are being modified and upgraded by installing an azimuth bow thruster, in mainly single screw tugs, by conversion of single screw tugs into conventional tugs with twin-screw propulsion, or by replacing conventional propulsion of twin-screw tugs by azimuth thrusters.

With the development of tugs, tug safety and the safety of operations have become governing factors. There has been a marked development in wheelhouse design, focused on ergonomic and efficient installation of control panels and instruments and on optimum visibility. The wheelhouse of a modern tug provides the captain with an excellent all-round view and a direct view of the tug's fore and aft ends, sides, working deck and towing equipment.

Deck equipment too has evolved. More tugs are equipped with towing winches, hence improving effective ship handling and tug safety. Modern synthetic fibres have created the possibility to make towlines stronger, lighter and easier to handle. There is also a growing tendency to install pollution control equipment on board tugs operating in ports and port approaches (see figure 10.2). In the 1980s an aluminium tug was built in Western Australia. The idea has proved very successful and another aluminium tug has been built. Aluminium may become a material more often used for tugs because of its low maintenance and longevity. The lower weight can be compensated for by more ballast. Wheelhouses are sometimes made of aluminium to bring the centre of gravity down, so increasing tug's stability.

Finally, a trend can be seen towards a smaller crew on board tugs. Several tugs have been built for a two-man crew, resulting in tugs with a high level of automation, efficient wheelhouses and easy to handle with respect to steering, engine and winch control, and towlines.

Requirements for escorting have resulted in studies to find the most suitable tugs and methods of tug assistance. Research has concentrated on the capabilities and limitations of all types of tug, required bollard pull, effective tug placement, hull form, towlines, propulsion systems, escort speeds and so on, in order to be able to optimise escort operations. In particular, the need for escorting at high speeds has increased the need for model tests and in-depth research on tugs and tug assistance, not only because of the high risk involved with tugs operating in indirect mode at high speeds.

Hull form has become important in order to generate high lift and steering forces in indirect towing mode and stability has become extremely important because of high towline forces. The original tractor tug design has been modified so as to provide a better view for the captain and to improve seaworthiness for escort operations. It has all resulted in the construction of powerful seaworthy tugs with omnidirectional propulsion and an efficient hull/skeg form for escort purposes.

The increased towing forces escort tugs, and also harbour tugs, can deliver places additional demands on the deck equipment of ships for securing of tugs. This is an important aspect still requiring attention, as is the case regarding the use of fibre towlines, which are often damaged by assisted ship's fairleads and bollards.

The consequence of the research is that much more knowledge has become available on tugs and tug performance. Model tests and study results can be used to optimis harbour tug design in general. In addition, simulation programs have been developed to provide a better insight into the capabilities and limitations of different tug types while assisting ships. It has all created the possibility to make better decisions regarding a required tug type and bollard pull. Tug simulation for training and port design can benefit from the study results.

Tug simulation on ship manoeuvring simulators has evolved from simple vector tugs towards interactive tug simulation enabling tug captains to handle their own tugs in interaction, closely reflecting a real world situation and so improving the training of pilots and tug captains and research into port developments.

Virtual reality (VR) technology is playing an increasing role in maritime simulation. It may also be well suited to simulating interactive tugs, as tug captains tend to work alone in the wheelhouse, communications are by radio or intercom and the physical controls used are relatively simple. The tug captain needs a very wide field of view, but the objects in the scene that are of importance are relatively close. All this is within the present possibilities of VR technology. So in the future this technology may play an important role in tug simulation. It will be a relatively cheap method, surpassing existing quality. Tug simulation for training and port design can benefit from the study results.

Parallel with developments in research stimulated by a particular growing need to obtain better insight into the performance of escort tugs, studies have been carried out in Japan on the feasibility of automatic berthing systems. Such systems could control a ship's manoeuvring devices as well as attending tugs during an approach to a berth and while berthing. Scientists realise that berthing a ship is a most difficult operation which becomes more complicated when tugs are involved. If an automatic berthing system was feasible, it would only be applicable to very specific situations, locations and tug assisting methods like push-pull. The practical use of such a system is doubtful, because a tug's crew is still needed to sail the tug and to come alongside a ship under way and to make fast, unless this too could be done automatically.

