Propulsion Trends in Tankers

Contents:

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Introduction

Tankers, bulk carriers and container vessels are the three largest groups of vessels within the merchant fleet and, therefore, this market segment deserves great attention, Ref. [1] and Ref. [2].

The economic and technical conditions for the tanker market are continuously changing. For example, 30 years ago the size of a crude oil tanker was to be as large as possible, and the limited safety and environmental demands gave room for the simple mono-hull construction, in comparison to the safer and more advanced double-hull construction of today.

In consequence of the globalisation and especially the economic growth in China since the turn of the millennium, the demand for oil has increased and caused increased freight rates because of an increased demand for oil tanker transports.

Moreover, the higher the price of oil products, chemicals and other goods, the greater is the demand for main engine propulsion system designs that offer higher ship speeds and, at the same time, optimised fuel consumption.

The optimum propeller speed is changing as well, becoming lower and lower, because the larger the propeller diameter that can be used for a ship, the lower the propulsion power demand, and the lower the optimum propeller speed.

All of these factors might have an influence on which main engine type is selected/installed as the prime mover, and also on the size of the tanker to be built.

The purpose of this paper – dealing with tanker sizes above 5,000 dwt, and based on an analysis of tankers built/ordered over the last eight years – is to illustrate the latest ship particulars used for modern tankers, and to determine their impact on the propulsion power demand and main engine choice, using the latest MAN B&W two-stroke engine programme as the basis.

Market Development

Definition of a tanker

In dictionaries, a bulk cargo is defined as loose cargo that is loaded directly into a ship's hold. Bulk cargo is thus a shipment such as oil, grain, ores, coal, cement, etc., or one which is not bundled, bottled, or otherwise packed, and which is loaded without counting or marking.

A bulk carrier is therefore a ship in which the cargo is carried in bulk, rather than in barrels, bags, containers, etc., and is usually homogeneous and capable of being loaded by gravity.

On the basis of the above definitions, there are two types of bulk carriers, the dry-bulk carrier and the wet-bulk carrier.

This paper describes the wet-bulk carrier type, normally known as tanker.

Oil was initially transported in barrels (0.1590 m^3) by rail and by general cargo ships. As demand increased, barrels were replaced by tanks. The first fully welded tanker was built in the USA in the mid 1920s. Since then, the tanker fleet has by far taken over the market for transportation of oil products.

The largest tanker ever built is the 565,000 dwt *Seawise Giant* from 1976, measuring L_{OA} = 458.5 m and B = 68.9 m, with a scantling draught of 24.6 m.

Tanker types

Depending on the products carried by the tankers, these may be divided into the following main types:

- Chemical tanker
- Product tanker
- Crude oil tanker
- Gas tanker.

The ship particulars of the gas tankers (LNG and LPG) are quite different from those of other types of tankers, such as for oil and chemical products. Therefore, gas tankers are not dealt with in the paper. Apart from this limited group of tankers, the other tanker types follow the same propulsion rules.

As indicated by its name, the chemical tanker is used to transport various types of liquid chemical products, whereas the product tanker carries products refined from crude oil and other fluids such as wine, juice, etc.

In total numbers, the product tankers and chemical tankers dominate for ship sizes below 55,000 dwt, while in the 60,000-75,000 dwt range, product and crude oil tankers dominate. For larger tankers, crude oil tankers dominate.

Tanker sizes

The deadweight of a ship is the carrying capacity in metric tons (1000 kg) including the weight of bunkers and other supplies necessary for the ship's propulsion.

The size of a tanker will normally be stated as the maximum possible deadweight tonnage, which corresponds to the fully loaded deadweight at full summer saltwater draught (normally a density of 1.025 t/m^3), also called the scantling draught of the ship.

However, sometimes the deadweight tonnage used refers to the design draught, which is normally less than the scantling draught and equals the average loaded ship in service. Therefore, the deadweight tonnage that refers to the design draught – which is used for design of the propulsion system – is normally lower than the scantling draught based deadweight tonnage.

The sizes of the tankers described in this paper are based on the scantling draught and a seawater density of 1.025 t/m^3, and all tankers are of the double hull design, which is required today for safety and environmental reasons for all tankers delivered after 6 July 1996.

In the context of tankers, the word barrel is often used to characterise the size of a vessel; for instance, a VLCC is a two million barrel crude oil tanker, which stems from when crude oil was stored and transported in barrels. In the oil industry, a barrel (0.1590 m^3) has a standard size of 42 US gallons (which is equivalent to 35 of the slightly larger imperial gallons).

Hull design

All tankers built today are of the double hull design, which is required for safety and environmental reasons, i.e. complying with IMO's "Marpol 73/78 Annex I Regulation 13F". This regulation requires all new tankers of 5,000 dwt and above delivered after 6 July 1996 to be fitted with double hulls separated by a space of up to 2 m. Furthermore, in general, all existing single hull chemical and oil tankers over 5,000 dwt in international trade have to be phased-out by the end of 2010 at the latest.

However, for single hull tankers of a special category, the phase-out time may be extended, but no later than to the end of 2015.

Tanker classes

Depending on the deadweight tonnage and hull dimensions, tankers can be split into the following main groups or classes; there will be, though, some overlapping into adjacent groups, see Fig. 1:

- Small tankers (< 10,000 dwt)
- Handysize (10,000 - 30,000 dwt)
- Handymax (30,000 - 55 000 dwt)
- Panamax (60,000 - 75,000 dwt)
- Aframax (80,000 - 120,000 dwt)
- Suezmax (125,000 - 170,000 dwt)
- VLCC (250,000 - 320,000 dwt)
- ULCC (≥ 350,000 dwt)

See also Figs. 2a and 2b regarding the distribution of the tanker classes today.

Small tankers (< 10,000 dwt)
The Small tankers, consisting in particular of chemical and product tankers, are comprehensive in number. Both four-stroke and two-stroke diesel engines are competing for the main engine installation.

Handysize (10,000 - 30,000 dwt)
Chemical and product tankers dominate this class, with a scantling draught below 10 m and a relatively high ship speed. Two-stroke engines now dominate as the main source of propulsion.

Handymax (30,000 - 55,000 dwt)
Chemical tankers and, in particular, product tankers dominate this class of tankers with an overall length of about 180 m. Almost all ships of this type (95%) have a two-stroke diesel engine installed for main propulsion.

Panamax (60,000 - 75,000 dwt)
Crude oil and product tankers dominate this class of tankers, which has a

Tanker type	Dimensions	Ship size (scantling)
Small		**up to 10,000 dwt**
Handysize Scantling draught up to	approx. 10 m	**10,000 - 30,000 dwt**
Handymax Overall ship length	approx. 180 m	**30,000 - 55,000 dwt**
Panamax Ship breadth equal to Overall ship length up to (re port facilities) Overall ship length up to (re canal lock chamber) Passing ship draught up to max.:	**max.:** 32.2/32.3 m (106 ft) 228.6 m (750 ft) 289.6 m (950 ft) 12.04 m (39.5 ft)	**60,000 - 75,000 dwt**
Aframax AFRA – American Freight Rate Association Ship breadth	approx. 41 - 44 m	**80,000 - 120,000 dwt**
Suezmax Ship draught up to Ship breadth up to Draught x breadth up to Overall ship length up to	**max.:** 21.3 m (70 ft) 70 m approx. 820 m^2 (945 m^2) 500 m	**125,000 - 170,000 dwt**
VLCC – Very Large Crude Carrier Overall ship length	above 300 m	**250,000 - 320,000 dwt**
ULCC – Ultra Large Crude Carrier		**more than 350,000 dwt**

Panama Canal	The lock chambers are 305 m long and 33.5 m wide, and the largest depth of the canal is 12.5 -13.7 m. The canal is about 86 km long, and passage takes eight hours. The canal was inaugurated in 1914 and its dimensions were based on Titanic (sunk 1912) to be the largest ship of that time. At present, the canal has two lanes, but a future third lane with an increased lock chamber size (427 m long, 55 m wide and 18.3 m depth) has been decided by the Canal Authority and is intended to open in 2014, at the 100th anniversary of the Canal.
Suez Canal	The canal is about 163 km long and 80 -135 m wide, and has no lock chambers. Most of the canal has only a single traffic lane with several passing bays. A continuing dredging of the canal may in the future open for bigger ships.

