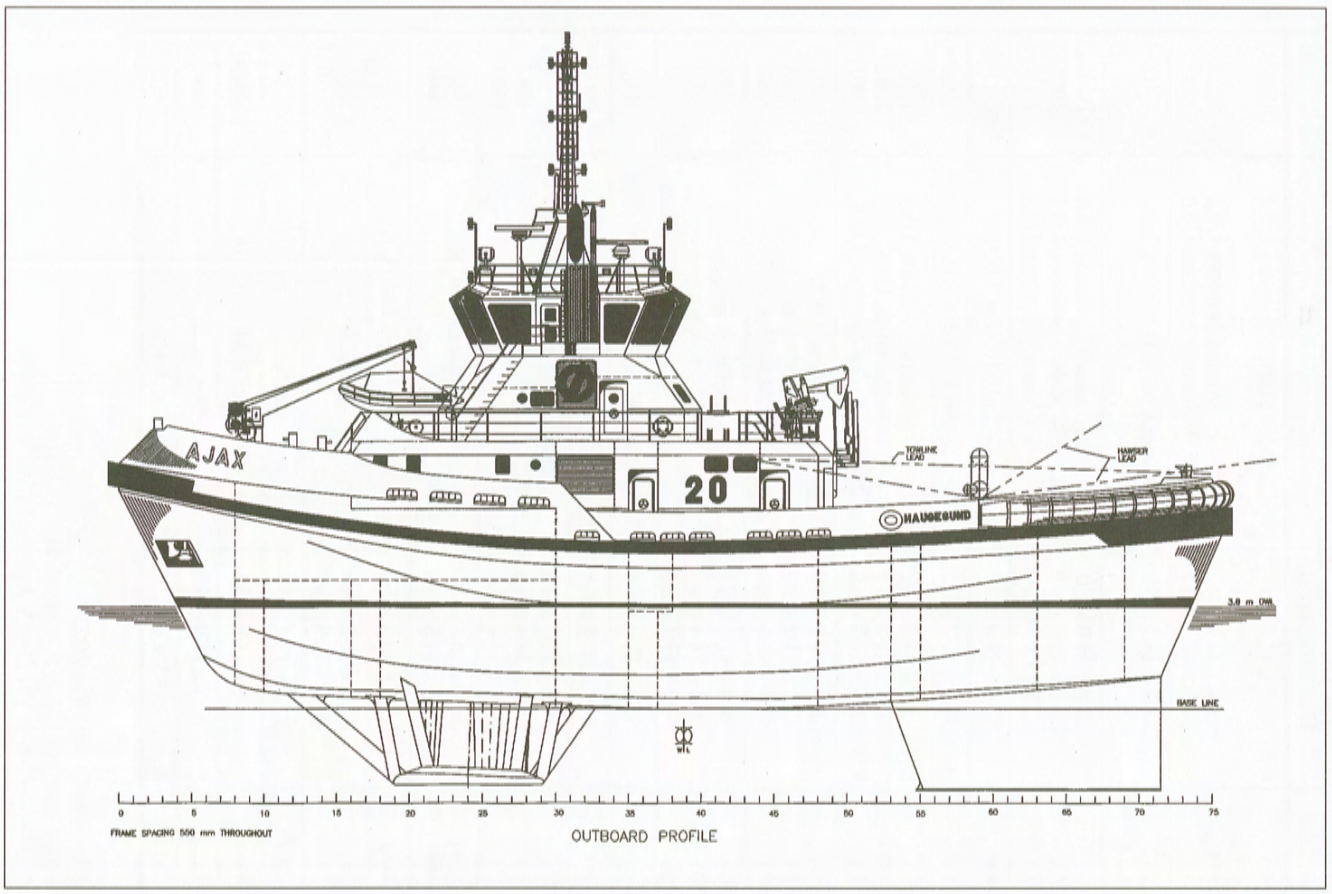
Name	Type	Escort area (1)	BHP and BP (2)	Dimensions (3)	Owner	Year built
Nanuq, Tan'erliq	VS	Prince William Sound, Alaska	10,192 / 95 t	46·6 x 14.6 x 6·6	Crowley Marine Services, USA	1999
Alert, Aware,						
Attentive (PRTs)	ASD		10,192 / 136 t	42·7 x 12.8 x 4·9	Crowley Marine Services, USA	2000
Protector class tugs	VS		5,400 / 55 t	36·6 x 12.6 x 5.2	Crowley Marine Services, USA	1997
Loop Responder	VS	LOOP (Louisiana Offshore Oil Port), USA	7,300 / ± 75 t	47·3 x 15.7 x 5·2	Edison Chouest Offshore Inc., USA	1992
Lindsey Foss, Garth Foss	VS	Strait of Juan de Fuca / Puget Sound	8,000 / 80 t	47·2 x 14·0 x 6·1	Foss Maritime Company, USA	1993, 1994
Protector class tug(s)	VS		5,400 / 55 t	36·6 x 12·6 x 5·2	Crowley Marine Services, USA	1997
Response	VS		7,200 / 68 t	39·5 x 14·0	Crowley Marine Services, USA	2002
Hawk, Eagle II	ASD	Tampa, Florida, USA	6,700 / 77 t	33·5 x 12·2 x 5·0	Seabulk Towing, USA	1995, 1996
Broward	Z-drive tractor	Port Everglades, USA	4,300 / 53 t	30·5 x 12·2 x 5·8	Seabulk Towing, USA	1995
Harbor class tugs	VS	Los Angeles / Long Beach, USA	4,800 / 49 t	32·2 x 11·0 x 4·6	Crowley Marine Services, USA	1998
Marshall Foss	ASD		6,250 / 76–68 t	29·9 x 12·2 x 5·1	Foss Maritime, USA	2002
Millennium Dawn	ASD		4,400 / 59 t	32·9 x 11·2 x 4.9	Harley Marine Services, USA	2001
Lynn Marie	Rev. tractor	San Francisco, USA	6,400 / 76–71 t	29·9 x 12·2 x 5·0	AmNav, USA	2001
Delta Linda	ASD		4,400 / 61 t	32·9 x 11·2 x 4·6	Baydelta Maritime, USA	1998
Andrew Foss	VS		4,000 / 50 t	32·6 x 11·6 x 4·4	Foss Maritime, USA	1982
Atlantic Willow	Rev. tractor	Port Hawkesbury, Nova Scotia, Canada	4,004 / 50 t	30·8 x 11·1 x 4·8	Atlantic Towing, St. John, Canada	1997
Atlantic Larch	Rev. tractor		4,004 / 50 t	30·8 x 11·1 x 4·8		2000
Atlantic Oak	ASD		5,000 / 62-60 t	30·8 x 11·1 x 4·8		2002
Placentia Hope, Placentia Pride	VS	Placentia Bay, Newfoundland	5,600 / 55–50 t	38·0 x 13·0 x 6·0	Newfoundland Transhipment, Canada	1997
Ajax	VS	Sture, Norway	10,400 / 93 t	41·6 x 15·9 x 6·8	Østesjø Rederi A/S, Norway	2000
Bess	VS	Statoil Mongstad, Norway	5,400 / 57 t	36·3 x 12·3 x 5·2	Buksér og Berging, Norway	1994/95
Bob	VS		5,168 / 52 t	35·2 x 12·4 x 5·3		1997
Boxer	VS		6,800 / 65 t	38·9 x 13·7 x 5·5		1998
Cramond, Dalmeny	ASD	BP Hound Point Terminal, Grangemouth, Scotland, UK	4,800 / 60–55 t	34·4 x 10·5 x 4·6	BP Exploration, UK	1994
Hopetoun	ASD		9,600 / 125–110 t	43·5 x 13·5 x 6·0		1996
Silex, Thrax	ASD	Fawley Esso, UK	5,000 / 60–57 t	35·1 x 10·8 x 5·0	Solent Towage Ltd., UK	1994
Redbridge	VS	BP Terminal, Southampton, UK	4,100 / 43 t	33·0 x 11·2 x 4·8	Adsteam Towage, UK	1995
Lyndhurst	VS		4,000 / 43 t	30·0 x 11·0 x 5·3		1996
Tystie, Dunter	VS	Sullom Voe, Shetlands, UK	5,400 / 55–51 t	37·6 x 13·4 x 5·7	Shetland Towage Ltd., UK	1996
Anglegarth, Millgart	ASD	Milford Haven, UK	5,100 / 66–60 t	32·7 x 11·8 x 5·1	Wijsmuller Marine, UK	1996/97
Sertosa Veintisiete	VS	La Coruña, Spain	3,800 / 42 t	29·5 x 11·0 x 5·0	Sertosa, Spain	1993
Ukko, Ahti	ASD	Refineries, south coast Finland	6,700 / ± 70 t	33·5 x 12·8	Fortum Oil & Gas Oy, Finland	2002

Figure 9.21 A selection of escort(-ing) tugs at different ports. Situation 2002
(1) Not all escort ports are mentioned, while in some of the ports mentioned more escort(-ing) tugs operate than indicated
(2) When two figures are given for the bollard pull, the second figure gives bollard pull on astern (3) Length, beam and draught in metres



Courtesy: Østensjø A/S, Norway

Figure 9.22 VS escort tug 'Ajax'.
L.o.a. 41·6m, beam 15·9m, operational draft 6·8m, engine power 10,400 bhp, bollard pull 93 tons, steering force at 10 knots 155 tons, braking force at 10 knots 180 tons, free sailing speed 15 knots, towing winch 200 tons pull, 300 tons brake

It is not easy to give a sharp definition of an escort tug, seeing all the different tugs used for escort operations. Basically an escort tug is a tug specifically built for escorting of ships, in particular tankers, at relatively high speeds. However, harbour tugs, often with enhanced escort capabilities, are also often used for escorting, in addition to their normal harbour operation duties. Both types are therefore shown in the list, and it is for that reason that the term escort(-ing) tugs is used for the list. It depends totally on the requirements of a port what kind of tug is used for escorting.