Although absolute safety with tugs will never entirely be reached, with ongoing research and proper training together with the input of practical experience, a situation of safe and efficient shiphandling with tugs may be achieved.

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APPENDIX 1

The port authorities and towing companies who provided information for the first edition of this book by completing a questionnaire and by sending additional information like brochures and photographs are, in alphabetical order by country:

AUSTRALIA
- Fremantle Port. Australia. Captain R.G. Howell, Shipping Services Manager, Fremantle Pilots and Towing Company.
- Gladstone Port Authority. Australia. Mr. J.M. Schuh, Marketing Analyst.
- Port Hedland Port Authority. Australia. Captain David Baker, Harbour Master.
- Port Kembla. Australia. Captain W. Hoogendorn.
- Port of Melbourne Authority. Australia. Mr. A.D. Honeyborne, Manager Port Operations, and Towing Company United Salvage Pty.
- Sydney Ports Corporation, Australia. Mr. Reg McGee, Marine Operations Manager.

BAHAMAS
- South Riding Point. Grand Bahama. Captain D.C. McNab, Marine Operations Manager.

BELGIUM
- Port Authority Antwerp. Belgium. Mr. J. Burvenich, Deputy Director-General, and Mr. P. Decock.

CANADA
- Port of Montreal. Canada. Captain Jean-Luc Bédard, Harbour Master.
- Port of Quebec Corporation. Canada. Captain Louis Riel, Harbour Master and Towing Company Quebec Tugs Limited.
- Saint John Port Corporation. Canada. Captain A.G. Soppitt, Manager, Operations and Harbour Master.
- Vancouver Port Corporation. Canada. Captain G.B. Drewery, Deputy Harbour Master Operations. Towing Companies C.H. Cates & Sons Limited, Mr. J. Claire Johnston, President & General Manager, and Seaspan International Ltd.

ENGLAND
- Port of Felixstowe. UK. Mr. P.S. Davey, Assistant to the Managing Director.

FINLAND
- Port of Helsinki and Towing Company Alfons Håkans Ltd. Finland.

FRANCE
- Port Autonome de Dunkerque and Remorquage Towage Dunkerque. France.
- Port Autonome de Marseille. France. Captain M. Castagnera, Harbour Master.

GERMANY
- Port Authority Hamburg. Germany.

HONG KONG
- Hong Kong. Marine Department, Mr. K.W. Chan and Towing Companies South China Towing Company Ltd. and The Hong Kong Salvage & Towage Co. Ltd.

JAPAN
- Nagoya Port Authority. Japan. Mr. Yoshia Isozaki. Port Promotion Manager.
- Port & Harbour Bureau, Marine Affairs Division, City of Yokohama. Japan.

MALAYSIA
- Port Klang. Malaysia. Captain David Padman, Marine Operations Manager.
- Penang Port SDN. BHD. Malaysia. Captain Ahmed Husni bin Haji Zakwan, General Manager (Marine & Ferry Service).

NEW ZEALAND
- Ports of Auckland Ltd. New Zealand. Mr. Ran Meckenzie.
- Port of Tauranga Ltd. New Zealand. Mr. Nigel Drake, Marine Services Manager.

NORWAY

- Oslo Port Authority. Norway. Mr. Harry Grytbakk, Dep. Harbour Master, Mr. Hans Chr. Gunneng, Traffic Manager.
- Statoil Mongstad Oil Harbour. Norway. Port Captain.
- Sture Crude Oil Terminal. Norway. Mr. Hans Schütt, Marine Supervisor.

PHILIPPINES

- Philippines Ports Authority. Mr. Francisco L. Tolin, Acting Assistant General Manager for Operations.