Fig. 1: Tanker classes and canals

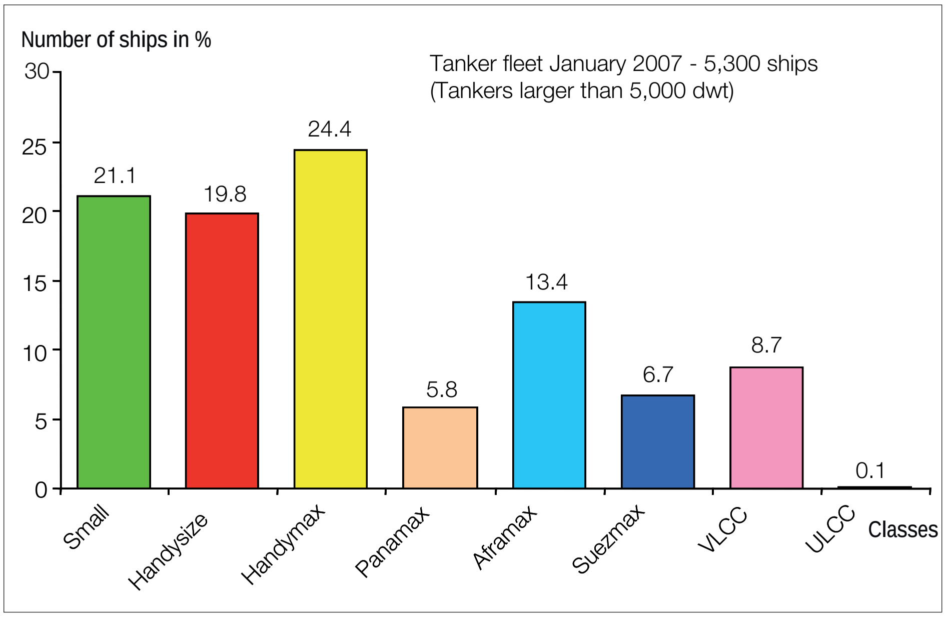

Fig. 2a: Distribution of tanker classes (number of ships)

maximum breadth (beam) of 32.3 m (106 ft), limited by the breadth of the present lock chambers of the Panama Canal.

Even though the maximum overall length limited by the lock chambers is 289.6 m (950 ft), the term Panamax-size is defined as 32.2/32.3 m (106 ft) breadth, 228.6 m (750 ft) overall length, and no more than 12.0 m draught (39.5 ft) for passage through the canal. The reason for the smaller length used with these ship types is that a large part of the world's harbours and corresponding facilities are based on this length.

Aframax (80,000 - 120,000 dwt)

Product tankers and, in particular, crude oil tankers dominate this class. These have a relatively wide breadth of about 41 - 44 m, giving a high cargo capacity, but a relatively low draught, thereby increasing the number of the port possibilities worldwide.

Often, tankers smaller than 80,000 dwt and with a breadth of e.g. only 36 m or 38 m, but wider than the Panamax breadth of 32.3 m, are also called Aframax tankers.

The term Aframax originates from the American Freight Rate Association and indicates the maximum tanker size for African ports.

However, AFRA in the meaning of Average Freight Rate Assessment, i.e. average costs for the freight of oil with tankers calculated by the Worldscale Association in London and based on an ongoing registration of all freight rates at particular points in time, is often, by mistake, referred to the term Aframax.

Suezmax (125,000 - 170,000 dwt)

Most Suezmax tankers are crude oil tankers, but product tankers are also represented in this group.

Due to the limited cross sectional area of the canal, the Suez Canal Authorities may for a given ship breadth (beam) demand that the draught of a loaded ship passing the Canal does not exceed a given maximum draught listed in a Beam and Draught Table.

Based on the present table, ships are, in general, authorised to transit the Suez Canal when the cross sectional area of the ship (breadth x draught) below the waterline is less than about 820 m^2. However, the latest revision says about 945 m^2 after dredging of the canal, but the term Suezmax used for many years is still referring to the ship sizes with a sectional area of less than about 820 m^2.

This means that e.g. a ship with a breadth of 50.0 m is allowed a maximum draught of 16.4 m (18.9 m) when passing through the Canal.

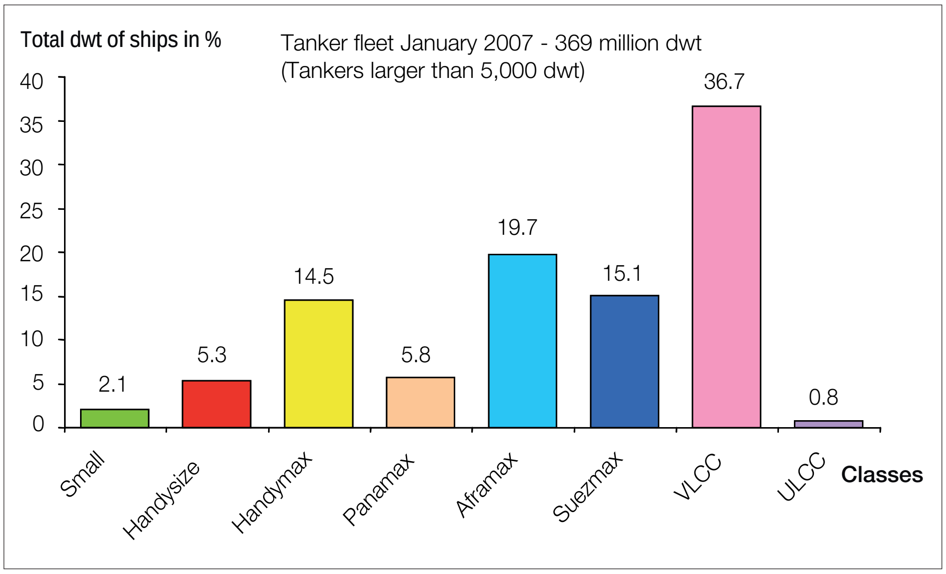

Fig. 2b: Distribution of tanker classes (deadweight tonnage)

A continuing dredging of the canal may in the future open for even bigger ships.

Very Large Crude Carrier – VLCC (250,000 - 320,000 dwt)
As indicated by the name, only crude oil is transported by VLCCs. The size of VLCCs is normally within the deadweight range of 250,000 - 320,000 dwt, and the overall length is above 300 m.

Compared to the Aframax and Suezmax tankers, the VLCC, with its considerable size, can offer relatively lower transportation costs.

However, as the Aframax tanker has a more diverse trade pattern than the Suezmax which, in turn, has a more diverse trade pattern than the VLCC, the freight rates charged for the transport of crude oil will be highest for Aframax, lower for Suezmax, and lowest for VLCC. Therefore, the relationship between the rates obtainable and the number of Aframax, Suezmax and VLCCs is very close.

Ultra Large Crude Carrier – ULCC (> 350,000 dwt)
Tankers exceeding 350,000 dwt are called ULCCs. As mentioned, the largest ever built is the 565,000 dwt tanker *Seawise Giant* from 1976, measuring L_{OA} = 458.5 m and B = 68.9 m, with a scantling draught of 24.6 m. After a reconstruction in 2004, the tanker is still in service, however, today functioning under the name Knock Nevis as an FSO (Floating Storage and Offloading).

All the very large ULCCs were built in the 1970s, whereas today only rather few ULCCs are ordered. Thus, the first ULCCs built after a lapse of a quarter-century are the four 442,500 dwt tankers delivered from Daewoo for Hellespont in 2002.

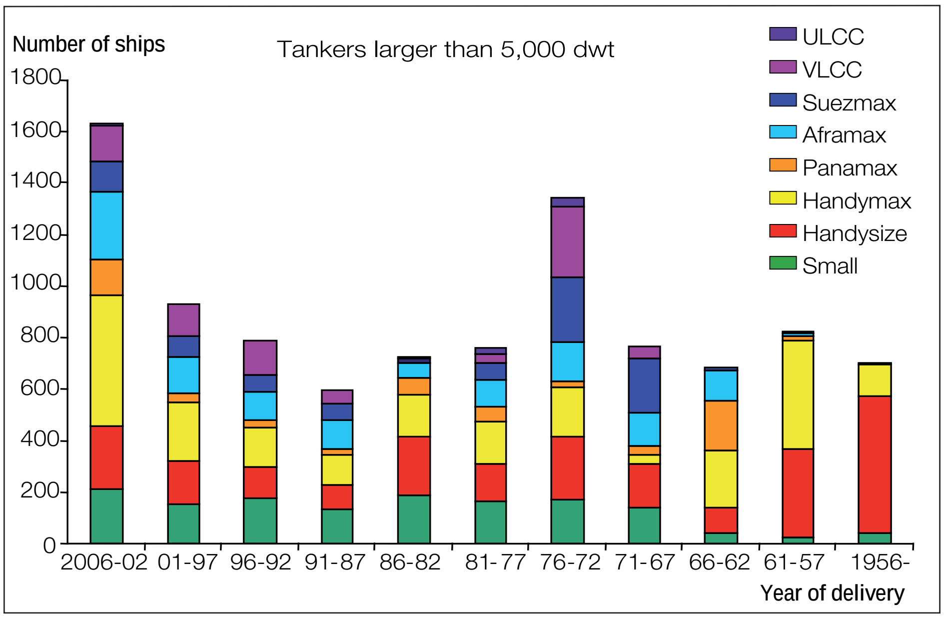

Fig. 3: Year of tanker deliveries

Tanker market

Distribution of tanker classes today
Today (January 2007) the fleet of tankers larger than 5,000 dwt accounts for approx. 5,300 ships.

