Propulsion Trends in Bulk Carriers

Contents:

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Introduction

Bulk carriers, container vessels and tankers are the three largest groups of vessels within the merchant fleet and, with our papers on container vessels and tankers already published, this is the third in the series, Ref. [1] and Ref. [2].

The demand for raw materials like coal, steel, copper, etc., has increased considerably since the turn of the millennium, especially in consequence of globalisation and the great demand for raw materials in China, owing to the economic growth in this large country. This means that the Chinese industry, among others, is absorbing large quantities of iron ore and other bulk cargoes.

This consequential higher demand for bulk transports, compared to the bulk supply, has caused a dramatic increase in freight rates.

The bulk carrier market, therefore, is very attractive, which has caused a boost in newbuildings.

The optimum propeller speed is changing as well, steadily becoming lower, because the larger the propeller diameter that can be used for a ship, the actual propeller speed and pertaining power requirement will be correspondingly lower, and the lower the propulsion power demand per ton bulk transported.

These factors have an influence on which main engine type should be selected/installed as the prime mover, and also on the size of the bulk carrier to be built.

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

Market Development

Definition of a bulk carrier

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, the latter better known as tanker.

This paper describes the dry-bulk carrier type, normally just known as bulk carrier or bulker.

Bulk carriers were developed in the 1950s to carry large quantities of non-packed commodities such as grain, coal, etc., in order to reduce transportation costs.

As mentioned, bulk carriers are one of the three dominating merchant ship types together with tankers and container vessels. Today, bulk carriers comprise about one third of the world fleet in tonnage terms.

The world's, so far, largest bulk carrier is the *M/V Berge Stahl* with 365,000 dwt, built in 1986. This huge iron ore bulk carrier measures 343 m in overall length and has a breadth of 63.5 m, and scantling draught of 23.0 m. This ship is propelled by an 18,300 kW MAN B&W two-stroke main engine, type 7L90MCE, and has a service ship speed of 13.5 knots.

Hull design of a bulk carrier

The double hull design has for several years, for safety and environmental reasons, been required for new tankers of 5,000 dwt and above. However, for bulk carriers the standard design, since the 1960s, has been a single hull ship with a double bottom, i.e. a hull with single side shells. Therefore, when talking about single or double hull, the words 'side', 'skin' or 'side shell' are often used instead of hull.

Studies have shown that the main cause of recorded bulk carrier losses is side shell damage, Ref. [3]. In principle, the application of double hull (skin) on bulk carriers, therefore, will increase the safety and reduce the number of bulk carrier losses. Today, only about 2% (2004) of the existing bulk carriers are born double sided.

Besides the increased safety and the ability to better withstand collisions, the use of double skinned bulk carriers will give a more efficient cargo handling caused by the absence of hull frames and brackets protruding into the cargo holds, replaced by the smooth side of the inner hull.

For safety reasons, IMO (International Maritime Organisation) and IACS (International Association of Classification Societies) are bringing in new regulations for implementation of water ingress alarms in cargo holds and forward spaces. They are also discussing the necessity of introducing regulations requiring double side shells for bulk carrier newbuildings longer than 150 m.

Today, there may be operational or commercial reasons for some owners to choose a double skin design, but there is no present legislation requiring a mandatory double hull bulk carrier design. At the 78th session held in May

2004 in the "Marine Safety Committee" of IMO, the double hull proposal was actually rejected by the majority of the members.

However, a number of shipyards and designers are already now offering double hull bulk carriers in order to meet the possible future demand, but also in order to obtain a more efficient cargo handling as required by some shipowners, especially when transporting e.g. the sticky coal or coke. Furthermore, it seems that the light weight of the double hull ship will be only slightly increased, if at all, because of the use of thinner steel plates. Of course, more welding needed for the double sides will increase the man-hours and, thereby, the price of the ship. Only a minor increase in propulsion power may be expected.

Bulk carrier sizes and classes

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 bulk carrier will normally be stated as the maximum possible dead-weight 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 bulk carriers described in this paper are based on the scantling draught and a seawater density of 1.025 t/m^3 and mainly on the single hull design normally used – as only 2% are of the double hull design.

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

- Small   < 10,000 dwt
- Handysize   10,000 – 35,000 dwt
- Handymax   35,000 – 55,000 dwt
- Panamax   60,000 – 80,000 dwt
- Capesize   80,000 – 200,000 dwt
- VLBC   > 200,000 dwt
  (VLBC = Very Large Bulk Carrier)

In numbers, both the Handysize, Handymax and Panamax bulk carriers built today are dominating.

Even Ultra Large Handymax bulk carriers, which have a deadweight tonnage of about 60,000 dwt, an overall length of max. 190 m (Japanese harbours) and a breadth of 32.2 m (Panama Canal), are now at the project stage.