PORTUGAL

- Porto de Sines. Portugal. Mr. Carlos Alves Botelho, Cte, Chefe de Divisão.

RUSSIA

- Port of Archangelsk. Russia. Captain V.A. Shershner, Harbour Master.

SCOTLAND

- Shetland Islands Council, Marine Operations Department. UK. Captain G. H. Sutherland, Director of Marine Operations and Captain K.J. Radley, Deputy Director of Marine Operations.

SOUTH AFRICA

- Port of Capetown. South Africa. Marine Manager Portnet.
- Port of Durban. South Africa. Captain R. van der Krol.
- Port of East London. South Africa. Captain B. Swemmer, Port Manager.

SRI LANKA

- Sri Lanka Ports Authority. Mr. L.P.M. Wijedoru, Addl. General Manager, Mr. Sgd. Sundra Jayawardhana, Chairman, and Harbour Master.

SPAIN

- Port de Barcelona, Spain. Captain A. Pérez Almoguera, Operations Manager.

SWEDEN

- Port of Göteborg, Sweden. Captain Jörgen Wallroth, Harbour Master, Manager Sea Traffic Department. Towing Company Röda Bolaget and Pilots.

TAIWAN

- Kaoshing Harbour Bureau. Taiwan. Captain Sun Hua-Tung. Harbour Master.
- Keelung Harbour Bureau. Taiwan. Mr. Wang Kuo-wei, Head of Working Vessel Center.

U.S.A.

- Port of Corpus Christi Authority. USA. Mr. Jerry Cotter, Director of Operations and Mr. Anthony C. Alejandro, P.E., Industrial Relations and Military Liaison Officer.
- Port of Houston Authority. USA. Mr. Michael T. Schubert, Operations Supervisor.
- Port of Mobile. USA. Crescent Towing Company. Mr. Prentiss D. Willcutt.
- Port of New Orleans. USA. Mr. Johnny J. Cefalu, Marine Terminals Superintendent, Marketing & Terminal Services and Mr. Charles Andrews, President Crescent Towing.
- The Port Authority of New York and New Jersey. USA. Mr. Joseph J. Birgeles, Manager, External Affairs Port Department, and Towing Companies: McAllister Towing and Transportation Co., New York City, and Moran Towing and Transportation Co., Connecticut.

APPENDIX 2

Department of Transport

Merchant Shipping Notice No. M.1531

Safety of Tugs While Towing
Notice to Shipowners, Masters and Shipbuilders
This notice Supersedes Notice No. M.748

Following another casualty to a tug the Department wishes to again emphasise the danger of capsising which may occur when the tow rope reaches a large angle to the centre line of the tug and the tug is unable to slip her tow.

The tug referred to above was engaged on harbour duties acting as a stern tug and had just commenced to cant a cargo ship, prior to berthing. During the manoeuvre the tow rope reached a position at right angles to the centre line of the tug (a position commonly referred to as "girting") causing an upsetting moment on the tug to the extent that she capsized and sank, fortunately without loss of life. The casualty became inevitable when the quick release mechanism on the towing hook failed to operate causing her to heel over to such an angle that the sills of the openings were immersed, allowing rapid flooding to occur.

Contributory causes to the casualty were:

(i) small freeboard
(ii) poor curve of righting levers
(iii) closing appliances to spaces leading below not secured.

In order to reduce the grave dangers associated with such conditions, particularly with smaller tugs engaged on harbour duties, the Department make the following recommendations:

1. It is of the greatest importance that the design of the towing gear should be such as to minimise the overturning moment due to the lead of the towline and that the towing hook should have a positive means of quick release which can be relied upon to function correctly under ALL operating conditions. It is desirable that the release mechanism should be controlled from the wheelhouse, the after control position (if fitted) and at the hook itself. The local control at the hook should preferably be of the direct mechanical type capable of independent operation. It is also essential that the greatest care should be taken in the maintenance of the towing gear to ensure its full efficiency at all times.