As can be seen from Fig. 2a, showing the distribution of the tanker fleet in classes, more than 65% of the tanker fleet – in number of ships – is smaller than 55,000 dwt, this number being almost equally split between by the Small, Handysize and Handymax vessels. The Panamax vessels account for 6%, and the large ships, Aframax to ULCCs, account for 29% of the fleet. When comparing the total deadweight, instead of the number of ships, the distribution of tanker classes changes in favour of the large tankers, see Fig. 2b. However, the need for deadweight tonnage of the ULCC seems very low.

Year of tanker deliveries
Fig. 3 shows the number of tankers delivered in different periods since 1920.

As may be seen, the boom in tanker orders in the period of 1972-77 is today followed by an even greater boom in orders.

Age of the tanker fleet
Fig. 4a shows the age structure of the tanker fleet as of January 2007. Fig. 4b also shows in % of originally delivered ships per five years time period, the number of ships still in operation.

About 31% of the tanker fleet larger than 5,000 dwt has been delivered within the last five years, and only 12% is older than 25 years.

When comparing the number of ships delivered with the age of the tanker fleet today, it will be seen that the average lifetime of a tanker is around 25 years. See Fig.4b.

When talking about the need for replacement of the ageing single hull tanker fleet, and the IMO's "International Convention for the Prevention of Pollution from Ships", it will be noted that the tanker fleet is normally replaced when 25-30 years old, and only Handysize tankers and downwards survive the age of 30. Only a few of the small tankers survive to the age of 35.

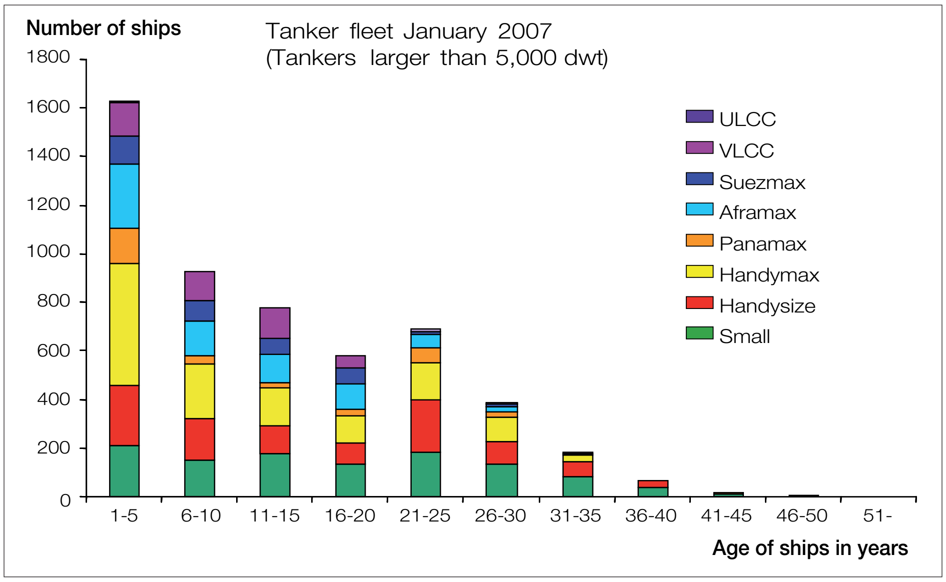

Fig. 4a: Age of the tanker fleet

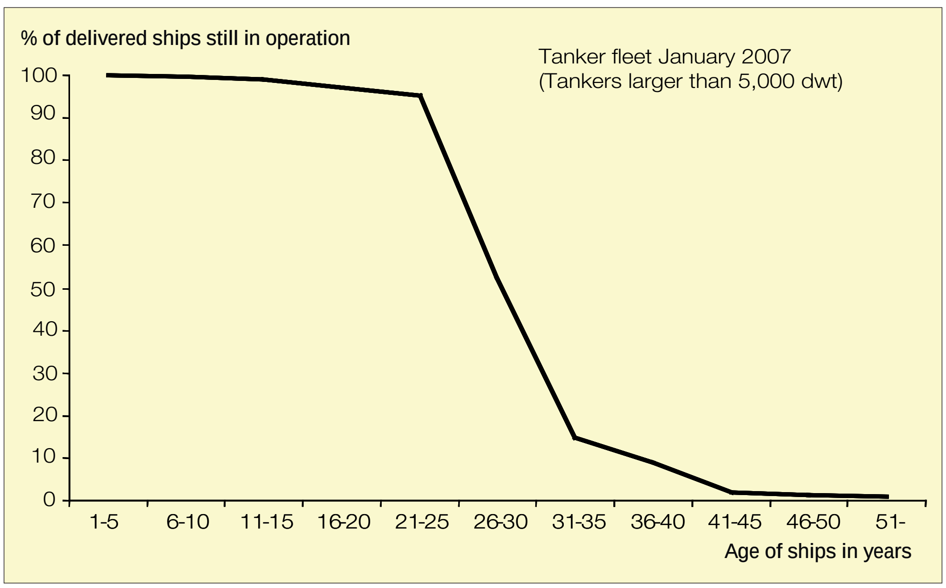

Fig. 4b: Percent of delivered tankers still in operation for a given 5-year period

Demand of tankers

In the coming years, there will be a demand for replacement of around 200 tankers per year just to maintain the current tanker capacity. To this we might add some 40 to 50 tankers in the sizes ranging from Handymax to the VLCC vessels to meet the increasing need for transportation of wet bulk commodities.

At the end of April 2007 the order book accounted for 1850 tankers corresponding to about 35% of the existing fleet in number.

As a main share of the wet bulk transportation segment is the transport of crude oil and oil products, the tanker market will continue to be very sensitive to the level of oil production within the Arab OPEC*) countries.

**) OPEC – The Organisation of the Petroleum Exporting Countries – is a cartel that controls two-thirds of the world oil exports and consists of 12 member countries, i.e. Algeria, Angola, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela.*

Average Ship Particulars as a Function of Ship Size

On the basis of tankers built or contracted in the period 1999-2007, as reported in the Lloyd's Register – Fairplay's "PC Register", we have estimated the average ship particulars. However, as only one size of ULCCs has been built in this period, it has for these tanker types also been necessary to look back to the 1970s.

Average hull design factor F_{des}

Based on the above statistical material, the average design relationship between the ship particulars of the tankers can be expressed by means of the average hull design factor, F_{des}, see below and Fig. 5:

$F_{des} = L_{PP} \times B \times D_{scant}/dwt_{scant}$ (m³/t)

where

L_{PP} : length between perpendicuars (m)

B : ship breadth (m)

D_{scant}: scantling draught (m)

dwt_{scant}: deadweight tonnage at scantling draught (t)

For tanker sizes above 55,000 dwt, the design factor F_{des} shown in Fig. 5 is reasonably exact, whereas the factor is less exact for smaller tankers. Based on the above design factor F_{des}, and with corresponding accuracy, any missing particular can be found as:

$L_{PP} = F_{des} \times dwt_{scant}/(B \times D_{scant})$ m

$B = F_{des} \times dwt_{scant}/(L_{PP} \times D_{scant})$ m

$D_{scant} = F_{des} \times dwt_{scant}/(L_{PP} \times B)$ m

$dwt_{scant} = L_{PP} \times B \times D_{scant}/F_{des}$ t

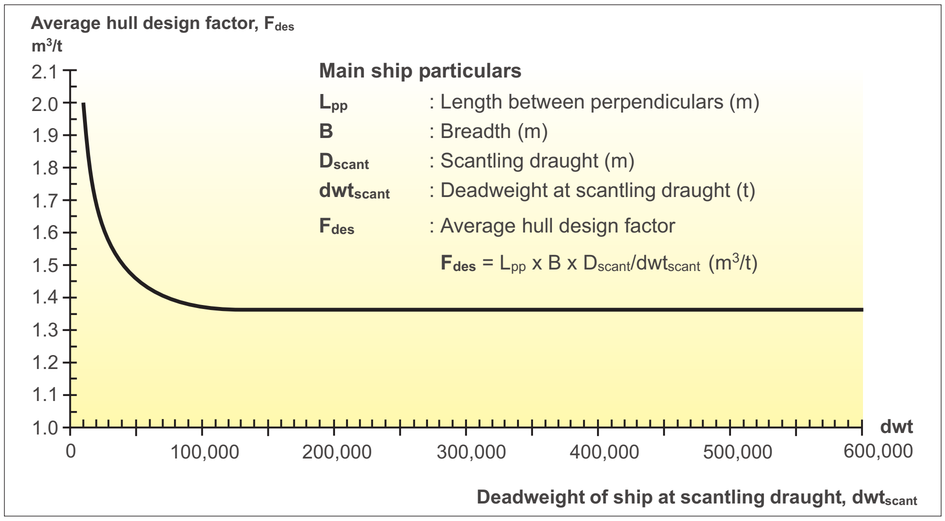

Fig. 5: Average hull design factor of tankers

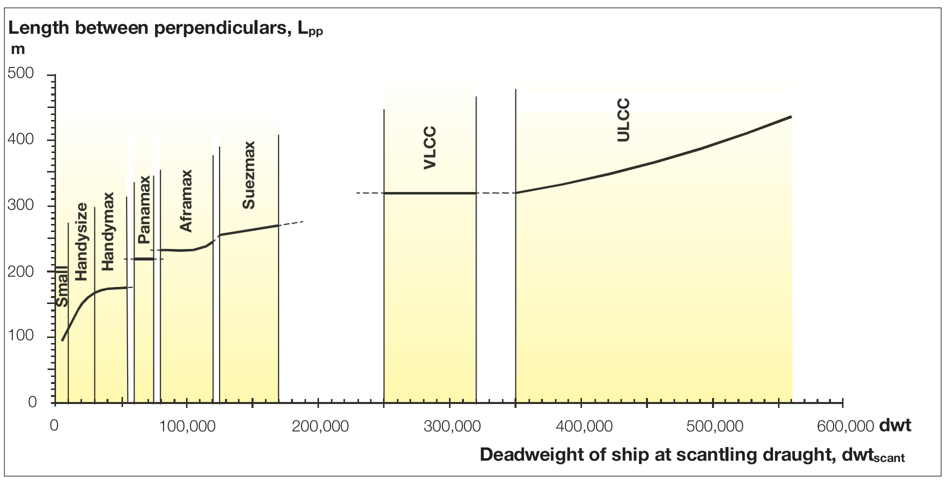

Fig. 6: Average length between perpendiculars of tankers

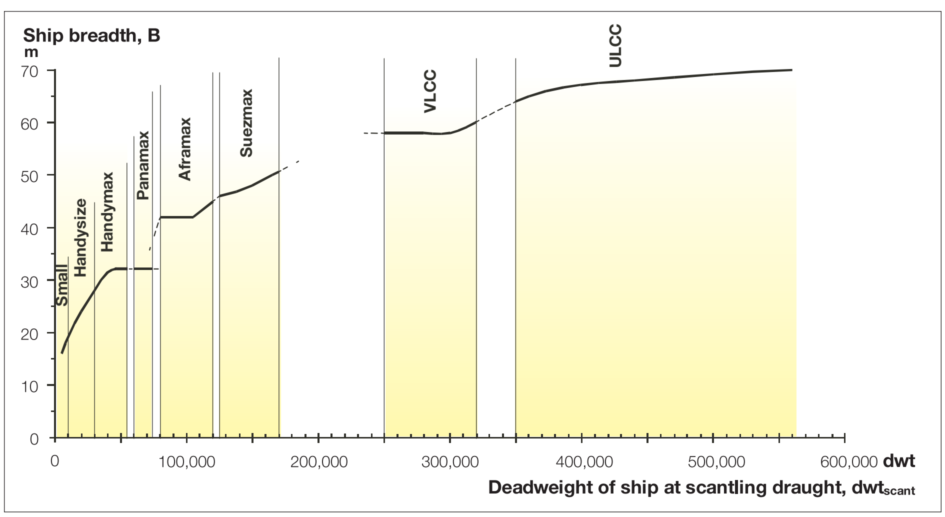

Fig. 7: Average ship breadth (beam) of tankers

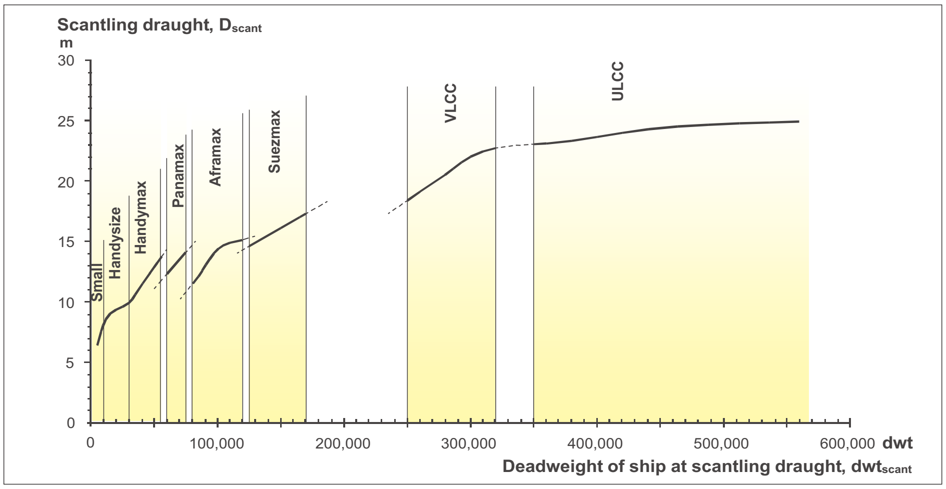

Fig. 8: Average scantling draught of tankers

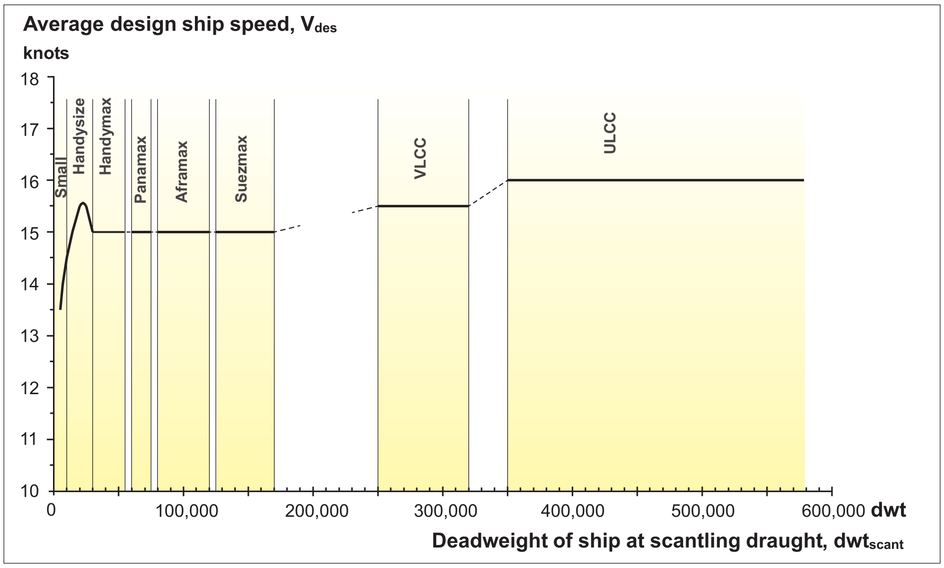

Fig. 9: Average design ship speed of tankers

In Figs. 6, 7 and 8, the first three ship particulars are shown as a function of the ship size (dwt_{scant}). The main groups of tanker classes normally used are also shown. Of course, there might be some exceeding and overlapping of the groups, as shown in dotted lines.

Average design ship speed V_{des}

In Fig. 9, the average ship speed V_{des}, used for design of the propulsion system and valid for the design draught D_{des} of the ship, is shown as a function of the ship size.

Handysize tankers, having a relatively low scantling draught, below 10 m, normally sail with chemicals and oil products of relatively high value. Therefore, these ships are designed for a relatively high ship speed, as shown in Fig. 9.

Fig. 9 also shows that today the average ship speed – except for small tankers – is generally higher than or equal to 15 knots. The trend shown for ULCCs is more doubtful as it is based on only one ship type being built today.

Ship speed V as a function of actual draught D

Depending on the actual deadweight and corresponding displacement, the actual draught D may be lower or higher than the design draught D_{des}.

This might – for the same propulsion power – influence the actual ship speed V, as shown in Fig. 10. This figure explains, among other things, why shipyards for a given ship design/size might specify different ship speeds. Thus, if in one case the specified design draught is low, the design ship speed will be higher than for the same ship type specified with a larger design draught, as for example equal to the scantling draught.