Even though the maximum overall length limited by the lock chambers is 289.6 m

Bulk carrier type	Dimensions	Ship size (scantling)
Small Overall ship length up to	approx 115 m	**Up to 10,000 dwt**
Handysize Scantling draught up to	approx 10 m	**10,000 – 35,000 dwt**
Handymax Overall ship length (re port facilities in Japan)	max 190 m	**35,000 – 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:** 32.2 / 32.3 m (106 ft) 225 m 289.6 m (950 ft) 12.04 m (39.5 ft)	**60,000 – 80,000 dwt**
Capesize Breadth	approx 43 - 45 m for 90,000 - 180,000 dwt	**80,000 – 200,000 dwt**
VLBC – Very Large Bulk Carrier Overall ship length	above 300 m	**More than 200,000 dwt**

Examples on special Bulk carrier **sub-classes**

- Kamsarmax: ~82,000 dwt Panamax with increased L_{OA} = 229 m
                (for Port Kamsar in Equatorial Guinea)

- Dunkirkmax: ~175,000 dwt large Capesize with max L_{OA} = 289 m and max B = 45 m
                (for the French port's eastern harbour lock at Dunkirk)

- Newcastlemax: ~185,000 dwt large Capesize with max beam B = 47 m
                (for use of the Australian port of Newcastle)

- Setouchmax: ~205,000 dwt large Capesize (VLBC) with a low design draught of 16.10 m
                and max L_{OA} = 299.9 m (for ports in Setouch Sea in Japan)

Fig. 1: Bulk carrier classes

(950 ft), the term Panamax-size is defined as 32.2/32.3 m (106 ft) breadth, 225 m overall length, and no more than 12.0 m draught (39.5 ft) for passage through the canal. The reason for the smaller ship size (length) used with these ship types is that a large part of the world's harbours and corresponding facilities are based on the length of 225 m.

Panamax bulk carriers continue to grow in cargo capacity as the pressure of worldwide competition forces shipyards to offer a little bit extra. Thus, a special so-called Kamsarmax Panamax type with an increased overall length of 229 m and 82,000 dwt has been built, and is the largest size able to load at the world's largest bauxite port, Port Kamsar in Equatorial Guinea.

The range of the Capesize bulk carriers, i.e. vessels with a deadweight tonnage higher than 80,000 dwt, has been in-creased, as the largest bulk carriers are becoming bigger and bigger. Often, the largest ones are called "Ultra Large Capesize" or just "Very Large Bulk Carrier" (VLBC). In this discussion, we have decided, in general, to use the latter name of VLBC for Capesize bulk carriers bigger than 200,000 dwt.

Besides the described main classes for bulk classes, special sub-classes are often used in order to describe the speciality of the ship in question, as for example the above-mentioned Kamsarmax bulk carrier.

Other examples of sub-classes are Dunkirkmax, Newcastlemax and Setouchmax, as stated in Fig. 1.

Bulk carrier market

Dry bulk like coal, iron and grain was initially transported in bags and barrels, etc., but owing to the development of the bulk carrier in the 1950s, it is today transported as non-packed commodities.

Distribution of bulk carrier classes today
The bulk carrier fleet has by far taken over the market for transportation of dry bulk products, and today the fleet of bulk carriers larger than 5,000 dwt accounts for more than 6,000 ships.

As can be seen from Fig. 2a, showing the distribution of the bulk carrier fleet (larger than 5,000 dwt) in classes, more than 70% of the bulk carrier fleet – in number of ships – is smaller than 55,000 dwt, with the dominating 32% being Handysize vessels. The Panamax vessels account for 17%, and the large ships, Capesize to VLBC, account for 10% of the fleet. When comparing the total deadweight, instead of the number of ships, the distribution of bulk carrier classes changes in favour of the larger bulk carriers as Panamax and Capesize, see Fig. 2b.
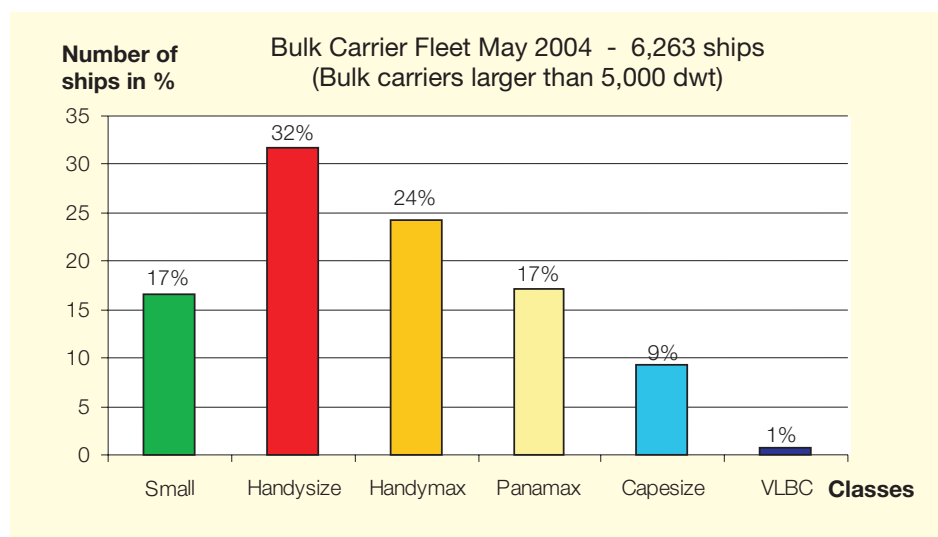