2. Openings in superstructures, deckhouses and exposed machinery casings situated on the weather deck, which provide access to spaces below that deck, should be fitted with weathertight doors which comply with the requirements for weathertight doors contained in paragraph 1, Schedule 4 of the Merchant Shipping (Load Line) Rules 1968. Such doors should be kept closed during towing operations. Engine room ventilation should be arranged by means of high coaming ventilators and air pipes should be fitted with automatic means of closure.

3. Stability criteria for tugs not subject to the requirements of the Merchant Shipping (Load Line) Rules 1968:

(i) In the normal working condition, the freeboard should be such that the deck-edge is not immersed at an angle of less than 10°.
(ii) The GM in the worst anticipated service condition should be not less than

Imperial	Metric
$\frac{K}{4f.C_B}$	$\frac{0{\cdot}076K}{f.C_B}$
Where: $K = 5 + 0{\cdot}08L - 0{\cdot}45r$	Where: $K = 1{\cdot}524 + 0{\cdot}08L - 0{\cdot}45r$

L = Length of the vessel between perpendiculars; feet or metres
r = Length of the radial arm of towing hook; feet or metres
f = Freeboard; feet or metres
C_B = Block coefficient

Any existing tug which cannot attain the GM calculated in accordance with sub-paragraph (ii) above might nevertheless gain some improvement in her stability by having structures on the weather deck closed in accordance with paragraph 2 above.

4. In cases where compliance with the recommendations in paragraph 2 and 3 cannot readily be attained consideration should be given to:

(a) substitution of permanent ballast for water ballast and conversion of peak ballast spaces to dry spaces.

(b) fitting a permanent device to minimise the possibility of the tow lead coming into the athwartships position.

5. In the case of the tugs which proceed to sea and are subject to the requirements of the Merchant Shipping (Load Line) Rules 1968 the stability criteria to be achieved and approved by the Department are as laid down in Schedule 4, Part 1, paragraph 2 of those rules.

Department of Transport
Marine Directorate
Southampton SO1 0ZD
June 1993

Note:
Merchant Shipping Notice No. M 1531 was cancelled on 30 August 1999. The contents have been included in the 'Loadline Instructions for the Guidance of Surveyors' of the Maritime and Coastguard Agency, UK. References to the Merchant Shipping (Load Line) Rules 1968, which are now the Merchant Shipping (Load Line) Regulations 1998, have been updated. The stability criteria mentioned apply to all non-seagoing harbour tugs and seagoing tugs of less than 80 net Tons,provided they are engaged in coasting trade, which means only voyages to destinations in the UK.

APPENDIX 3

DET NORSKE VERITAS
Rules for Ships, January 1996
Pt.5 Ch.7 Sec.16

SECTION 16
ESCORT VESSELS

Contents

A General
A 100 Classification
A 200 Definitions
A 300 Documentation

B. Arrangement and Design
B 100 Arrangement

C. Steering Force and Manoeuvring
C 100 Escort rating number
C 200 Manoeuvring

D. Stability
D 100 Stability
D 200 Stability criteria

E. Full Scale Testing
E 100 Procedures
E 200 Recordings during full scale trials

A. General

A 100 Classification

101 The requirements in this Section apply to vessels specially intended for escort service.

102 Vessels built in compliance with the following requirements may be given the class notation **Escort (n, V)**, where **n** indicates maximum transverse steering pull (FS in Fig. 1) exerted by the escort tug on the stern of assisted vessel, and **V**, the speed at which this pull may be attained.

103 The escort rating number **(n, V)** is to be determined by approved full scale trials. A test certificate indicating the escort rating number **(n, V)** may be issued on completion of approved full scale trials.

104 The requirements for **Tug** notation given in Pt.5 Ch.7 Sec.2 are to be complied with.

A 200 Definitions

201 The term *Escort Service* includes steering, braking and otherwise controlling the assisted vessel. The steering force is provided by the hydrodynamic forces acting on the tug's hull. See Fig. 1.