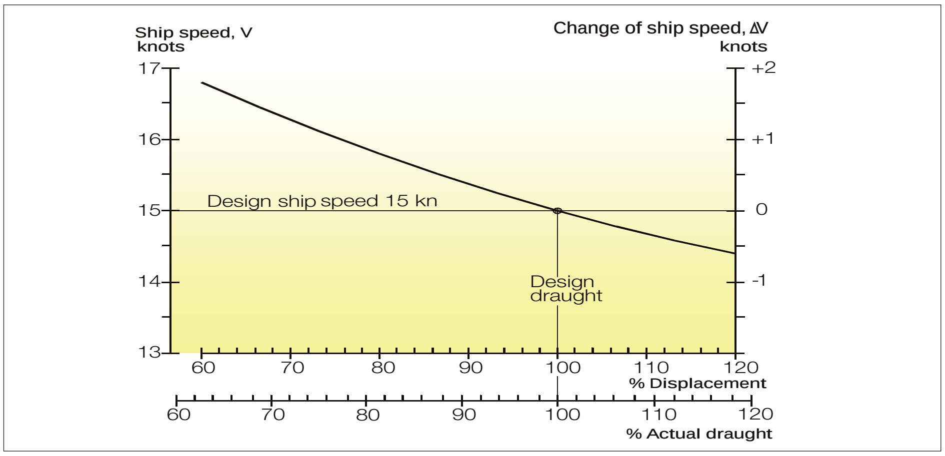

Fig.10: Ship speed at actual draught for the same propulsion power of tankers

Propulsion Power Demand as a Function of Ship Size

Average tankers (without ice class notation)

Based on the already described average ship particulars and ship speeds for tankers built or contracted in the period of 1999-2007, we have made a power prediction calculation (Holtrop & Mennen's Method) for such tankers in various sizes from 5,000 dwt up to 560,000 dwt.

For all cases, we have assumed a sea margin of 15% and an engine margin of 10%, i.e. a service rating of 90% SMCR, including 15% sea margin.

The average ship particulars of these tankers are shown in the tables in Figs. 11-14. On this basis, and valid for the design draught and design ship speed, we have calculated the specified engine MCR power needed for propulsion.

The SMCR power results are also shown in the tables in Figs. 11-14 "Ship Particulars and Propulsion SMCR Power Demand" together with the selected main engine options. These are valid, in all cases, for single-screw double hull tankers. The similar results valid for +/- 0.5 knots compared to the average design ship speed are also shown.

The graph in Fig. 15 shows the above-mentioned table figures of the specified engine MCR (SMCR) power needed for propulsion of an average tanker without ice class notation. The SMCR power curves valid for +/- 0.5 knots compared to the average design ship speed are also shown.

Average tankers with ice class notation

When sailing in ice with a tanker, the ship has to be ice-classed for the given operating need of trading in coastal states with seasonal or year-round ice-covered seas.

Besides the safety of the hull structure under operation in ice, the minimum required propulsion power for breaking the ice has to be met.

Depending on the ice class rules and specific ice classes required for a ship, the minimum ice class required propulsion power demand may be higher or lower than the above-mentioned SMCR power used for an average tanker without ice class notation.

The ice class rules most often used and referred to for navigation in ice are the "Finnish-Swedish Ice Class Rules", which have just been updated. These rules are issued by the Finnish Maritime Administration and apply to all classification societies via IACS (International Association of Classification Societies).

Based on the above-described tankers, the minimum power demand of the ice classed ships, class 1A Super, 1A, 1B and 1C, have been estimated for all the tanker classes up to 170,000 dwt and drawn-in in Fig. 16. In general, the lowest ice classes, 1B and 1C can – powerwise – almost always be met.

However, the strongest classes, 1A Super and 1A, will require a higher propulsion power than the normally needed average SMCR power for tankers without ice class notation.

Model tests have shown that the power found when using the above new ice class formulae is often in excess of the real power needed for propulsion of the ship. Furthermore, it has been concluded that the formulae can only be used within certain limitations of ship particulars and therefore Annex 1, listing the restrictions to the validity of the formulae, has been added to the rules.

Ships outside the limitations stipulated in Annex 1 have to be model tested individually, e.g. Suezmax tankers longer than the max. limitation for ship length stated in Annex 1 ($65.0 \text{ m} < L_{oa} < 250.0 \text{ m}$).

It is to be expected that many owners may choose to use model tests in any case, and independent of the ship length, because the model test may show that a smaller engine can be installed than what can be calculated using the formulae.

		Small		Handysize			
Ship size (scantling)	dwt	**5,000**	**8,000**	**10,000**	**15,000**	**20,000**	**25,000**
Scantling draught	m	6.4	7.5	8.0	9.0	9.3	9.6
Length overall	m	100	116	124	141	155	170
Length between pp	m	94.5	110	117	133	147	161
Breadth	m	16.0	18.0	19.0	21.9	24.0	25.5
Design draught	m	6.0	7.1	7.5	8.4	8.6	8.9
Sea margin	%	15	15	15	15	15	15
Engine margin	%	10	10	10	10	10	10
Average design ship speed	**knots**	**13.5**	**14.0**	**14.5**	**15.0**	**15.5**	**15.5**
SMCR power	**kW**	**2,340**	**3,300**	**4,100**	**5,700**	**7,100**	**7,700**
Main engine options:	1.	6S26MC6	5S35MC7	6S35MC7	5S40ME-B9	5S50MC6	5S50MC-C7/ME-B8
	2.		6L35MC6	6L35MC6	7S35ME-B9	5S50MC-C7/ME-B8	6S50MC6
	3.		5S35ME-B9	5S35ME-B9	6S42MC7	6S46MC-C7	6S46MC-C7
	4.				8S35MC7	7S40ME-B9	7S40ME-B9
Average ship speed – 0.5 kn	knots	13. 0	13.5	14.0	14.5	15.0	15.0
SMCR power	kW	2,000	2,830	3,530	4,900	6,200	6,800
Main engine options:	1.	5S26MC6	5L35MC6	5S35MC7	6S35ME-B9	5S50MC6	5S50MC-C7/ME-B8
	2.			5L35MC6	5S40ME-B9	5S46MC-C7	5S50MC6
	3.			5S35ME-B9	5S42MC7	6S40ME-B9	5S46MC-C8
	4.				7S35MC7	6S42MC7	6S40ME-B9
Average ship speed + 0.5 kn	knots	14.0	14.5	15.0	15.5	16.0	16.0
SMCR power	kW	2,760	3,840	4,750	6,600	8,200	8,800
Main engine options:	1.	5S35MC7	6S35MC7	7S35MC7	6S40ME-B9	6S50MC-C7/ME-B8	6S50MC-C7/ME-B8
	2.	7S26MC6	6L35MC6	8L35MC6	8S35ME-B9	6S50MC6	7S50MC6
	3.		5S35ME-B9	6S35ME-B9	7S42MC7	7S46MC-C7	7S46MC-C7
	4.				9S35MC7	8S40ME-B9	8S40ME-B9

Fig.11: Ship particulars and propulsion SMCR power demand, Small and Handysize tankers

		Handymax				Panamax	
Ship size (scantling)	dwt	**30,000**	**35,000**	**40,000**	**50,000**	**60,000**	**70,000**
Scantling draught	m	9.9	10.6	11.6	12.4	12.3	14.1
Length overall	m	176	176	183	183	228.6	228.6
Length between pp	m	168	168	174	174	219	219
Breadth	m	28.0	30.0	31.5	32.2	32.2	32.2
Design draught	m	9.0	9.6	10.0	11.3	11.0	12.6
Sea margin	%	15	15	15	15	15	15
Engine margin	%	10	10	10	10	10	10
Average design ship speed	**knots**	**15.0**	**15.0**	**15.0**	**15.0**	**15.0**	**15.0**
SMCR power	**kW**	**7,400**	**8,000**	**8,500**	**9,400**	**10,100**	**10,800**
Main engine options:	1.	5S50MC-C7/ME-B8	6S50MC-C7/ME-B8	6S50MC-C7/ME-B8	6S50MC-C7/ME-B8	5S60MC-C7/ME-C7	5S60MC-C7/ME-C7
	2.	6S50MC6	6S50MC6	6S50MC6	7S50MC6	5S60MC6	6S60MC6
	3.	6S46MC-C7	6S46MC-C8	5S50ME-B9	6S50ME-B9	6S60MC-C7/ME-C7	6S60MC-C7/ME-C7
	4.	7S40ME-B9	8S40ME-B9	7S46MC-C7		6S50ME-B9	7S50ME-B9
Average ship speed – 0.5 kn	knots	14.5	14.5	14.5	14.5	14.5	14.5
SMCR power	kW	6,000	7,000	7,500	8,200	9,000	9,600
Main engine options:	1.	5S50MC-C7/ME-B8	5S50MC-C7/ME-B8	5S50MC-C7/ME-B8	5S50MC-C8/ME-B8	5S60MC-C7/ME-C7	5S60MC-C7/ME-C7
	2.	5S50MC6	5S50MC6	6S50MC6	6S50MC6	5S60MC6	5S60MC6
	3.	5S46MC-C7	6S46MC-C7	6S46MC-C7	5S50ME-B9	6S50ME-B9	6S50ME-B9
	4.	6S40ME-B9	7S40ME-B9	7S40ME-B9			
Average ship speed + 0.5 kn	knots	15.5	15.5	15.5	15.5	15.5	15.5
SMCR power	kW	8,500	9,100	9,700	10,600	11,300	12,100
Main engine options:	1.	6S50MC-C7/ME-B8	6S50MC-C7/ME-B8	6S50MC-C8/ME-B8	7S50MC-C7/ME-B8	5S60MC-C7/ME-C7	6S60MC-C7/ME-C7
	2.	6S50MC6	7S50MC6	7S50MC6	6S50ME-B9	6S60MC6	6S60MC6
	3.	7S46MC-C7	7S46MC-C7	6S50ME-B9		6S60MC-C7/ME-C7	7S50ME-B9
	4.	8S40ME-B9	8S40ME-B9			6S50ME-B9	