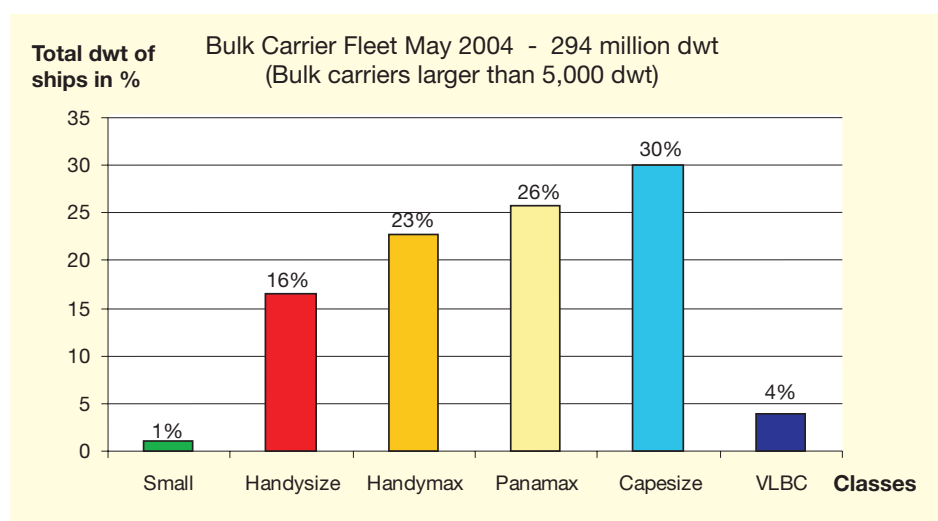Fig. 2a: Distribution of bulk carrier classes (number of ships)

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

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Age of the bulk carrier fleet

Fig. 3 shows the age structure of the bulk carrier fleet as of May 2004. Fig. 3 also shows in percent of originally delivered ships, the number of ships still in operation. More than 18% of the bulk carrier fleet larger than 5,000 dwt has been delivered within the last four years, and only 20% is more than 25 years old. Only 8% is older than 30 years.

Year of bulk carrier deliveries

Fig. 4 shows the number of bulk carriers delivered in different periods since the 1950s. When comparing the number of ships delivered with the age of the bulk carrier fleet today, see Fig. 3, it will be seen that the lifetime of a bulk carrier is around 25-30 years. More than 40% of the bulk carriers delivered in the years 1975-1979 have left the fleet, and more than 75% built in the years of 1970-74 have also left the fleet.
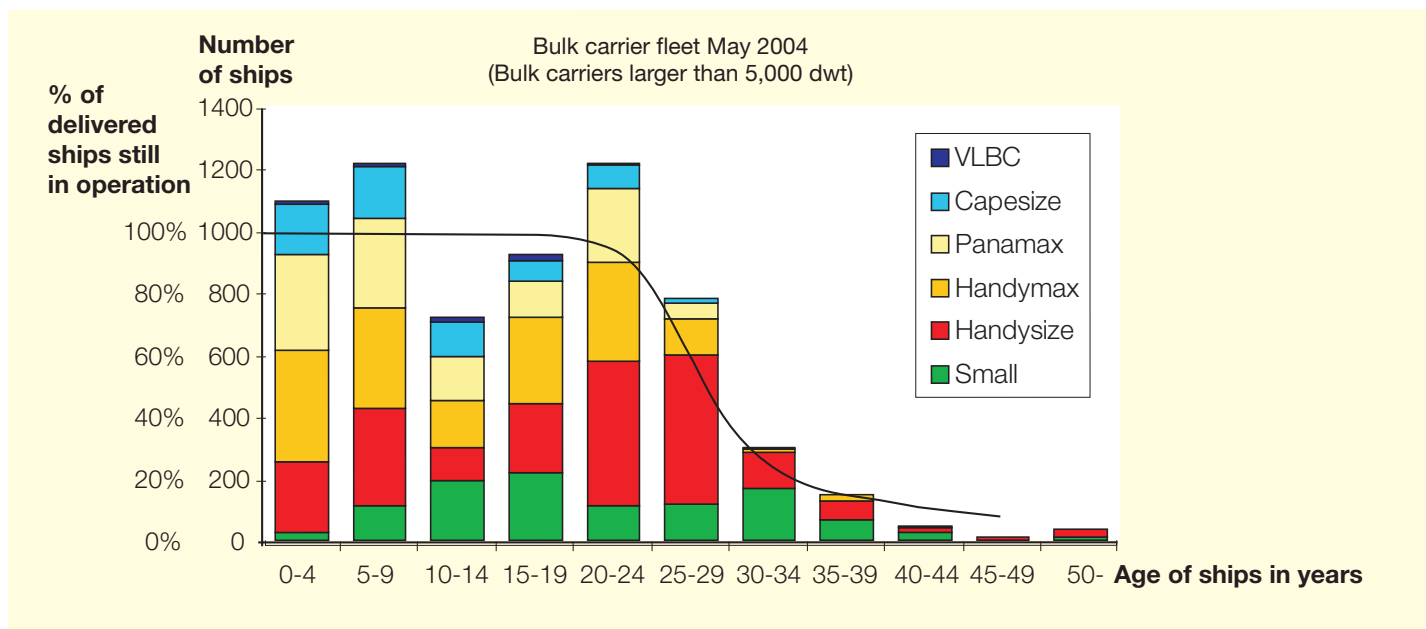