9.5.3 Training and pilotage

Escorting has been introduced to reduce the risk of pollution arising from failures on board a tanker. Expensive escort tugs are deployed as a safeguard, sometimes over large distances. The full advantages of escort tugs can only be achieved by proper training of all persons directly involved. With escorting speeds up to 12 knots the human element becomes extremely important. This means that training should be an essential part of learning and building up escort experience. Training should naturally include practical on the job training for tug captains and crew, but also some theoretical training. This should include training of tug captains and crew, pilots and possibly also ship's masters, in:

- Escort procedures and communications.
- Escort speeds.
- Ship's possible behaviour after a failure.
- Capabilities and limitations of escort tugs, various assist manoeuvres, including the most effective way of applying steering and braking forces in case of an engine or rudder failure on board the escorted vessel.
- Towing equipment and towline handling.

Such training can be given based on videos of escorting. Desktop computer simulation of emergency situations (see section 8.3.3) can be a significant tool for escort education and emergency preparedness. A large number of failure scenarios can be simulated under various circumstances and environmental conditions and the effect of tug interventions can be compared. The utmost importance of a quick response to a failure can also be shown. For getting insight into the capabilities of a certain escort tug, a program can be used as shown in figure 8.2.

For escort training of pilots, tug captains and shipmasters, use can also be made of a full mission simulator, provided such a simulator can be made

suitable for training with escort tugs. With a simulated escort tug and assisted ship, procedures and failure scenarios for the most critical locations under different environmental conditions can be exercised. Different assist manoeuvres can be trained for, as well as changing from one assist mode to another, for instance, from braking mode to the indirect steering mode, or steering a ship having a rudder failure through a bend in a controlled manner.

Pilots are one of the essential links in escorting. For ports accommodating other shipping, or with a large number of pilots, it is recommended that a limited number of pilots are selected and used for escort jobs, a so-called choice pilot system. Training can then be intensified and the system increases the experience of these pilots in a quicker way. In very sensitive areas or for large tankers a second pilot might even be required.

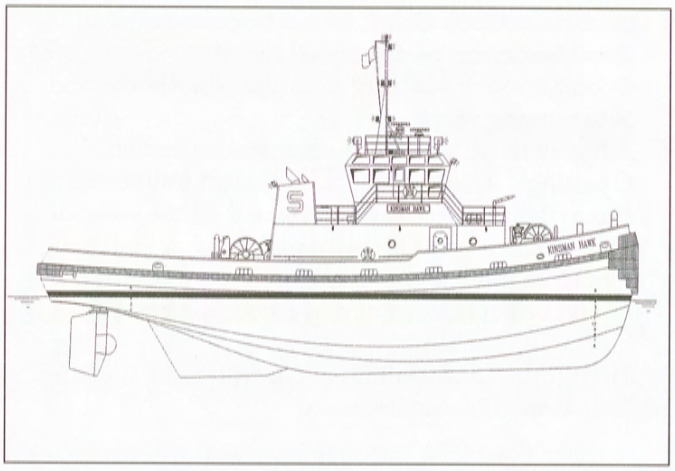
The other essential human link is the tug captain and his crew. In case of a failure much depends on how fast a tug captain can react and bring his tug in the correct position to apply the steering and/or braking forces required. A high level of experience in handling his tug is of utmost importance, particularly regarding all the possible tug manoeuvres that might be required to control a disabled vessel in the most effective way. The higher the escort speed and the more adverse the conditions, the more important becomes a tug captain's experience.

It may never happen that a pilot and escort tug captain has to come into action due to a failure on board an escorted vessel. Nevertheless experience should be maintained at a high level. Regular training and instruction is a necessity, therefore, making use of experiences already gained. The best way such training and instruction can be performed is:

- A regular refresher course on a full mission simulator for pilots and tug captains, together with, if possible, ship masters.
- Real life exercises with a tanker and escort tug. This could, for instance, be done with an incoming tanker if time and circumstances allow, and the ship master agrees.

How important training is can best be illustrated by the following conclusions made by classification society DNV. Since 1990 DNV has attended several full scale tests and also issued escort rating certificates on a number of occasions.

DNV found that the most important observation during the full scale escort tests was that *'practice makes perfect'*, and that this could not be emphasised enough. Tugs undertaking escort operations as witnessed should be purpose built and the crews need to have ample training.



Aquamaster-Rauma Ltd.

Figure 9.23 Powerful ASD escort tug 'Hawk' (l.o.a. 33·5m, beam 12·2m, bollard pull 75 tons)

The importance of a well-designed purpose built escort tug in combination with a high level of experience has furthermore been proven by risk assessment analyses carried out by DNV for several oil terminals. These studies show that a purpose built escort tug with appropriate manning reduces the risk picture significantly, while an escort tug not properly equipped or manned increases the risk dramatically.

Note: When normal harbour tugs are used for escorting, instead of specific escort tugs, the same type of training can be utilised. In addition to the previously mentioned training subjects, the most appropriate tug placement can be exercised, if needed, and the effect of ship's speed on tug efforts after a failure can be demonstrated.

9.5.4 Summary of escort tug requirements

- Optimal manoeuvrability and high free sailing speed.
- High working reliability.
- Good sea keeping conditions, free sailing as well as in the escort operating direction.
- Sufficiently high freeboard.
- Good static and dynamic stability.
- A safe working deck for handling of towlines in rough sea conditions and at high speeds.
- Ability to apply high steering and/or braking forces over the whole escort speed range and capable of assisting in different ways.
- A safe and effective location of the towing point with respect to heeling angle, achievable towline forces and tug engine failure.
- Deck equipment construction should be suitable for escort operations and be such that it can easily withstand the high towline forces. Towlines should have a high safety factor and preferably be made of light and strong synthetic fibres with a positive buoyancy to enable safe, fast and easy handling. In case the ship requiring assistance has no power available at the mooring stations fore and aft, it should

be possible that the towlines can be passed manually.
- Good fendering, preferably all round.
- Good all round visibility from the wheelhouse and of the towing winch.
- A highly reliable radio communication system.
- 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 watertight doors. These doors should be kept closed during escort operations.

Firefighting and pollution control tasks include additional specific requirements.

9.6 Escort tug regulations

A selection of various escort regulations in force in the USA, Canada and Europe are summarised here, starting with those in the United States of America, where federal, state and local regulations are in force in a number of compulsory escort areas. Federal regulations override state and local regulations. In these regulations the term 'escort vessels' is often used, which can be normal harbour tugs used for escorting or specifically designed escort tugs.

The rules and regulations described here reflect the 2002 situation and are subject to change due to new developments and insights. The Oil Pollution Act of 1990 (OPA 90) rule about escort vessels has the legislative intent of enhancing tanker navigation safety. Under Title IV (prevention and removal) of OPA 90, single hull tankers of 5,000 gross tons or over transporting oil in bulk in defined areas of Prince William Sound (State of Alaska) and Puget Sound (State of Washington) must be escorted by at least two escort vessels with specific performance capabilities. Double hull tankers are not required to have tug escorts in these waters.

The Prince William Sound and Puget Sound Federal Tanker Escort Regulations (Code of Federal Regulations 33 CFR 168, mandated by OPA and effective 17 November 1994) require certain performance and operational capabilities. Escort vessels must be positioned near the tanker such that timely response to a propulsion or steering failure can be effected. Tankers should not exceed a speed beyond which the escort vessels can reasonably be expected safely to bring the tanker under control within the navigational limits of the fairway. The escort vessels, acting singly or jointly in any combination as needed (but not less than two escort vessels), and considering the applied force vectors on the tanker's hull, must meet minimum requirements to tow, stop, hold and turn a disabled tanker:

- Tow a tanker at four knots in calm conditions, and hold it in a steady position against a 45 knot headwind.
- Stop a tanker within the same distance that it could crash-stop itself from a speed of six knots using its own propulsion (temporarily suspended).
- Hold a tanker on a steady course against a 35° locked rudder at a speed of six knots.
- Turn a tanker through 90°, assuming a free-swinging rudder and a speed of six knots, within the same distance (advance and transfer) that it could turn itself with a hard-over rudder.

Alaska State Law requires all loaded tankers, single or double hull, to be escorted by escort tugs. There is, furthermore, a requirement for oil spill response equipment along the tanker route through the Prince William Sound. This equipment is provided by, amongst others, the following escort tugs, the 10,192 hp VS tugs *Nanuq*, *Tan'erliq* and the 10.192 hp ASD-tugs *Alert*, *Aware* and *Attentive*, being fitted with skimming and onboard storage capabilities for an initial oil spill recovery.

Summarised, the following are required by the U.S. Coast Guard Captain of the Port for all tankers passing through Prince William Sound (PWS) regarding escorting as mentioned in the Vessel Escort & Response Plan (VERP) and based on the use of available tugs ranging in size from approximately 6,000 – 10,000 hp as mentioned in the Charter Escort Vessel Fleet list in the VERP:

- A minimum of two escort vessels for all loaded tankers from the terminal to sea and vice versa.
  The primary escort vessel is one of the 10,192 hp VS or ASD-tugs mentioned above. The second escort vessel may be any other tug of the Charter Escort Vessel Fleet. Smaller tugs, the 5,500 hp VS-tug *Protector* or *Guard*, can be the primary tug for tankers in the 90,000 dwt class or smaller. If that is the case, then an Escorting Response Vessel (ERV) will be assigned. ERVs are, as the escort vessels mentioned above, fitted with skimming and onboard storage capabilities practicable for the initial oil recovery planned for a cleanup operation as identified by the oil spill removal organisation.
  An ERV will be either part of the escort convoy, or pre-positioned on sentinel duty during transit.
- The loaded tanker shall not exceed a speed beyond which the escort vessels can reasonably be expected to safely bring the tanker under control.
- The maximum allowable speed through the water for loaded tankers is between six knots (Valdez Narrows) and 12 knots, depending on the area.
- When wind in the Valdez Narrows exceeds 40 knots, transit is prohibited for all tanker traffic.
- Outbound loaded tankers will not be allowed to transit Hinchinbrook Entrance when winds exceed 45 knots or seas exceed 15 feet.
- Two escort vessels shall maintain close escort within 0·25 nautical miles of a loaded tanker.
  In Central Prince William Sound, however, the primary escort vessel shall maintain close escort, while the second escort vessel may be any vessel of

the Charter Escort Vessel Fleet stationed at an appropriate location underway (so-called sentinel vessels).
- All loaded tankers shall have the primary escort vessel tethered in the Valdez Narrows and part of the Valdez Arm. The second escort vessel shall then move into a position close astern of the tethered escort vessel.
- Maximum allowable speed through the water in Valdez Narrows for tankers in ballast is 12 knots; there is no speed limit elsewhere in Prince William Sound.
- Tankers in ballast are escorted by Sentinel vessels (see above).
- Different regulations and procedures apply to ice conditions.