Fig.12: Ship particulars and propulsion SMCR power demand, Handymax and Panamax tankers

Ship size (scantling)	dwt	Aframax 85,000	Aframax 105,000	Suezmax 115,000	Suezmax 125,000	Suezmax 150,000	Suezmax 165,000
Scantling draught	m	12.1	14.7	15.0	14.6	16.1	17.0
Length overall	m	244	244	250	270	274	274
Length between pp	m	233	233	239	256	264	264
Breadth	m	42.0	42.0	44.0	46.0	48.0	50.0
Design draught	m	11.0	13.4	13.5	13.5	14.8	15.6
Sea margin	%	15	15	15	15	15	15
Engine margin	%	10	10	10	10	10	10
Average design ship speed	**knots**	**15.0**	**15.0**	**15.0**	**15.0**	**15.0**	**15.0**
SMCR power	**kW**	**12,300**	**13,400**	**14,300**	**15,200**	**16,000**	**16,800**
Main engine options:	1.	6S60MC-C7/ME-C7	6S60MC-C7/ME-C7	6S60MC-C8/ME-C8	7S60MC-C7/ME-C7	5S70MC-C8/ME-C8	6S70MC-C7/ME-C7
	2.	6S60MC6	7S60MC6	7S60MC6	5S70MC-C7/ME-C7	6S70MC6	6S70MC6
	3.	5S70MC6	5S70MC6	5S70MC-C7/ME-C7	6S70MC6	8S60MC6	8S60MC-C7/ME-C7
	4.	5S65ME-C8	5S65ME-C8	5S65ME-C8	6S65ME-C8	6S65ME-C8	6S65ME-C8
Average ship speed – 0.5 kn	knots	14.5	14.5	14.5	14.5	14.5	14.5
SMCR power	kW	11,000	12,000	12,800	13,600	14,400	15,100
Main engine options:	1.	5S60MC-C7/ME-C7	6S60MC-C7/ME-C7	6S60MC-C7/ME-C7	6S60MC-C8/ME-C8	7S60MC-C7/ME-C7	7S60MC-C7/ME-C7
	2.	6S60MC6	6S60MC6	7S60MC6	7S60MC6	5S70MC-C7/ME-C7	5S70MC-C7/ME-C7
	3.		5S70MC6	5S70MC6	5S70MC6	6S70MC6	6S70MC6
	4.		5S65ME-C8	5S65ME-C8	5S65ME-C8	6S65ME-C8	6S65ME-C8
Average ship speed + 0.5 kn	knots	15.5	15.5	15.5	15.5	15.5	15.5
SMCR power	kW	13,800	15,000	16,000	16,900	17,900	18,700
Main engine options:	1.	5S70MC-C7	5S70MC-C7/ME-C7	6S70MC6	6S70MC6	6S70MC-C7/ME-C7	6S70MC-C8/ME-C8
	2.	6S60MC-C8/ME-C8	6S70MC6	5S70MC-C8/ME-C8	6S70MC-C7/ME-C7	7S70MC6	7S70MC6
	3.	7S60MC6	7S60MC-C7/ME-C7	7S60MC-C8/ME-C8	8S60MC-C7/ME-C7	8S60MC-C7/ME-C7	7S65ME-C8
	4.	5S65ME-C8	6S65ME-C8	6S65ME-C8	6S65ME-C8	7S65ME-C8	

Fig.13: Ship particulars and propulsion SMCR power demand, Aframax and Suezmax tankers

Ship size (scantling)	dwt	VLCC 260,000	VLCC 280,000	VLCC 300,000	VLCC 319,000	ULCC 360,000	ULCC 440,000	ULCC 560,000
Scantling draught	m	19.1	20.5	22.0	22.7	23.1	24.3	24.7
Length overall	m	333	333	333	333	341	380	460
Length between pp	m	320	320	320	319	327	362	440
Breadth	m	58.0	58.0	58.0	60.0	65.0	68.0	70.0
Design draught	m	17.7	19.0	20.4	21.0	21.4	22.5	22.8
Sea margin	%	15	15	15	15	15	15	15
Engine margin	%	10	10	10	10	10	10	10
Average design ship speed	**knots**	**15.5**	**15.5**	**15.5**	**15.5**	**16.0**	**16.0**	**16.0**
SMCR power	**kW**	**24,100**	**25,000**	**25,900**	**27,100**	**30,600**	**34,200**	**42,200**
Main engine options:	1.	7S80MC-C7/ME-C7	7S80MC-C7/ME-C7	7S80MC-C7/ME-C7	7S80MC-C7/ME-C7	8S80MC-C7/ME-C7	7S90MC-C7/ME-C7	8S90MC-C8/ME-C8
	2.	7S80MC6	7S80MC6	6S90MC-C7/ME-C7	6S90MC-C7/ME-C7	6S90MC-C8/ME-C8	10S80MC6	12S80MC6
	3.	6S80MC-C8/ME-C8	6S80MC-C8/ME-C8	6S80ME-C9	6S80ME-C9	9S80MC6	8S80ME-C9	
	4.	6S80ME-C9	6S80ME-C9			7S80ME-C9		
Average ship speed – 0.5 kn	knots	15.0	15.0	15.0	15.0	15.5	15.5	15.5
SMCR power	kW	21,800	22,600	23,500	24,600	27,800	31,100	36,700
Main engine options:	1.	6S80MC6	6S80MC-C7/ME-C7	6S80MC-C8/ME-C8	6S80MC-C8/ME-C8	6S90MC-C7/ME-C7	8S80MC-C7/ME-C7	7S90MC-C8/ME-C8
	2.	6S80MC-C7/ME-C7	7S80MC-C7/ME-C7	7S80MC6	7S80MC6	7S80MC-C8/ME-C8	6S90MC-C8/ME-C8	11S80MC6
	3.	7S80MC6	7S80MC6	6S80ME-C9	6S80ME-C9	8S80MC6	9S80MC6	9S80ME-C9
	4.					7S80ME-C9	7S80ME-C9	
Average ship speed + 0.5 kn	knots	16.0	16.0	16.0	16.0	16.5	16.5	16.5
SMCR power	kW	26,600	27,600	28,700	30,000	33,500	37,600	44,000
Main engine options:	1.	7S80MC-C7/ME-C7	6S90MC-C7/ME-C7	6S90MC-C7/ME-C7	8S80MC-C7/ME-C7	7S90MC-C7/ME-C7	8S90MC-C7/ME-C7	9S90MC-C7/ME-C7
	2.	6S90MC-C7/ME-C7	7S80MC-C8/ME-C8	7S80MC-C8/ME-C8	6S90MC-C8/ME-C8	10S80MC6	11S80MC6	
	3.	8S80MC6	8S80MC6	8S80MC6	9S80MC6	8S80MC-C8/ME-C8	9S80ME-C9	
	4.	6S80ME-C9	7S80ME-C9	7S80ME-C9	7S80ME-C9	8S80ME-C9		