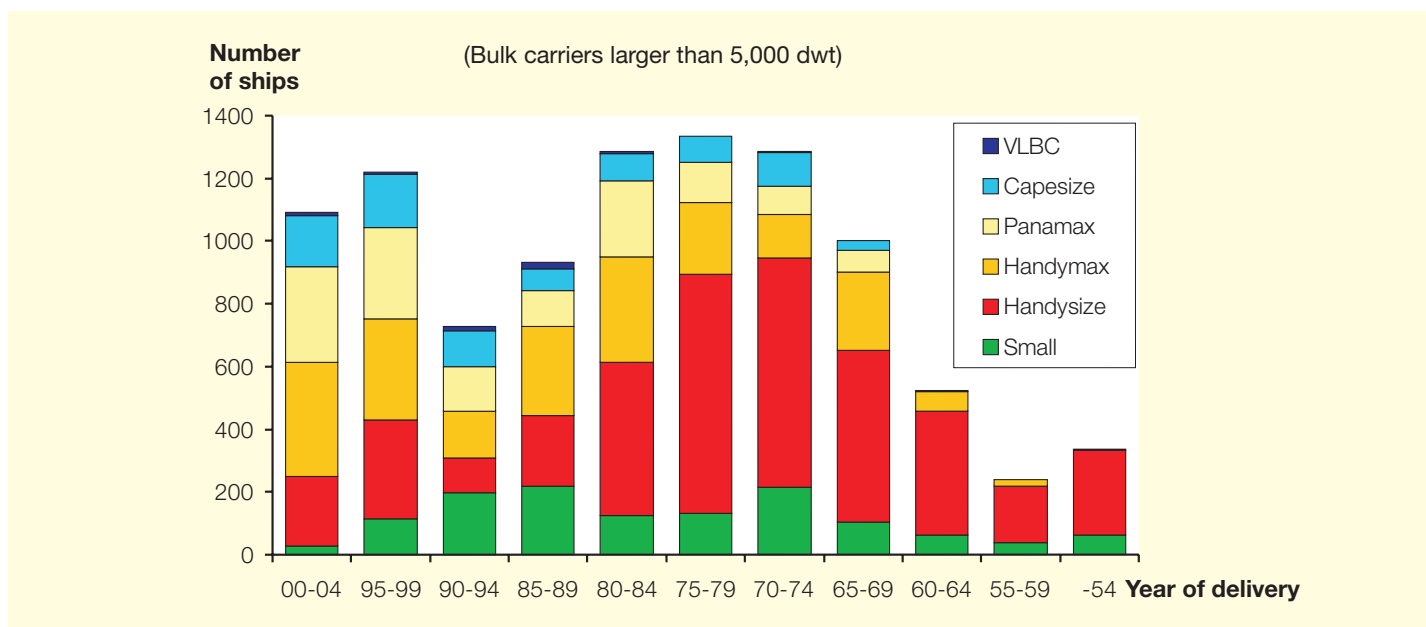Fig. 3: Age of the bulk carrier fleet and per cent of delivered ships still in operation (curve)

Fig. 4: Year of the bulk carrier deliveries

Average Ship Particulars as a Function of Ship Size

On the basis of bulk carriers built or contracted in the period 1996-2003, as reported in the Lloyd's Register - Fairplay's "PC Register", we have estimated the average ship particulars.

Average hull design factor, F_{des}

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

$$F_{des} = L_{PP} \times B \times D_{scant}/dwt_{scant} \quad (m^3/t)$$

where

L_{PP}	: length between perpendiculars	(m)
B	: ship breadth	(m)
D_{scant}	: scantling draught	(m)
dwt_{scant}	: deadweight tonnage at scantling draught	(t)

For bulk carrier 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 bulk carriers. Based on the above design factor F_{des}, and with corresponding accuracy, any missing particular can be found as:

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

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

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

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

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 bulk carrier classes normally used are also shown. Of course, there may be some exceeding and overlapping of the groups, as shown by dotted lines.

The three figures show an alternative ship design for a 35,000 dwt Handymax bulk carrier with a relatively narrow ship breadth B, but with a longer ship length L_{PP} and higher draught D. This narrower ship design (B = max. 23.7 m) is used in the narrow Canadian St. Lawrence Canal to the Great Lakes.