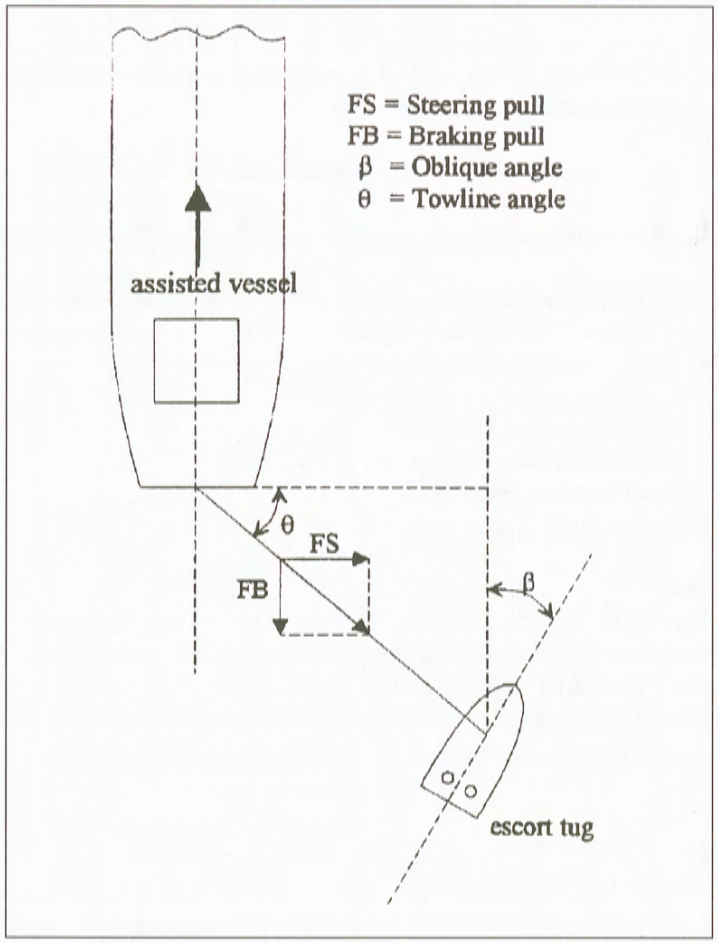

Fig. 1
Typical Escort configuration

Guidance note:

As the hydrodynamic forces acting on the tug's hull increases approximately with the square of the speed, the steering ability increases more than proportionally with the speed. Escort service should therefore normally be undertaken in the speed range of 8 to 10 knots.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e

202 By the term *Escort Test Speed* is understood the speed at which the full scale measurements are to be carried out, namely 8 knots and/or 10 knots.

203 By the term *Escort Tug* is understood the tug performing the escort service.

204 By the term *Assisted Vessel* is understood the vessel being escorted.

205 The Escort Rating Number **(n, V)** is defined as the steering force, n in tonnes determined according to C100 acting on the stern of assisted ship in tonnes, at **V** knots. If **n** is determined at both 8 and 10 knots the escort rating number will consist of 4 digits.

A 300 Documentation

301 The following plans and particulars are to be submitted for information:

- towing arrangement plan including towline path and minimum breaking strength of towing line components
- preliminary calculation of steering pull at 10 knots including propulsion components for balancing of oblique angular position of tug
- preliminary stability calculations.

B. Arrangement and Design

B 100 Arrangement

101 The hull of the tug is to be designed to provide adequate hydrodynamic lift and drag forces when in indirect towing mode. Due attention is to be paid to the balance between hydrodynamic forces, towline pull and propulsion forces. Freeboard is to be arranged so as to avoid excessive trim at higher heeling angles. Bulwark is to be fitted all around exposed weather deck.

102 The towing winch is to have a load reducing system in order to prevent overload cause by dynamic oscillation in the towing line. Normal escort operation is not to be based on use of brakes on the towing winch. The towing winch is to be able to pay out towing line if the pull exceeds 50% of the breaking strength of towing line. The towing line is to have a breaking strength of at least 2.2 times the maximum mean towing pull as measured during the test.