In the VERP, furthermore, much emphasis is placed on the need to respond immediately to failures, on the proper and safe use of a tethered escort tug, the emergency towing equipment, and on exercises. The VERP meets the earlier mentioned federal requirements (Code of Federal Regulations 33 CFR Part 168).

The State of Washington regulations on escorting (Washington Tanker Law, September 1975) do not require two tugs. The state escort rules require escort tug(s) to have an installed power equal to 5% of the deadweight of the escorted tanker, so a 100,000 dwt tanker would require a 5,000 hp tug as escort (if one tug was used). Moreover, according to state rules, escorting is compulsory for loaded oil tankers and gas tankers of more than 40,000 dwt, except for tankers which meet certain requirements, such as twin screws and double bottoms. Since federal rules are in force in Puget Sound, tankers of 5,000 gross tons or over have to be escorted by two tugs.

How to comply with State and Federal statutory provisions and performance obligations is worked out in the Puget Sound Tanker Escort Plan. The escort plan is to be specific to tankers, waterways and weather conditions and suggests a team approach between tanker master, pilot and tug captain. The tanker Specific Escort Plan is the final correlation of waterway and weather data with critical tanker data for the purpose of evaluation and selecting escort tugs and the coordination and execution of a successful transit.

The escort tugs are selected from a fleet of conventional tugs and VS tractor tugs, ranging in size from 3000 to 8000 hp. The 8000 hp tugs are the large VS escort tugs *Lindsay Foss* and *Garth Foss.* As an indication of escort practice the "ARCO Escort Plan – Quick Reference Guide", is used. The following is a summary:

- The size of the primary tug depends on tanker size: The 8000 hp tug for tankers of 90,000 dwt and more and the 4000 hp VS tractor tug for smaller tankers.
- Escort speed depends on the zone.
- Whether tethered or untethered depends on zone and escort speed.
- The untethered escort position for the primary tug is bow first within half a ship's length off, in line with the bridge.

The State of California's OPA 90 legislative parallel, the Lempert-Keene-Seastrand Bill (SB2040) was passed in May 1993. Escort guidelines are developed by the Harbor Safety Committees of the ports and after approval mandated by the State. The regulations in general are the same for all ports, but each port has specific rules that may differ. As an example the escort regulations for the San Francisco Bay region will be addressed briefly. For the San Francisco Bay region the Office of Spill Prevention and Response of the California State Department of Fish and Game published in October 1993 interim escort regulations which took effect 11 January 1994. These were amended in July 2001. The revised escort regulations became effective 4 October 2001.

These state regulations require both single and double hull tankers and barges carrying over 5,000 tons of oil in bulk when underway in defined areas of San Francisco, San Pablo and Suison Bays to be escorted. The regulations do not apply to double hull tankers when equipped with fully redundant steering and propulsion systems, which shall include at least the following: (1) two independent propulsion systems, each with a dedicated propeller; and (2) two independent rudders with separate steering systems; and (3) propulsion and steering components in separate spaces; and (4) a bow thruster with an assigned power source.

Regulations are given for escort plans and a pre-escort conference. The escort plan can be based on a checklist and should include matters such as the intended route(s) and speed(s), a communication plan, the escort tugs to be used, the response actions most likely to be implemented in case of an emergency, the characteristics of the tanker with respect to the locations and strength of bitts and chocks to be used by escort tugs, pushing surfaces on the hull, any pertinent performance characteristics of steering and propulsion system(s) and related limitations.

Requirements for escort tugs apply to aspects such as registration, number of crew members, working hours, training, braking force verification, stability and equipment. The latter should include a line throwing gun, winches, towline (with a breaking strength of two and a half times the certified braking force of the escort tug), a quick release device and appropriate fendering. Tankers should have chocks and bitts that are of sufficient size, strength and number for the escort tugs.

While engaged in escort activity escort tugs should maintain a station keeping distance of no more than 1000 feet ahead or aside, or 500 feet astern of the tanker. Depending on the zone tanker speed should not be in excess of eight or 10 knots, however, the speed or speeds

selected for transit must permit stationing the escort tug(s) to allow them effectively to influence the tanker's movement in event of a casualty.
In contrast to the federal regulations, a single escort tug may be used for compliance with the California State Regulations so long as the bollard pull (bollard pull – ahead or astern – for tractor tugs and bollard pull astern for conventional tugs) meet the criteria as given by the tanker-escort tug(s) matching criteria. The maximum number of escort tugs to be used is three.

The required braking force depends on ship's displacement, the assisting current velocity and the zone. Required forces are given in a Default Matrix Option for Matching Tugs to Tankers.

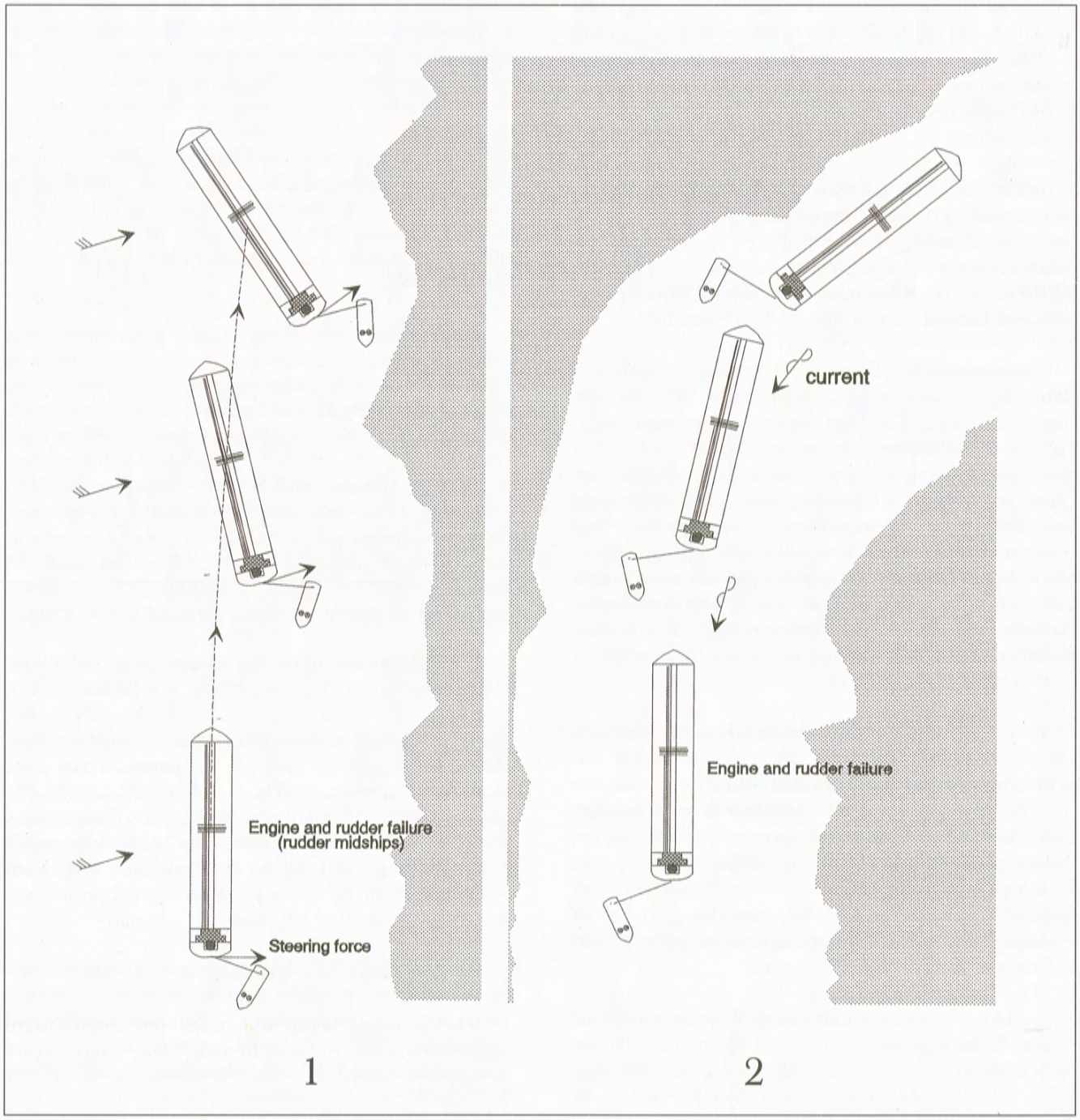


Figure 9.24 Can the escort tug prevent a grounding?
Situation 1: A half loaded tanker experiences an engine and rudder failure. To avoid too much drifting, the escort tug steers the ship to port. Tanker speed will drop due to engine failure and some braking force of the tug. Consequently, the ship will drift faster and the drift angle has to be further increased. The result is constantly two forces to starboard – steering force and wind force. The ship will most probably drift onto the shoals unless a tug forward is secured in time
Situation 2: Just before the loaded tanker has to take a bend, an engine / rudder failure occurs. The escort tug tries to steer the ship through the bend. However, in addition to the steering force, the current is also pushing the ship to port and counteracts the turn. Due to the decreasing ship's speed, the steering and current force, both to port, the tanker will most probably drift onto the shoals. When the underkeel clearance is small, the ship will turn with even more difficulty and the influence of the current will be much larger, resulting in a higher risk of grounding in the case of a failure

Escorting is utilised in some other USA areas, for example at the Louisiana Offshore Oil Port (LOOP). In Canada loaded oil tankers while transiting to and from terminals in Placentia Bay, Newfoundland, are required to be escorted by an escort tug. The Tanker Escort Plan, as prepared by Canship Ugland Limited, contains guidelines and procedures for pilots, tanker masters and tug captains.