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.
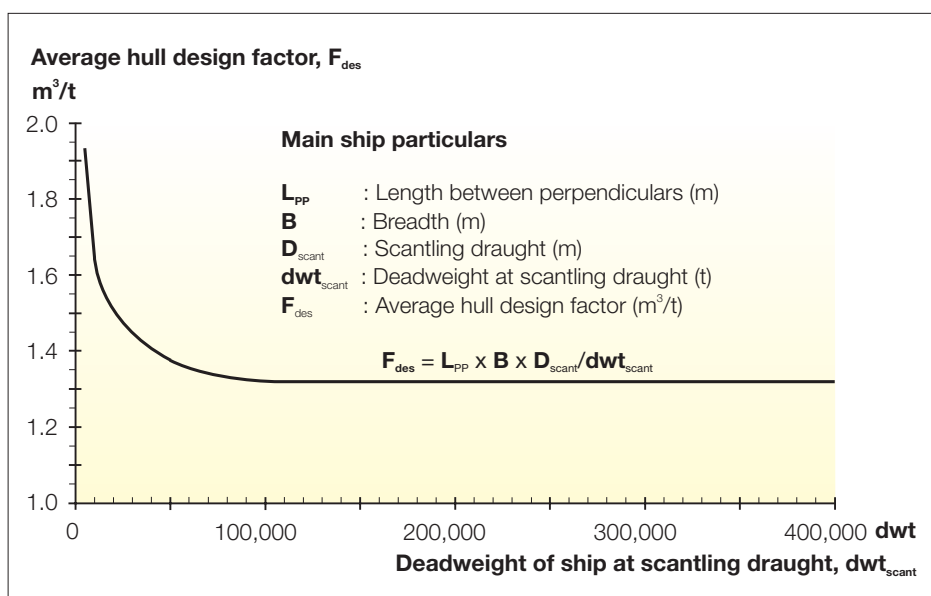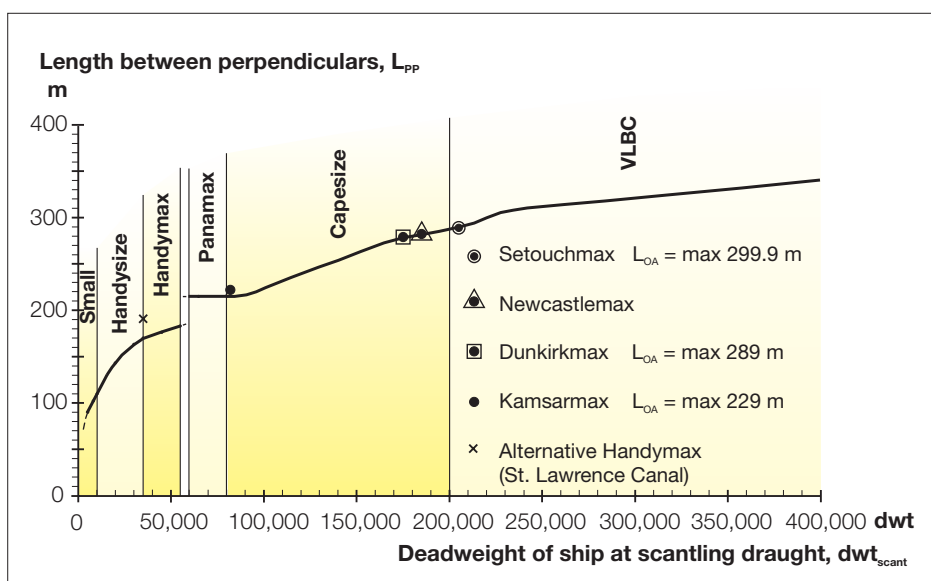

Fig. 5: Average hull design factor of bulk carriers

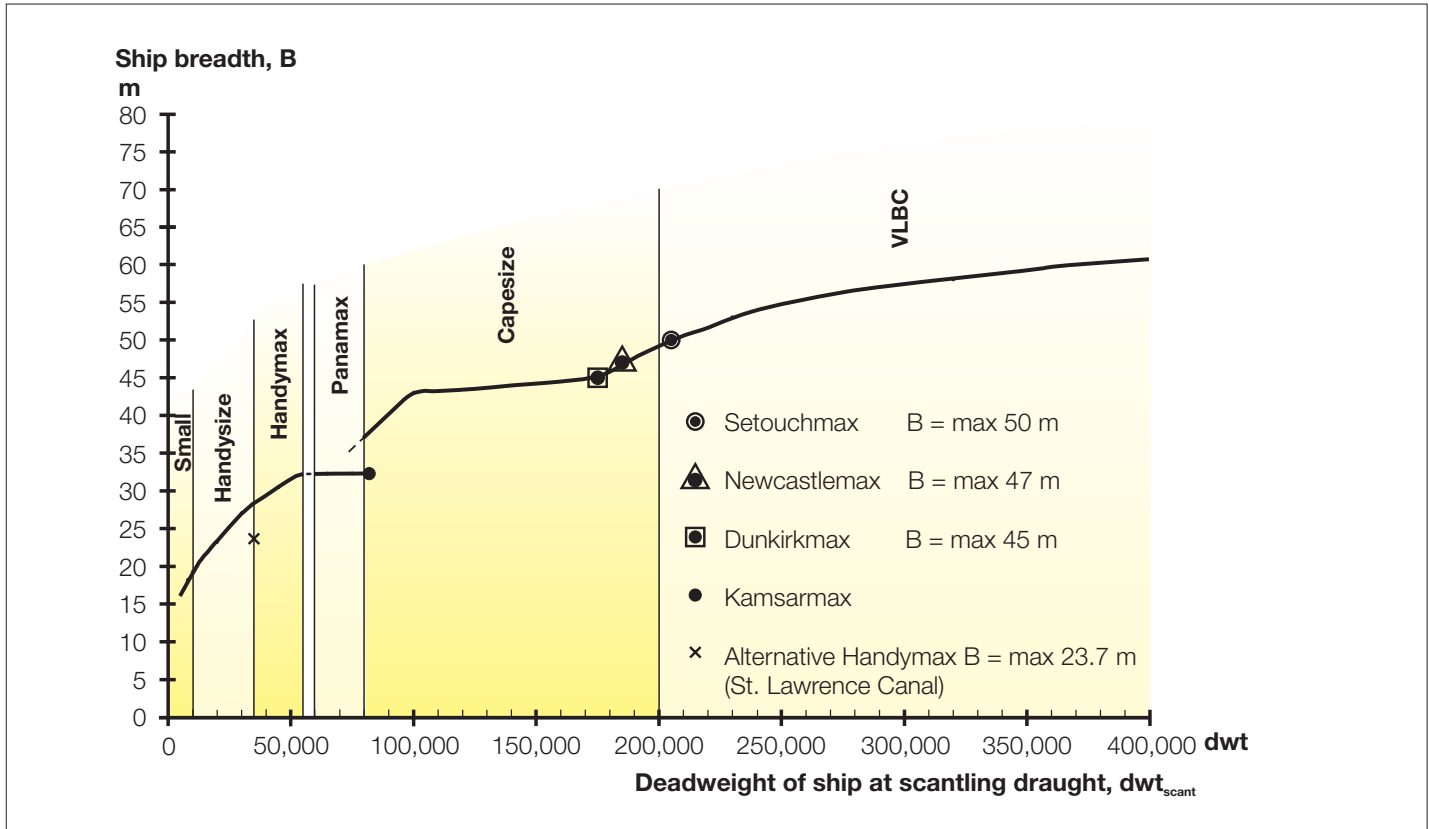
Fig. 6: Average length between perpendiculars