103 The propulsor shall be able to provide ample thrust for manoeuvring at higher speeds for tug being in any oblique angular position.

C. Steering Force and Manoeuvring

C 100 Escort rating number

101 The escort rating number, (**n, V**), to be based on full scale measurements at 8 and/or 10 knots.

n = FS C (tonnes)

FS = steering force from tug

C = $\frac{k28}{t}$ or 1, whichever is less

k = 1,1
(28 secs is the manoeuvring time required by Rules Pt.3 Ch.3 Sec. 2 J100)

t = Manoeuvring time in seconds from maintained oblique position of tug giving maximum steering force on one side of assisted vessel to mirror position on the other side. Towline angle θ need not to be taken less than 30°.

C 200 Manoeuvring

201 The vessel is to be designed so that forces are in equilibrium with a minimum use of propulsive force except for providing forward thrust and balancing transverse forces during escorting service.

202 In case of loss of propulsion, the remaining forces are to be so balanced that the resulting turning moment will turn the escort tug to a safer position with reduced heel.

Guidance note:

Due attention should be paid to sudden loss of thrust which may be experienced beyond certain angles of water inflow to propulsion units at higher speeds. Prediction of forces acting on the tug when escorting is necessary for scantling, manoeuvrability and preliminary stability calculations. Model testing may indicate hydrodynamic forces for indirect towing.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e

D. Stability

D 100 Stability

101 The general stability criteria in Pt.3 Ch.7 Sec.2 E are to be complied with. In addition, the stability criteria given in 201 and 203 are to be satisfied.

D 200 Stability criteria

201 The area under the righting arm curve and heeling arm curve are to satisfy the following ratio:

$$R_{ABS} \geq 1{,}25$$

where

R_{ABS} = Ratio between righting and heeling areas between equilibrium and 20° heeling angle. Equilibrium is obtained when maximum steering force is applied from tug.

202 Heeling arm is to be derived from the test. The heeling arm is to be kept constant from equilibrium to 20°, See Fig. 2.

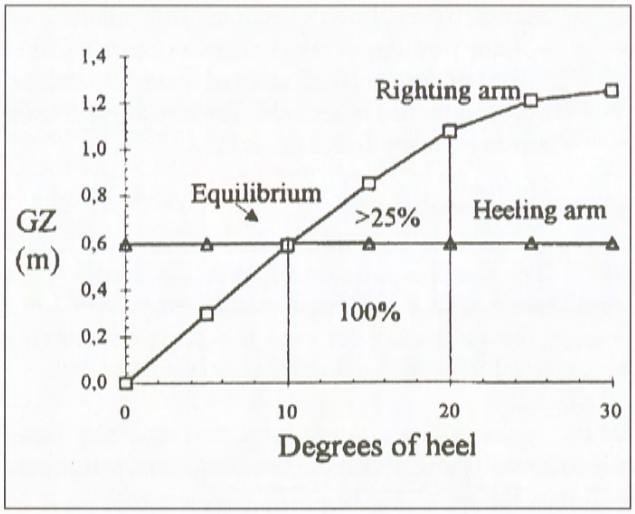

Fig. 2
Equilibrium to 20 degrees

Guidance note:

Possible model testing to include heeling angle measurements as to predict dynamic stability margin. This requires a high degree of accuracy in determining light ship weight and centre of gravity.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e

203 The following requirement is to be satisfied:

$$A + B \geq 1{,}4\ (B + C)$$

where

A + B = area under the GZ curve

B + C = area under the heeling moment curve

The areas are taken from 0° heel to the angle of down flooding or 40°, whichever is less. See Fig. 3.