Three escort modes are mentioned in the plan: active mode (tethered), close passive escort (the VS escort tug has then to follow the tanker stern first and close to the tanker's stern and in view of the tanker's bridge team) and passive escort (escort tug to be positioned abeam and forward of the tanker's bridge approximately 0·25 nautical miles from the tanker and in view of the bridge team).

Depending on the escort area, the passive, close passive or active escort mode has to be utilised. Maximum escort speed for the active escort mode is eight knots, except for tankers of 160,000 dwt or less, when outbound, for which the maximum speed is 10 knots. A pre-escort conference between tanker master, pilot and tug captain is mandatory. Conference subjects are mentioned in the plan.

In Europe, escort regulations are mainly local terminal regulations, agreed between port authority, pilots and tug owners, except for Norway where escorting of tankers is mandated by the government. There are not yet any regulations regarding the required bollard pull or horse power of tugs. This is more or less based on research. In most ports, but not all, escorting is usually carried out by one purpose built tug.

A selection of European escort tug regulations:

- Hydro, Sture Crude Oil Terminal, Norway: Escort tugs compulsory for arriving and departing oil tankers exceeding 20,000 GRT.
- Statoil Terminal, Mongstad, Norway: escorting compulsory for LPG carriers over 5000 m^3 as well.
- Esso Terminal, Fawley, Southampton, UK: Escorting of inbound and outbound oil tankers above 60,000 dwt.
- BP Terminal, Southampton, UK: all ships exporting crude oil. Visibility should be not less than one mile.
- Port of Sullom Voe, UK. The following regulations are in force for the main tanker route:
  - All inbound crude oil and gas tankers shall be attended by two tugs and when outbound by at least two tugs.
  - One escort tug shall be secured to the ship's stern ready to apply indirect towing techniques. In escort locations with severe swell conditions, the escort tug shall be in close attendance, ready to pass the line at any time should an emergency occur. The second tug shall be at such a position that it is able to respond in timely fashion when required.
  - Maximum speed in the escort zone for departing loaded tankers is eight knots.

A marked difference between US federal rules for escorting and other escort rules in force is that the US federal rules apply to single hull tankers only, while other escort rules, probably all, apply to single as well as double hull tankers.

9.7 Concluding remarks

Some remarks should be made regarding escorting. According to a 1993 publication by Shell International Limited, most studies recognise that human error is the immediate cause of at least 80% of shipping casualties. This figure will not have changed much recently and it means that, amongst other things, improvements can be made by proper training. The need to train captains, mates and pilots, therefore, should be emphasised. Full mission simulators can play a more important role in this than has been the case until now.

Pollution cases in port approaches should be carefully investigated in order to establish what caused the accident. When technical failures on board tankers are a main cause, then further insight is required into the types of failure and their causes. When similar failures are systematically the cause, modifications in tanker design should be proposed and agreed. Research should be carried out into whether tankers can be designed such that they can operate safely in port and port approaches without the need of escort tugs.

Good developments in this field are, amongst others, the 140,000 dwt double hull Endeavour class tankers of Polar Tankers, Inc., with two independent engine rooms, twin propellers, twin rudders and a 3,000 hp bow thruster, of which the first one of a series of five came into service in July 2001. The 315,000 double hull VLCC of the Stena V-Max design, also has two completely separate engine rooms, double rudders and double propellers, of which the first of this type came into service October 2001 and the recently built North Sea double hull shuttle tankers of approximately 130,000 dwt have redundancy in propulsion and steering (high lift rudders) and bow thrusters.

The same applies to human failures. Good insight into the type and cause of human failures may permit the possibility of preventing such failures by, for example, adapting appropriate rules and procedures.

Escort tugs now have to compensate for the technical and human failures on board tankers but escorting may not and will not avoid all tanker accidents. This refers particularly to escorting with one purpose built escort tug. In figure 9.24 two imaginary but fully normal situations are given, where the escort tug most probably will not prevent a grounding. In situation 1 of figure 9.24, a grounding could probably be avoided by having

the escort tug towing at the bow of the ship. These are just some examples. Other situations could be described, but perhaps readers will quote from their own experience

When full scale escort trials are carried out in deep water, they give too optimistic a view of escort tug capabilities. With a small underkeel clearance, often the case in port approaches, the situation is far more difficult and complicated. The influence of currents is much larger, ship's rudder effectiveness decreases, and more power is needed to turn and stop a vessel. In case of a failure, much more effort is required from the escort tug to avoid an accident, and hopefully it can then deliver the required forces.

Chapter TEN

TUG DEVELOPMENTS

TUG ASSISTANCE IN PORT AND PORT APPROACHES has been the subject of much research over many years for safer tugs with improved capabilities. This has sometimes resulted in tug concepts which have never been realised. However, the world tug fleet nowadays generally consists of a large number of tugs with extensive capabilities and developments still continue.

10.1 Special developments in the design of tugs

Particularly amongst harbour tugs with azimuth thrusters there is a continuous development of ideas. For different reasons only a very few of these became reality and resulted in tugs with real differences from normal tug designs. These alternative designs and trends can more or less be categorised as follows:

- Developments in the number and configuration of azimuth thrusters.
- Developments based on the systematic use of hydrodynamic forces working on a tug hull.
- Developments in tug power in relation to tug size.

Several of these alternative designs and one specific trend in tug design will be addressed below.

10.1.1 Developments in the number and configuration of azimuth thrusters

Novel New Tractor Tug Design (1984)

This design has become reality. Tugs *TP I* and *TP II* have been built and operate at the coal port at Ridley Island, Canada. They have two azimuth propellers in line, one forward and one aft. The idea of building this type of tug was developed after two platforms powered by a 3,600 hp diesel driving two azimuth thrusters came onto the market for sale. The platforms were originally built for the St. Lawrence Seaway Authority to evaluate the principle of using shunters. The original intention was to connect one powered platform, a shunter, to the stern and one to the bow to assist ships transiting the Welland Canal in Ontario (see figure 10.1). The experiment was discontinued because bulk carrier size increased and because of problems with the locking arrangement between shunter and transiting vessel.

The shunters were converted into the present tugs with the following particulars: length overall 30·33m, beam 10·97m., engine 3600 hp (2650 kW), bollard pull 45 tons. Bollard pull ahead, astern and sideways is almost the same. When thrusters operate in line there is loss of thruster efficiency. The only data the designers could find with respect to this related to thrusters operating in semi-submersibles. The data indicated that if the distance between thruster centrelines was six times the diameter or greater, the effect would be less than 10% loss of thrust. The ratio between nozzle diameter and distance between thrusters of the *TP I* and *TP II* is 1 to 8. In theory this gives a loss of about 6%. So when pulling or pushing with thrusters in line the bollard pull is approximately 42 tons. However, in such situations the thrusters are always set at a slight angle.

The two tugs have been a cost effective investment. Their total cost was less than two thirds of the cost of one comparable traditional tug with azimuth thrusters. They are specific ship docking tugs and operate for ships arriving at the coal terminal in the push-pull mode often parallel to the ship with a towline from the tug's bow secured to the ship. The tugs operate very successfully at the coal terminal and, according to the owners, can safely handle vessels in the 180,000 to 200,000 dwt range.

The optimum harbour tug: The Supertug (1986)

This is more or less similar to the previous design. It has an azimuth thruster aft as main propulsion, and one forward as a kind of bow thruster. A difference from the previous design is that the towing point is located above the main thruster. The underlying idea is that when towing on a line with a ship having speed through the water, towing forces can be applied directly against the towline while reducing the resistance of the tug's hull through the water by steering the tug with the azimuth bow thruster more or less in line with the incoming water flow (see figure 10.3). It is recognised that the high athwartships forces of the towline will have consequences for the tug's stability and therefore a kind of radial hook is suggested to reduce heeling angle. There is no indication that this concept has ever been realised.

Tug Omni 2000 (1994)

The Omni 2000 was a proposed concept for an omnidirectional tug with four thrusters. The tug was fully symmetrical fore and aft. The objective was to propose a tug with absolutely the lowest costs and omnidirectional propulsion, which could satisfy a particular harbour operation. The concept was not accepted by the client.

The ROTOR tug (1999)

A new concept in tugs with azimuth thrusters is the ROTOR escort tug. Basically it is a normal tractor tug with azimuth thrusters, but the skeg is replaced by a third azimuth thruster arranged on the tug's centreline. Three small fins are located under the stern to give course stability in transit. Guard plates and struts provide protection to the thrusters and when docking.