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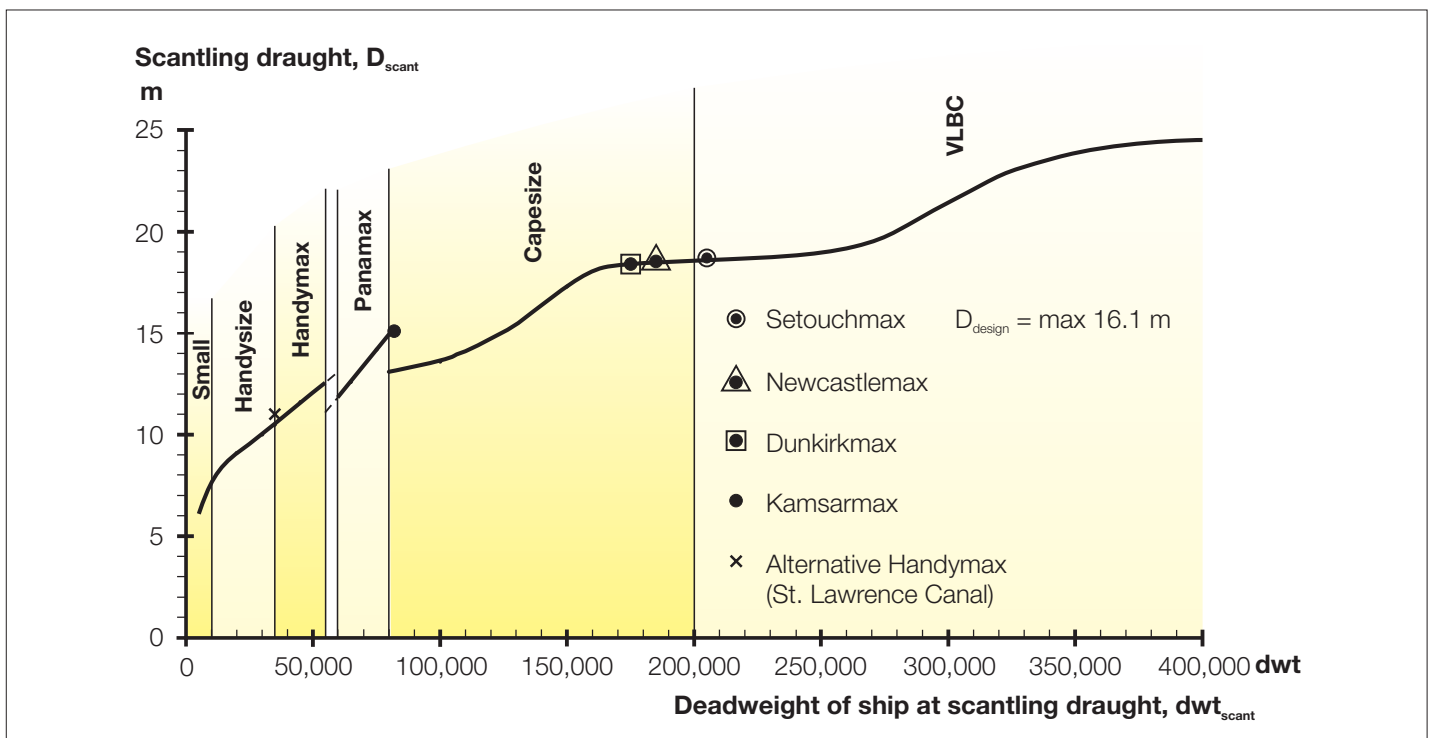Fig. 7: Average ship breadth (beam) of bulk carriers