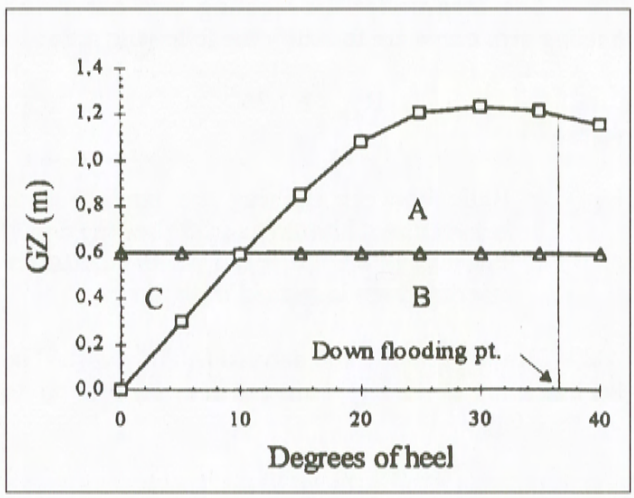

Fig. 3
Total Area Requirements

E. Full Scale Testing

E 100 Procedures

101 A plan with documentation covering the full scale trials is to be approved prior to the trials being undertaken.

102 The documentation is to include a towing arrangement plan showing different components in towing gear including the load cell. Verification of SWL of strong points on board the assisted vessel is to be submitted.

103 The escort test speed is 8 knots and/or 10 knots. The speed should be taken relative to the sea. Estimates of current during the trials may be required.

Guidance note:

The current may be estimated by logging speed by GPS and relative log in separate runs while proceeding with and against the current.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e

E 200 Recordings during full scale trials

201 At least the following data is to be recorded continuously in real time mode during trials for later analysis:

- position of assisted vessel and escort tug is to be recorded by differential GPS equipment
- speed of assisted vessel by differential GPS
- speed of assisted vessel by log relative to the sea
- heading of both vessels from gyro compasses
- rudder angle on assisted vessel
- heeling angle on tug
- towline tension
- length of towline
- angle of towline.

Weather condition and sea state are to be noted. Manual measurements are to be read as back up to continuous readings. Bearing from tug to assisted vessel is to be recorded. Suitable test forms are to be used.

Guidance note:

Assisted vessel is to sail on auto pilot during trials. Size of vessel is to be sufficient as to withstand steering forces from tug without using too large angles.

---e-n-d---o-f---G-u-i-d-a-n-c-e---n-o-t-e

Note:
Rules are in the phase of updating (2002).

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The Author

Captain Henk Hensen FNI, 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 also spent seven years as a part-time Nautical Adviser to the Nederlands Maritiem Instituut and the last two years as a pilot with the Rotterdam Pilot Association.

Captain Henk Hensen FNI

Captain Hensen, after initial education and Nautical College, was apprenticed to Nederland Line Royal Dutch Mail. Later he served with Redwijs and the Wagenborg Shipping Company before taking up the pilot appointment with the Port Authority of Rotterdam.

Following his retirement in 1990 he started his own consultancy, Nautical Safety Consultancy and works as marine consultant on the nautical aspects of port studies, including simulator research, tug advice and simulator training.

Projects have included the pilot and tug captain simulator training courses, defining the parameters for a pilot and tug captain manoeuvring simulator and port studies for the Port of Rotterdam. Captain Hensen has been involved with a port entrance study in India, a nautical safety study in Curaçao, several port entrance studies for large container vessels in Rotterdam, tug performance studies for ship bridge simulators, studies for the development of LNG terminals, container terminals and a fishing port, simulator studies for safe bridge passages and mooring studies. He has, furthermore, been involved in the development of the planned port extension seawards for the Port of Rotterdam.

As an author, apart from this book, he has published the monograph "Manoeuvring Single Screw Vessels fitted with a Controllable Pitch Propeller in Confined Waters" (1994); the first edition of the book "Tug Use in Port" (1997); chapters of the book "The Nautical Institute on Pilotage and Ship Handling" (1990); chapters of the book "The Work of the Harbourmaster" (1998) and numerous articles in nautical magazines referring to tug assistance, ship handling in relation to different types of tug, the construction and use of bow thrusters, manoeuvring simulators, accident control in port and fairways, line handling and controllable pitch propellers.

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