Four tugs have been built with this concept, the *RT Innovation*, *RT Pioneer*, *RT Spirit* and *RT Magic* and since

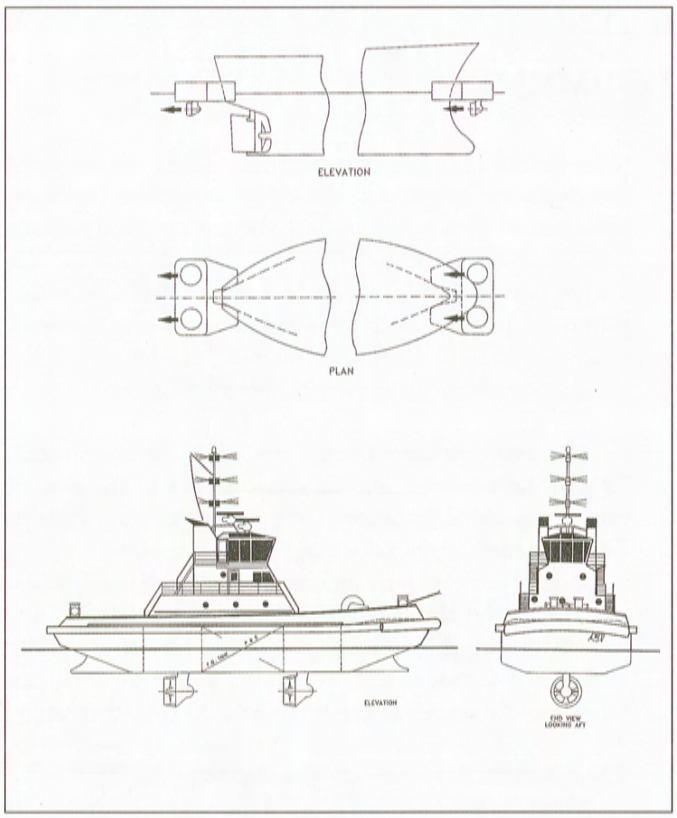


Figure 10.1 Novel new tractor tug design with sketch of the original shunters

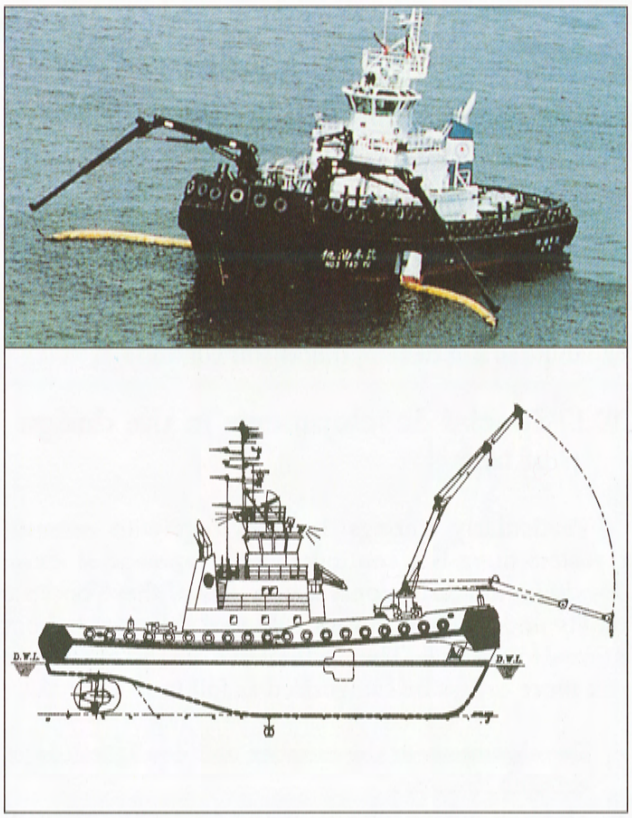


Figure 10.2 Taiwanese reverse tractor tug 'No 3 Tao-Yu' (l.o.a. 33·0m, beam 11·7m, draught 3·7m, bollard pull 43 tons) combines ship handling and oil spill recovery. The cranes can be used to deliver the tow line to the ship to be assisted, or for oil spill recovery. In the event of an oil spill, the tug can be converted within minutes into a fully self-sufficient oil recovery vessel

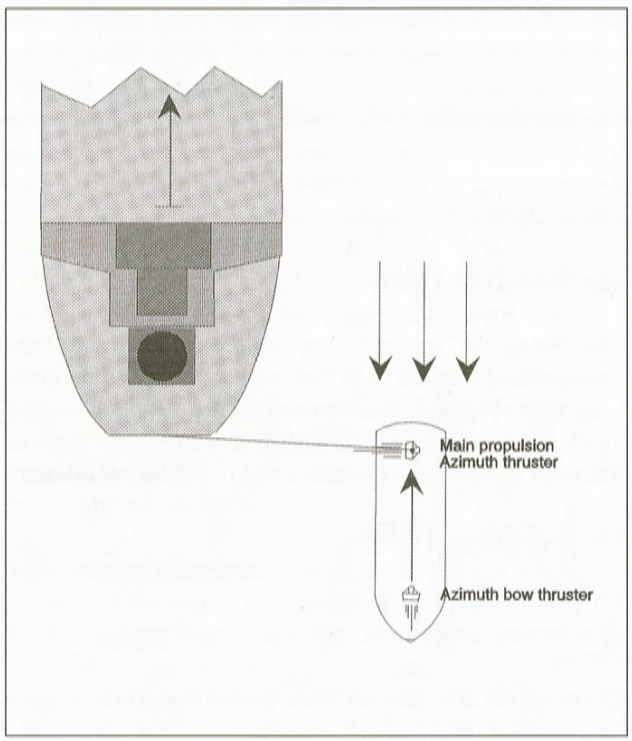


Figure 10.3 The optimum harbour tug concept

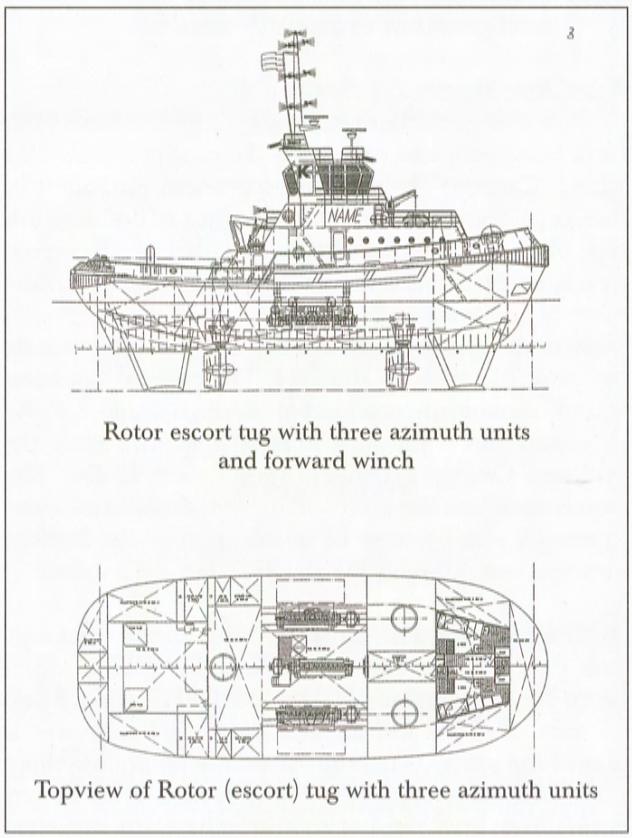


Figure 10.4 ROTOR Escort Tug concept

1999 they operate in the ports of Rotterdam, Hamburg and Bremerhaven and for offshore operations. The advantages of the tugs are:

- Excellent manoeuvrability, which includes amongst others things turning on the spot with a high rate of turn, astern speed equal to ahead speed and a side-stepping speed of approximately six knots.
- Fast positioning and re-positioning and a large variety of assist modes with short response times.
- A high bollard pull or, alternatively, the same bollard pull with less draft, compared to a normal tractor tug with two azimuth thrusters.
- High side thrust up to 95% of bollard pull to assist vessels through narrow passages, locks and bridges.
- Better reliability because two units bring sufficient manoeuvrability and bollard pull for day to day shiphandling work; in case of breakdown of an engine, the tug is still operational and repairs can be postponed until a suitable time.
- There is hardly any risk of damaging the azimuth thrusters on the bulb of an assisted ship as can happen with stern drive tugs, due to the thruster protection.
- Dynamic positioning systems can be installed for offshore operations.
- Escort work is possible over the stern as well as over the bow at relatively high speeds.

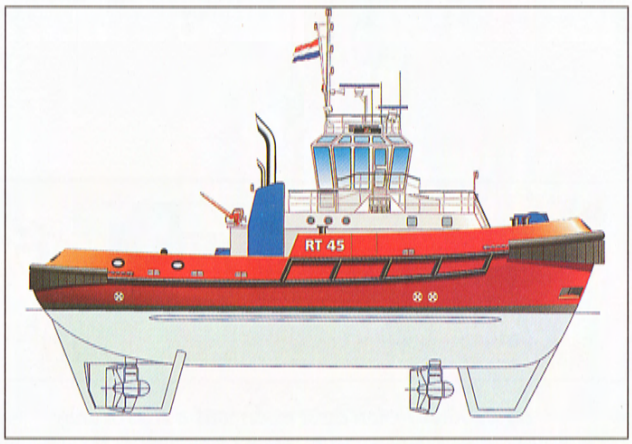
Three different versions of this type of tug were proposed:

a) Three engines and three azimuth units with a total bollard pull of 80 tons.
b) Two engines, two azimuth units and a skeg like a normal tractor tug but designed in such a way that a third engine and azimuth unit can be installed at a later stage.
c) Three engines, three azimuth units and an anchor/towing winch on the foredeck to escort VLCCs. This is the ROTOR Escort Tug (see figure 10.4).

Photo: KOTUG, The Netherlands

Figure 10.5 The Rotor Escort Tug 'RT Magic' (l.o.a. 31·6m, beam 12·0m, draught 5·9m, engine power 6,300 bhp, bp 80 tons) of towing company KOTUG, Rotterdam, The Netherlands

The main characteristics of the Kotug ROTOR (Escort) Tug are: length overall 31·6m; beam 12m; draught 5·9m; propulsion 3 x 2,1000 bhp, bollard pull approximately 80 tons. Based on experience gained, the concept will be modified in such a way that the aft thruster will be located further aft, either right below or behind the aft towing point, depending on tug size. This will enhance the performance of the tug (see figure 10.6).



Drawing: Kooren Shipbuilding and Trading, Rotterdam

Figure 10.6 Modified ROTOR tug concept with aft thruster located more aft, behind the aft towing point

Three variants of this ROTOR tug concept will be brought on the market: a tug with a length overall of 23·2m, 25·8m and 27·8m, respectively 30, 45 and 60 tons bollard pull. A ROTOR escort tug of 42m length, 10,000 hp and 125 tons bollard pull, possibly with a specific performance enhancing device, is in the phase of development.