Fig. 8: Average scantling draught of bulk carriers

Average design ship speed, V$_{des}$
Knots
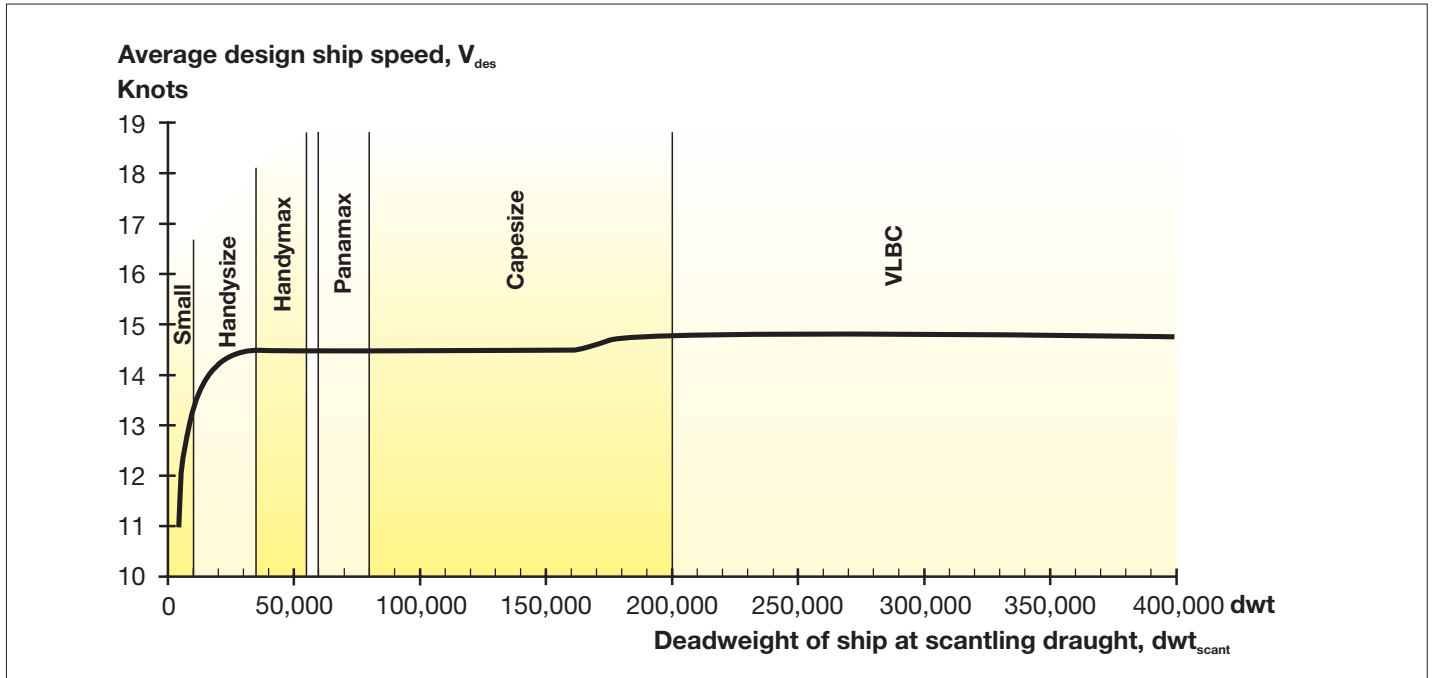
Fig. 9: Average design ship speed of bulk carriers

Ship speed, V
knots

Change of ship speed, ΔV
knots

Design ship speed 14.5 kn

Design draught
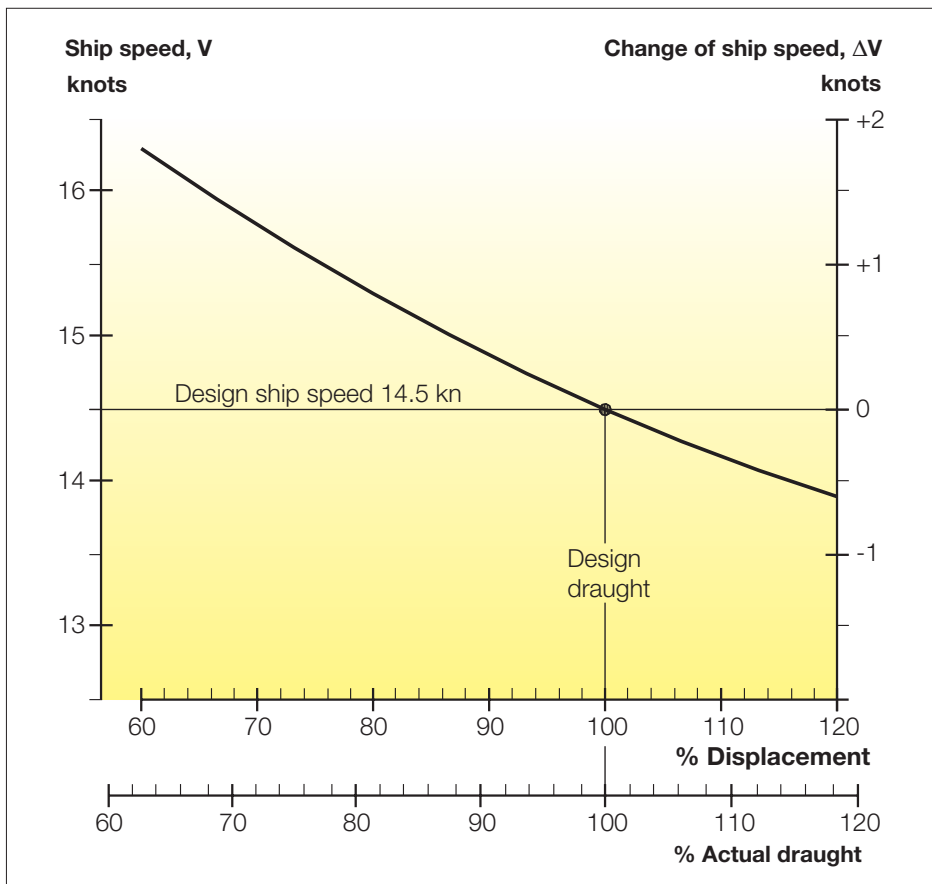
Fig. 10: Ship speed at actual draught for the same propulsion power of bulk carriers