Fig.14: Ship particulars and propulsion SMCR power demand, VLCCs and ULCCs

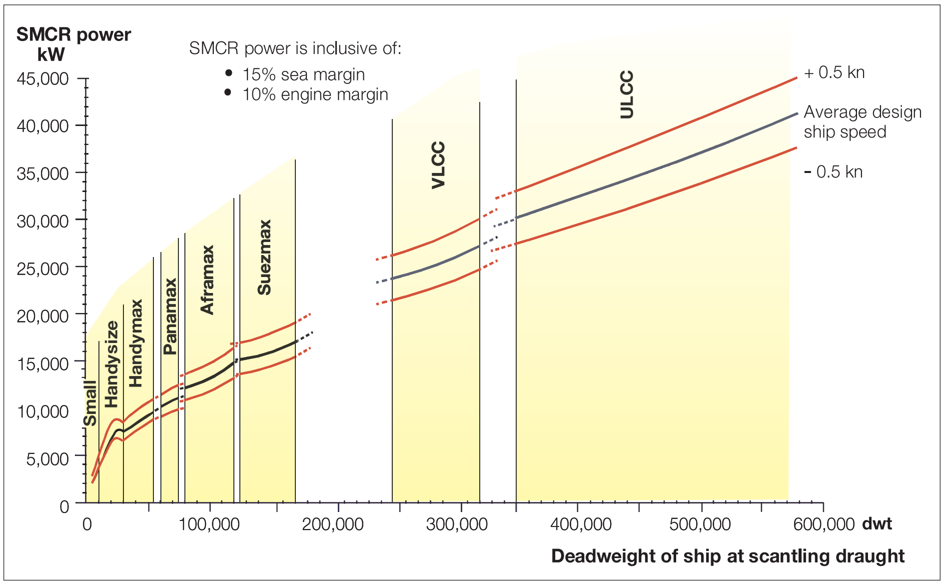

Fig.15: Propulsion SMCR power demand of an average tanker

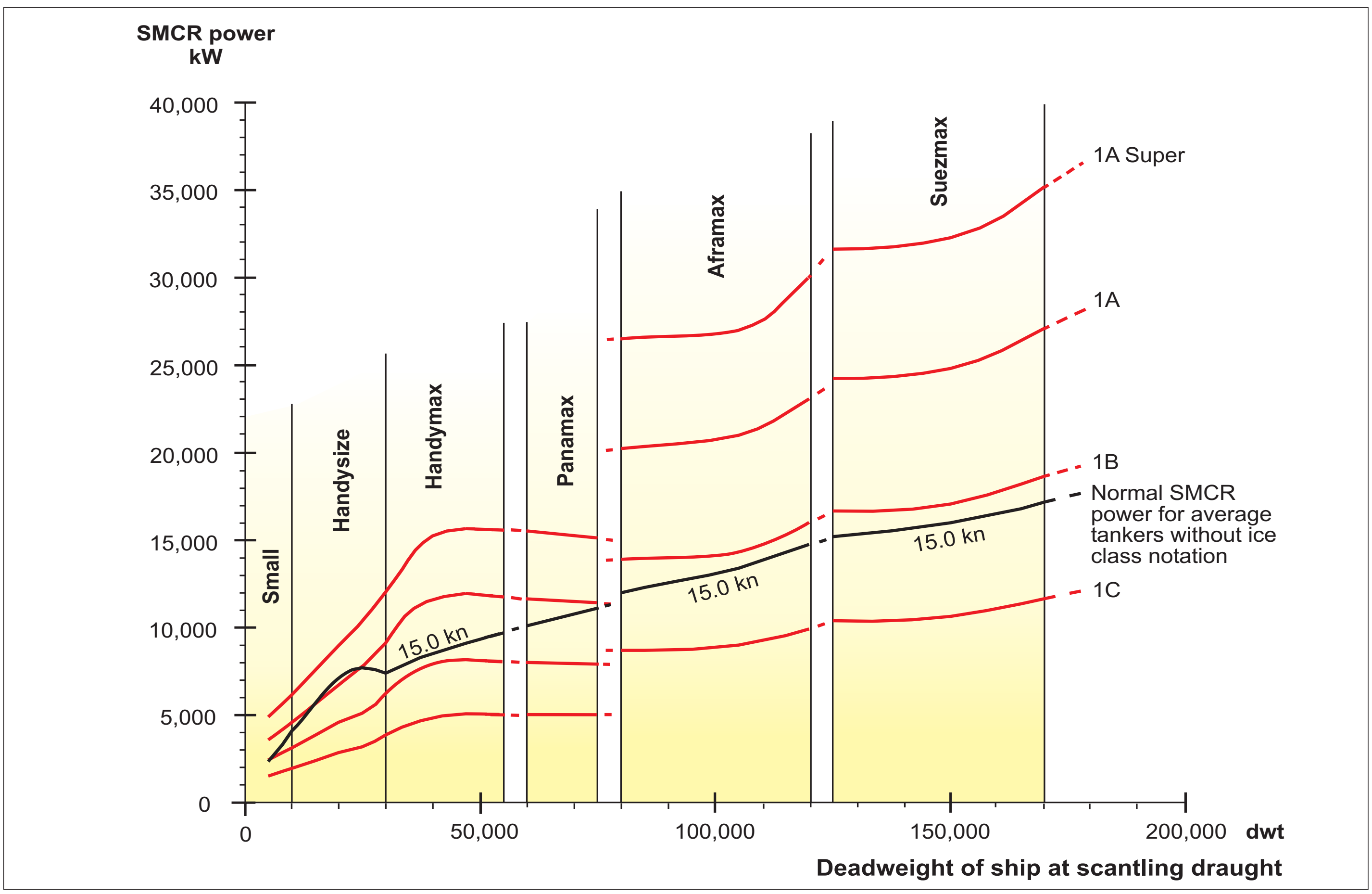

Fig.16: Minimum required propulsion SMCR power demand (CP-propeller) for average-size tankers with Finnish-Swedish ice class notation (for FP-propeller add +11%)

Propulsion Power Demand of Average Tankers as a Function of Ship Speed

When the required ship speed is changed, the required SMCR power will change too, as mentioned above, and other main engine options could be selected.

This trend – with the average ship and average ship speed as the basis – is shown in detail in Figs. 17-20. See also the description below giving the results of the main engine selection for the different classes of tankers.

If to a required ship speed, the needed nominal MCR power for a given main engine is too high, it is possible to derate the engine, i.e. using an SMCR power lower than the nominal MCR power, which involves a lower specific fuel consumption of the engine.

Therefore, in some cases it could be of particular advantage when considering the high fuel price today, to select a higher mark number than needed and derate the engine.

Small and Handysize tankers

For Small and Handysize tankers, see Fig. 17, the selection of main engines is not so distinct as for the larger tanker classes. One owner/shipyard might prefer four-stroke engines, and another, two-stroke engines. One owner/yard might prefer a 6S42MC7 (6,480 kW at 136 r/min), and the other, a 7S35ME-B9 (6,090 kW at 167 r/min).

For the larger tanker classes, the selection of main engine is, as mentioned, more uniform, see below

Handymax tanker

The main engines most often selected for Handymax tankers, see Fig. 18, are the 5 and 6S50MC-C/ME-B, with the 6S50ME-B9 being the optimum choice for meeting the power demand of all Handymax tankers sailing up to 15.5 knots in service.

Panamax tanker

The main engines used for Panamax tankers, see Fig. 18, are mainly the 5 and 6S60MC-C/ME-C, with the 6S60MC-C8/ME-C8, being the optimum choice for meeting the power demand for nearly all Panamax tankers sailing up to 16.0 knots in service.

Aframax tanker

In particular, the 6 and 7S60MC-C/ME-C and 5S65ME-C8 engines are today used for propulsion of the Aframax tankers, see Fig. 19.