Several advantages have been mentioned, some additional remarks will be made below. The Rotor Escort Tug can be used for operating at the ship's side, e.g. push-pull, as well as for towing on a line in different ways. At speed, performance of the ROTOR escort tug differs principally from a normal tractor tug due to replacing the skeg by a thruster, particularly at the higher escorting speeds. As a stern tug in indirect mode, no use can be made of the high hydrodynamic forces generated by the skeg.

Additional loss of thruster effectiveness will be experienced due to the interaction of the three thrusters. High braking forces can be achieved in the reverse arrest mode, which is possible at speeds not higher than eight knots due to engine overload, while at higher speeds the transverse arrest mode delivers high braking forces (see fig. 9.5 for terminology).

Tug handling with three thrusters becomes more complicated, which can give problems in tense situations, although basically the tug is handled like a tractor tug, while the third thruster is used in addition to enlarge the capabilities. A proper training in thruster and tug handling and in the various specific assist

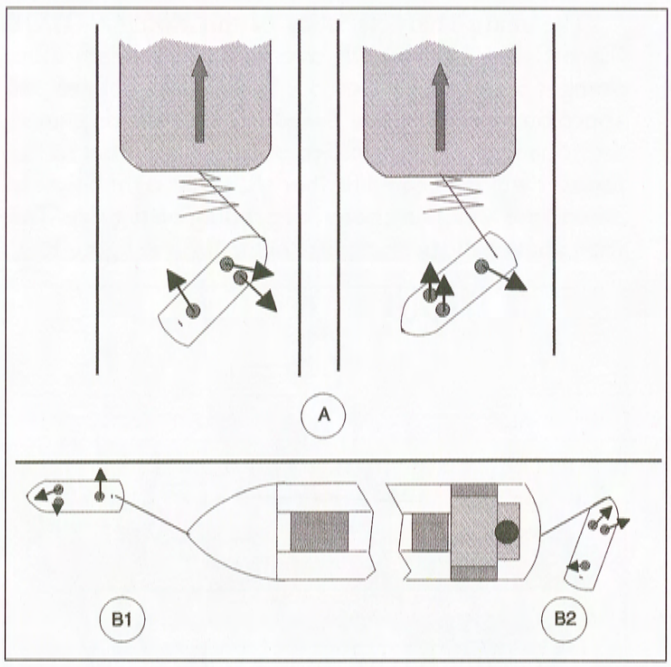


Figure 10.7 Typical assist modes with a ROTOR tug. The tug can operate within a ship's beam (depending on the ship's size). A: Tug assist modes for passing a bridge or entering a lock. B: Tug assist modes while berthing. B1: Tug captain can observe approach speed and distance to berth and can easily anticipate. B2: Tug assist mode during berthing when little berthing space is available (same manoeuvre can be carried out over tug's stern).

manoeuvres that can be performed is important. Some of these specific assist modes are shown in figure 10.7. The ROTOR tugs have a 'master pilot' system, but this is seldom used.

Ship Docking Module (SDM) (1997)

This type of harbour tug has been developed by Hvide Marine (USA), now Seabulk Towing in Tampa (USA). Seabulk Towing has three SDMs Mark I and one SDM Mark II. SDM Mark II is a follow-up of the original SDM design with the same dimensions but some higher bollard pull. The first SDM was the *New River*, delivered in 1997, followed by the *St. Johns* in 1998, the *Escambia* in 1999 and the SDM Mark II *Suwannee River* in 2000. Towing company Marine Towing of Tampa acquired two SDMs Mark II in 1999, named *Tug Florida* and *Endeavor.*

The original idea was to have a tug with maximum bollard pull in all directions, which could get in position quickly, stay in an optimum position without using towlines and which could work in confined areas and in semi-sheltered waters. The SDMs operate in the Port of Tampa and Port Everglades. The tugs have a very wide beam compared to the more or less normal length for a harbour tug and are equipped with two azimuth thrusters and two skegs (see figure 10.9 and 10.10). One azimuth thruster is located at approximately a quarter of the tug's length from forward and at some distance to starboard from the tug's centreline and one thruster is located at approximately a quarter of the tug's length from aft and at some distance to port of the tug's centreline. In the centreline at each end of the tug a skeg is placed. The main characteristics of the SDM Mark 1 are as follows:

- Length over all 27·43m
- Maximum beam 15·24m
- Draught 4·9m
- Engine power 4000 hp
- Bollard pull 50 tons

Engine power of the Mark II SDM has been increased to 4,200 hp (54–55 tons bp), while the central towing staple has been moved to a midships position at equal distance from bow and stern.

The tugs can produce almost full bollard pull in any direction. The tug is highly manoeuvrable. Free sailing speed is approximately 12·5 knots and a sideways speed of 6·5 knots can be achieved. The sides of the tugs are flared in order to provide larger righting moments when heeling and to prevent contact between the tug's underwater part and the ship's hull. The two skegs improve course stability and aid in dry-docking. There is a hole in the skegs to reduce the difference in pressure between both sides of the skegs caused by the accelerated water flow into the forward nozzle and exiting from the aft nozzle. Without these holes the tug captains had to correct the tug's track by steering the aft thruster five to ten degrees to starboard.

The SDMs are pure harbour tugs, which is included in the name, and operate successfully in the ports of which conditions and circumstances will have played a role in the design. The tugs can operate in certain wave conditions as well. Two men can operate the tugs. The deckhouse construction is well within the bulwarks, which enables the tug to operate under the flare and/or overhanging stern of ships.

Due amongst other things to the wide beam, stability of the tugs is large and consequently the tugs can operate

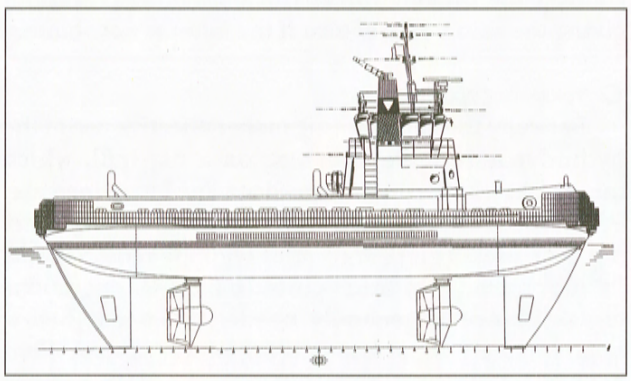
Photo: Hans Haoffman

Figure 10.8 SDM 'New River' of Seabulk Towing (USA) (l.o.a. 27·43m, beam 15·24m, draught 4·9m, engine power 4,000 bhp, bollard pull 50 tons)

safely. Loss of effectiveness will be the case when one or both thrusters are operating close to the ship's hull, which often will be the case, as the tug generally operates close to the ship's hull. With certain tug assist manoeuvres, thruster configurations may affect tug effectiveness when part of the wash of a thruster is hitting the nearest skeg and/or the nearest skeg disturbs the inflow of water towards a thruster.

Assist modes utilised by the SDMs depend on the towing company, circumstances in the port, tug master and pilot. Assist modes used are shown in figure 10.11, such as the mode generally used, and the assist mode for close quarter operations, when room between ships and piers is limited.

High side forces can be applied which makes the tug very suitable to work in narrow areas, although when operating at the ship's side the large beam can be a disadvantage when passing bridges, in locks and dry-docks, where the available width is mostly at a minimum. The tug could then tow on a line, using the centre staple, which enables the tug to apply sideways forces to the ship within a smaller width. The reader is invited to compare the capabilities of the TP I/II, ROTOR tug, SDM and compact tugs.



Drawing: Marine Towing of Tampa/Halter Marine

Figure 10.9 Side view of SDM Mark II

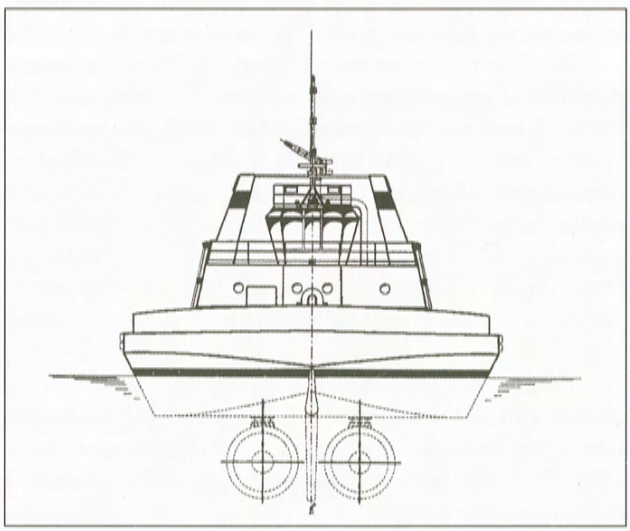


Figure 10.10 Bow view of SDM

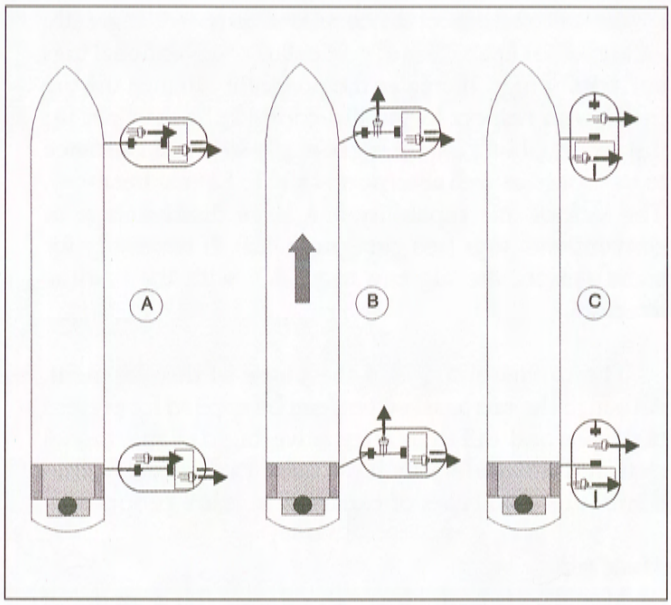


Figure 10.11 Assist modes SDMs.
A: General assist mode (pulling or pushing).
B: Pulling or pushing and moving the ship forward or aft.
C: Assist mode for close quarter situations

10.1.2 Developments based on systematic use of hydrodynamic forces working on a tug hull

Carrousel tug

The basic principle of a carrousel tug is a radial system. New with the system as applied on the carrousel tug is that it is not half a circle, or less, but a full circle and has a diameter equal to the tug's beam.