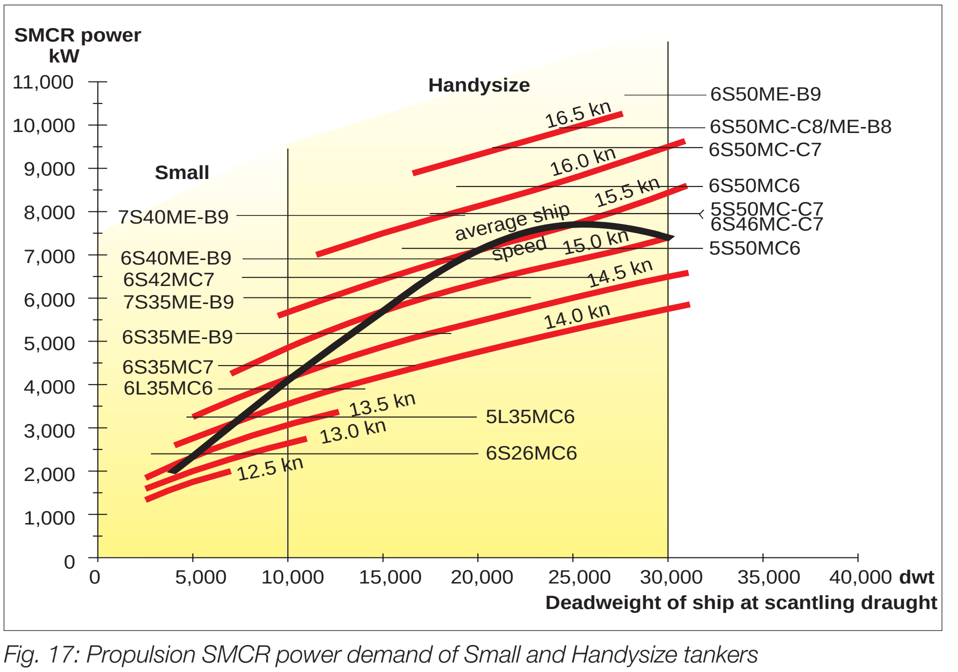

Fig. 17: Propulsion SMCR power demand of Small and Handysize tankers

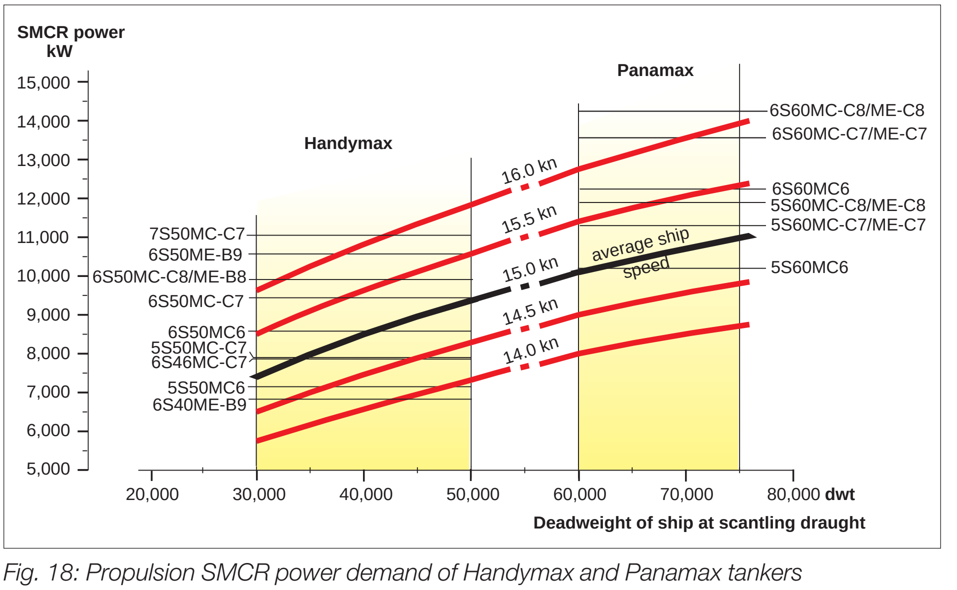

Fig. 18: Propulsion SMCR power demand of Handymax and Panamax tankers

Suezmax tanker

For Suezmax tankers, the 6S70MC-C/ME-C and 6S65ME-C8 types are almost exclusively used as the main engine today, see Fig. 19.

Very Large Crude Carrier – VLCC

For VLCCs, see Fig. 20, the 7S80MC6, in particular, has often been used as the main engine, and today also the 6S90MC-C/ME-C is used, for example, when a ship speed higher than about 15.4 knots is required for a 300,000 dwt VLCC. The 7S80MC-C/ME-C is now also used as a main propulsion engine for VLCCs, the first engine of this design was delivered in 2001.

Ultra Large Crude Carrier – ULCC

For the moment, this is a rather limited market, but both the 7S90MC-C/ME-C and 8S90MC-C/ME-C, and even the 9S90MC-C/ME-C for high service speeds, are potential main engine candidates for this segment, see Fig. 20.

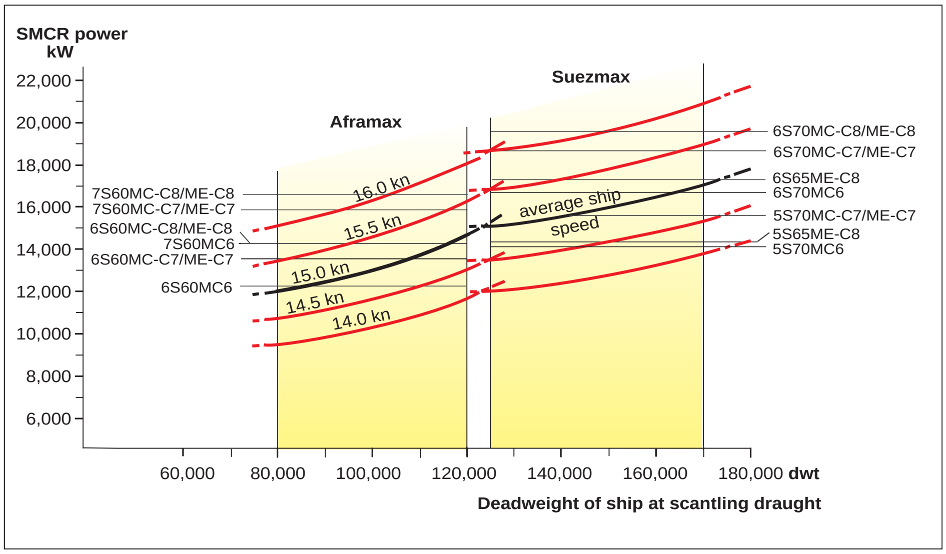

Fig. 19: Propulsion SMCR power demand of Aframax and Suezmax tankers

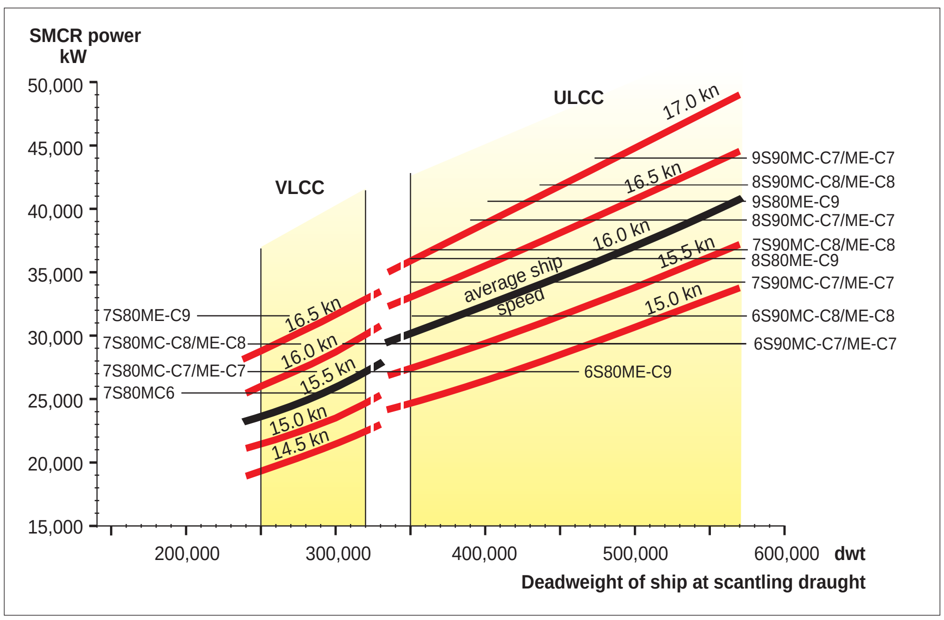

Fig. 20: Propulsion SMCR power demand of VLCCs and ULCCs

Summary

The tanker market is an increasingly important and attractive transport segment, which, due to the ever increasing global market economy, could be expected to become of even greater importance in the future.

Fluctuations in oil production within the OPEC countries and in the world market economy might, of course, in the short term, influence the demand for tanker deadweight tonnage and also the type of tankers being ordered. Low OPEC oil production, for example, will result in low freight rates for VLCCs/ULCCs, with a correspondingly low incitement to order these types of tanker.

However, as in the long run, there will always be a demand for tankers, the profitability of tankers ordered is often based on an expectedly long lifetime of more than 25 years.

The demands on the reliability, efficiency, and low maintenance costs of the main engines are growing, and only the best two-stroke diesel engines can meet these demands.

As described, MAN Diesel is able to meet the engine power needs of any size or type of vessel in the modern tanker fleet.

References

[1] Propulsion Trends in Container Vessels, MAN Diesel A/S, Copenhagen, Denmark, December 2004.

[2] Propulsion Trends in Bulk Carriers, MAN Diesel A/S, Copenhagen, Denmark, August 2007.