The radial system itself is not new. It has been applied for decades on several harbour tugs and in former times on tugs on the River Rhine. The system has been discussed in paragraph 7.2 and the advantages of the system are dealt with in paragraph 4.2.3. With a radial system tug's heel due to a transverse towline force is limited. Performance and safety of several conventional tugs has so been increased significantly. The carrousel, as the system is called, is initially situated above the lateral centre of pressure for a crosswise water flow. The advantages of the carrousel are:

- The tug can safely cope with large towline forces generated by the hydrodynamic forces working on the tug hull, while heeling angles are smaller than without such a system. Capsizing due to high athwartships towline forces is not possible.
- It enables the tug to turn freely, in no way restricted by the towline coming in contact with the superstructure.

The first aspect is related to speed. The higher the speed the higher the forces that can safely be generated in the towline and applied to the ship to be assisted. Also, high braking forces can be achieved because the system enables a stern tug to operate safely broadside behind the ship.

The second aspect is not related to speed. It greatly enlarges the capabilities of particularly conventional tugs and combi-tugs. It creates the possibility to turn the tug freely with respect to the direction of the towline, for instance enabling a stern tug to apply steering assistance to starboard as well as to port at a ship having headway. The lack of this capability is a large disadvantage of conventional tugs (see paragraph 4.3). If necessary for some reason, the tug can turn 180° with the towline attached.

The carrousel tug is in the phase of development. Although the carrousel system can be applied for present tug types and different alternative tug designs, model tests and full scale tests have been carried out with a combi-tug. Two types of carrousel tugs are proposed.

Model tests

Model tests have been carried out with a model of the Dutch combi-tug *Multratug 12* (see figure 10.13). Right below the carrousel two vertical skegs were fitted, representing full scale skegs with a length of six metres and a depth of 0·4m. Each skeg was located at a quarter of the tug's width from the side.

High towline forces were achieved, as shown in figure 10.15. The high steering forces are of particular interest. The maximum forces are limited by the fact that with high towline forces either the tug's stern is submerged slowly or the turning moments on the tug could not be overcome by the tug's propulsion. The first (showing the importance of a proper buoyancy, freeboard and hull shape) happened when the tug's bow had a small angle with the incoming water flow, while the latter happened when the tug's heading was more or less perpendicular to the direction of the incoming water flow.

Full scale tests

Full scale tests have been carried out with the tug *Multratug 12* fitted with a carrousel and with skegs as used for the model tests. The tests confirmed the working of the system as well as the forces measured during the model tests. Even higher towline forces could be achieved due to a more stable position of the full scale tug. The photo (figure 10.14) shows the carrousel tug applying steering forces.

Aspects that require attention or further study

As the carrousel tug is still in the phase of development, some aspects require further attention. A number of them will be mentioned below:

- The lead of the towline for all possible ships to be assisted, assist manoeuvres, conditions and circumstances, needs to be considered.
- Safety of deck operations, including the possibility of efficient and safe towline handling under all working conditions and with a minimum of crew, requires attention.
- The possibility to install an appropriate towing winch, strong enough to withstand the high towline forces that can be generated, needs further study. A towing winch is of particular importance when the carrousel tug will also be used for escort operations.
- The carrousel requires a constant tension in the towline, which also requires attention, because for most tug manoeuvres even a small constant tension in the towline often may create an unwanted increase in ship's speed and a turning moment, which should be avoided.

Carrousel tug designs may require additional model studies regarding the optimum location of the carrousel in relation to the locations of centre of pressure at different angles of inflow, focusing on such aspects as the overall behaviour and optimum performance of the carrousel tug when towing, while appropriate reserve buoyancy, freeboard and hull shape, and in particular safety of operations and safe limits should be studied as well. Further aspects to be considered are, amongst others, workable heel angles, safe abort manoeuvres and performance in wave conditions.

While high steering forces can be generated, attention is also needed to determine whether high and controllable braking forces can be delivered without giving the ship a rate of turn if the latter is not wanted.

Carrousel tug applications

Basically the carrousel tug makes effective use of the hydrodynamic forces working on a tug hull, which means that with increasing speed towline forces increase. When speed decreases the effectiveness of the carrousel tug decreases. This is in contrast with the requirements for tug assistance in many ports. In harbour operations tug assistance is generally needed at speeds below approximately six knots. Full tug power is then often needed for steering, braking and controlling a ship's position.

The carrousel tug is not designed for tug operations at the ship's side as applied in many ports around the world. For this operating mode tugs with omni-directional propulsion systems and a towing point at the tug's end are most suitable. However, the carrousel system can improve the capabilities and safety of operations of harbour tugs to a large extent and particularly of the conventional type of harbour tugs and of combi-tugs. As a forward or aft tug, amongst others, high steering forces can safely be handled, while the tug is not restricted by the direction of the towline.

Altogether it means that basically the carrousel tug design can most effectively be applied for situations where tug assistance is required during a transit, such as in channels, fairways and port approaches, more or less as an escort tug.

The free turning capability is an advantage of the system at low as well as at higher speeds. All provided that the system is practical and safely applicable. It is not without reason that two versions of the carrousel tug are proposed, the Inner Port Design A (for operations in port areas) with focus on thrust, and the Outer Port Design B (for port approaches) with focus on thrust and highest possible hydrodynamic lift forces. The location of the carrousel on design A will be above the centre of pressure for highest drag and for design B above centre of pressure for highest lift. Design B is shown in figure 10.16. Main characteristics are given in figure 10.12.

Characteristics	Inner Port Design A	Outer Port Design B
Length over all	33 m	37 m
beam	11 m	10 m
draught	4 m	4.5 m
skegs	short twin skeg	along full length
propulsion	twin CPP (possibly FPP)	single CPP + azimuth bow thruster
steering	high lift rudders	steerable nozzles
engine power	≈4000 kW	≈4000kW
bollard pull	≈85 tons	≈80 tons
dynamic pull at 10 knots	≈150 tons	≈225 tons

Figure 10.12
Characteristics of Design A and Design B of the carrousel tug

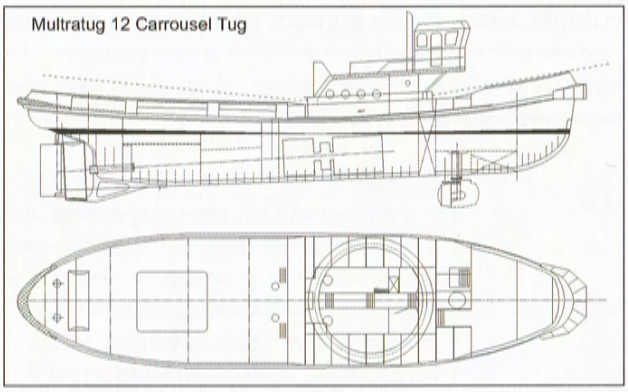


Figure 10.13
Combi-tug 'Multratug 12' (l.o.a. 28·5m, beam 6·6m, bollard pull 21 tons, retractable azimuth bow thruster 450 hp)

Figure 10.14
Modified combi-tug 'Multratug 12' during full scale trials

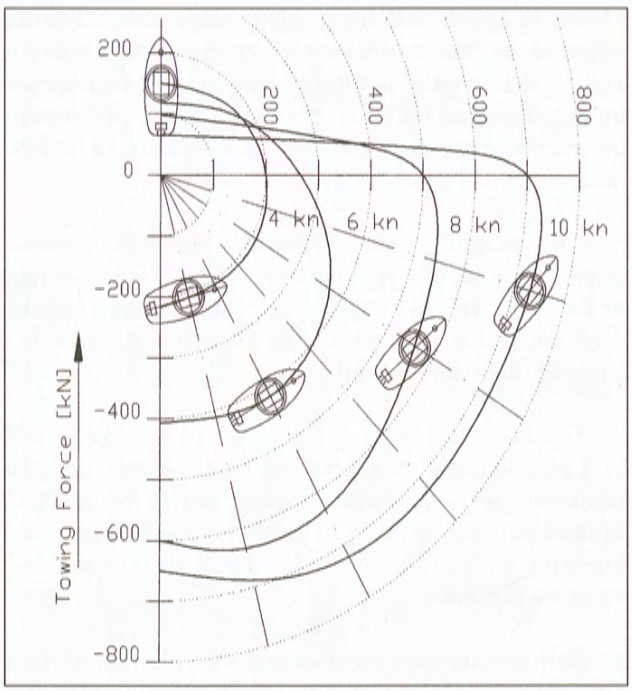


Figure 10.15
Towing forces based on model tests with a model of the 21 tons bollard pull combi-tug of figure 10.13

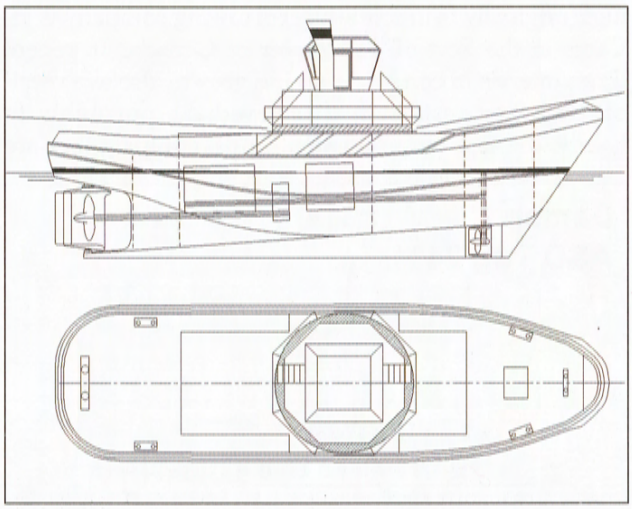


Figure 10.16 Carrousel tug Outer Port Design

As said, the carrousel tug is in the development phase and several aspects have still to be studied. The final design may be a combination of the two designs proposed, viz. a more multi-functional tug.

10.1.3 Developments in tug power in relation to tug size

Compact tugs

The name 'compact tugs' is used for small powerful harbour tugs with a length overall of less than 24 metres. There is, however, not a clear definition of what could

be called a 'compact tug'. Seeing the small powerfull tugs that are built and taking into account the needs for higher bollard pulls, in this paragraph compact tugs will be regarded as harbour tugs with a length overall between approximately 20 and 24 metres and a bollard pull ahead of 40 tons or more.

Such compact tugs are generally of the ASD/reverse-tractor type, mainly reverse-tractor tugs. Compact tugs of the ASD/reverse-tractor tug type will therefore be dealt with, although many may aspects apply to other compact tug types as well.

The tugs have a large beam, up to approximately 11·5 m, compared to a relatively small length. Length/beam ratio varies between approximately 2·6 and 2·0. Bollard pull can be up to 70 tons. The smallest compact tugs may have the largest bollard pull and the smallest length/width ratio.

Compact tugs are more or less a continuation in the development of harbour tugs, from originally large tugs with low powered engines and a low manoeuvrability towards smaller tugs with high-powered engines and a high manoeuvrability. Small powerful tugs have been built for more than twenty years, such as several 'Cates' tugs (originally twin screw tugs) of towing company C.H. Cates in the Port of Vancouver in Canada. In recent times interest in compact tugs has grown, also as a result of the lower costs and, if required the possibility to handle the tugs with two men. Most compact tugs are designed by naval architects Robert Allan and A.G. McIlwain, while Damen Shipyards in The Netherlands has the compact tug design ASD Tug *2411* (see figure 10.17). The tugs operate successfully in several ports and can for instance be found in ports in Canada, USA, Hawaii, Australia and New Zealand.

Compact tugs should be seen as pure harbour tugs, operating in sheltered waters. Some compact tugs do operate in more exposed waters, e.g. Hawaii, but such operating conditions should be accounted for in the design, as is the case when operating in ice conditions as with the ice-reinforced compact tugs in the Port of Montreal. Essential aspects of the compact tugs will be reviewed below.

Lateral resistance

Design of these tugs is such that lateral resistance is as low as possible. This means that basically the tugs have no skegs, or just an open docking skeg. The centre of lateral pressure lies forward of the midships. For the reverse-tractor tug operating modes this results in high pushing, pulling and towing capabilities when taking into account normal harbour speeds, and below, and in short response times.

For a number of reasons compact tugs may have a specific skeg type, for instance to improve a tug's course stability when running astern or ahead, to increase performance at higher speeds as a stern tug in the indirect mode, and, in addition, of an ASD compact tug when towing over the stern.

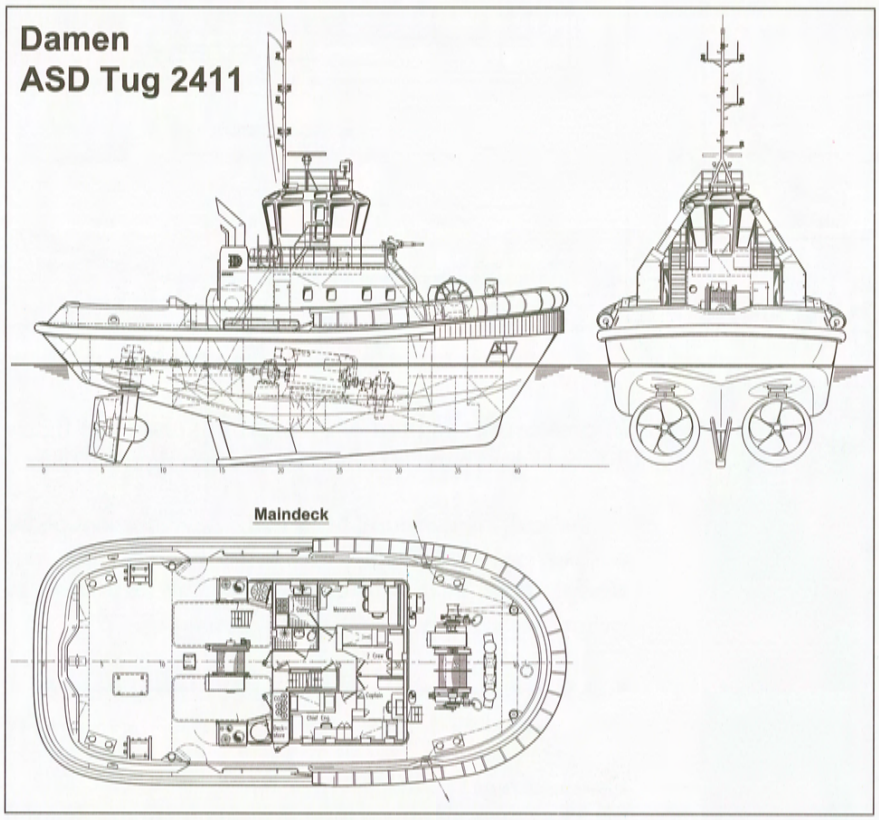


Figure 10.17 Damen ASD Tug '2411' with an open docking skeg, extending as a closed skeg forward (l.o.a. 24·55m, beam 11·49m, draught approxiamtely 4·70m)

Stability

As a result of, amongst others, the wide beam, stability of compact tugs is large, which is a necessity seeing the high trust and consequently the high towline forces that can be generated. A large stability is also required for effectively pushing at a ship having speed. The towing point and pushing point of compact tugs is low compared to many other ASD/reverse-tractor tugs of the same bollard pull, resulting in relatively smaller heeling moments.

Some compact tugs may have an aluminium wheelhouse to bring the centre of gravity further down and the sides of the tugs can be flared (sponsons) in order to provide larger righting moments when heeling.
GM values of the small high powered tugs are around 3.0 m, amongst others, because of the wide beam required to accommodate the large drive units.
The very high thrust, the high rates of turn that can be reached and the high towline forces do also require a good dynamic stability.

Manoeuvrability and training

The compact tugs are extremely manoeuvrable with short response times, also as a result of the relatively low weight of the tugs, and, in particular if thrusters can be turned with high rotational speeds. Compact tugs are, mainly due to the large beam, inherently course unstable. However, course can be simply maintained because the tugs have a lot of steering power. On the other hand, a small steering effort can result in a quick course change, with the tendency for tug operators then to overcompensate in reaction. It means that a proper and thorough training is a necessity for this tug type.

While the power and quick response make them more efficient at manoeuvring and assisting ships, training becomes the more important for this tug types because the high power and responsiveness could equally cause them to get into difficulties faster if an equipment or operator failure occurs. In addition, a malfunction of the control system or an operator leaves little time for the tug master to ascertain the situation and take appropriate action. The training should therefore include knowledge of possible system failures, how to respond to engine and control system failures and how to handle the tug with one operational azimuth unit only. (See also References for report 'Waka Kume')

Deckhouse and hull shape

The deckhouse construction is low and often small and constructed such that the tug can operate under the flare and/or overhanging stern of ships.

There is an aspect to be aware of regarding the design of compact tugs. When turning, many tugs get a lot of water on the aft deck. This can be dangerous if the tug lacks sufficient reserve buoyancy aft or when deck openings are left open. Therefore the shape of the aft section of compact tugs is particularly important; these must be drawn to generate dynamic lift and ideally deflect water downward when turning (see References for article 'Small is beautiful').

Tug operations

As said, the tugs operate very successfully in several ports. Compact tugs meet the requirements for a good harbour tug (see paragraph 2.2 and Chapter 4), particularly for speeds below approximately six knots, although harbour tug requirements may differ by port, as has been discussed in chapter 1. The Dead Slow Ahead speed of ships is generally six to seven knots. At lower speeds, with engine stopped (or propeller pitch at zero), ship's controllability decreases fast and active tug assistance is then required. Due to the small dimensions, low lateral resistance, high bollard pull and stability, these highly manoeuvrable tugs can operate safely and effectively as harbour tugs, with short response times and in restricted harbour areas. At speeds higher than approximately six knots, towing on a line as bow tug becomes more difficult for a reverse-tractor tug and effectiveness decreases fast (bow-to-bow operations). An ASD-tug towing over the stern is then more effective.

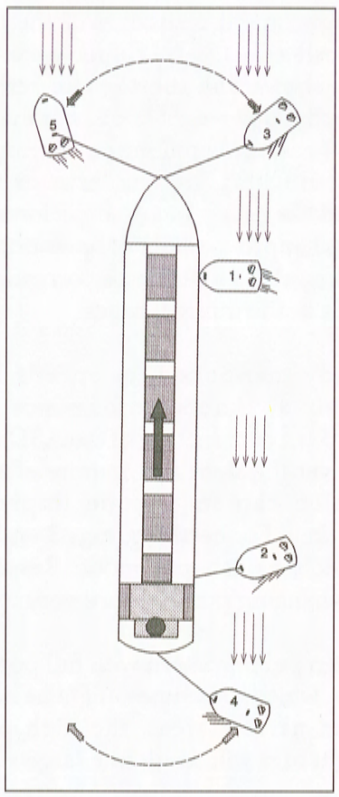


Figure 10.18
Compact tugs.
Common assist modes

In figure 10.18 common assist modes are shown. The ship has a harbour speed up to approximately six knots.

Courtesy: Mackenzie's Tug Service, Port of Esperance, Australia

Figure 10.19 Example of a compact tug – 'Cape Pasley'
(l.o.a. 22·7m, beam 10·7m, draught 4·6m, engine power 5,000 bhp, bollard pull ahead 67 tons, astern 66 tons)