Fig. 9 also shows that today the average ship speed – except for Small and Handysize bulk carriers – is generally higher than or equal to 14.5 knots. The trend shown for large Capesize and VLBC is more doubtful as it is based on only few ship types being built.

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.

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Propulsion Power Demand as a Function of Ship Size

Average bulk carriers
(without ice class notation)

Based on the already described average ship particulars and ship speeds for bulk carriers built or contracted in the period of 1996-2003, we have made a power prediction calculation (Holtrop & Mennen's Method) for such bulk carriers in various sizes from 5,000 dwt up to 320,000 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 bulk carriers are shown in the tables in Figs. 11-13. 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. 11-13, "ship particulars and propulsion SMCR power demand" together with the selected main engine options. These are valid, in all cases, for single-screw bulk carriers. The similar results valid for +/-0.5 knots compared to the average design ship speed are also shown.

The average ship particulars used are, basically, referring to single hull bulk carriers, but the SMCR power demand found may, as a good guidance, also be used for double hull bulk carriers, by referring to a slightly higher deadweight tonnage than valid for the double hull design. For example, a 54,000 dwt double

Bulk carrier class		Small		Handysize		
Ship size (at scantling draught)	dwt	5,000	8,000	10,000	20,000	30,000
Scantling draught	m	6.1	7.3	7.8	9.1	10.0
Length overall	m	95.0	107.0	117.0	153.0	170.0
Length between pp	m	90.0	102.0	110.0	143.0	163.0
Breadth	m	16.0	18.2	19.3	23.2	27.0
Design draught	m	5.7	6.8	7.3	8.6	9.4
Sea margin	%	15	15	15	15	15
Engine margin	%	10	10	10	10	10
Average design ship speed	Knots	12.0	13.0	13.5	14.2	14.5
SMCR power	kW	1,510	2,440	2,920	4,970	6,700
Main engine options	1.	5S26MC	4L35MC	4S35MC	5L42MC	5S50MC-C/ME-C
	2.		7S26MC	5L35MC	5S42MC	5S50MC
	3.				7S35MC	6S46MC-C
Average design ship speed - 0.5 kn	Knots	11.5	12.5	13.0	13.7	14.0
SMCR power	kW	1,280	2,080	2,510	4,320	5,920
Main engine options	1.	4S26MC	4L35MC	4S35MC	4S42MC	5S50MC-C/ME-C
	2.		4S35MC	5L35MC	5L42MC	5S50MC
	3.		6S26MC		6S35MC	5S46MC-C
Average design ship speed + 0.5 kn	Knots	12.5	13.5	14.0	14.7	15.0
SMCR power	kW	1,780	2,860	3,400	5,710	7,780
Main engine options	1.	5S26MC	5L35MC	5S35MC	6L42MC	5S50MC-C/ME-C
	2.		8S26MC	6L35MC	6S42MC	6S50MC
	3.				8S35MC	6S46MC-C

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

Bulk carrier class		Handymax				Panamax		
Ship size (at scantling draught)	dwt	35,000	alt. St. Law.	45,000	55,000	65,000	75,000	82,000 (Kamsarmax)
Scantling draught	m	11.0	10.5	11.6	12.7	12.6	14.2	15.1
Length overall	m	200.0	178.0	185.0	190.0	225.0	225.0	229.0 (max)
Length between pp	m	191.0	170.0	177.0	183.0	216.0	217.0	222.0
Breadth	m	23.7	28.0	30.4	32.26	32.26	32.26	32.26
Design draught	m	10.0	9.5	10.5	11.5	11.2	12.6	13.4
Sea margin	%	15		15	15	15	15	15
Engine margin	%	10		10	10	10	10	10
Average design ship speed	Knots	14.5		14.5	14.5	14.5	14.5	14.5
SMCR power	kW	6,730		7,180	8,400	9,350	9,760	10,280
Main engine options	1.	5S50MC-C / 5S50ME-C		5S50MC-C / 5S50ME-C	6S50MC-C/ME-C	6S50MC-C/ME-C	5S60MC-C/ME-C	5S60MC-C/ME-C
	2.	5S50MC		6S50MC	6S50MC	7S50MC	5S60MC	6S60MC
	3.	6S46MC-C		6S46MC-C	7S46MC-C	5L60MC	7S50MC-C/ME-C	7S50MC-C/ME-C
Average design ship speed - 0.5 kn	Knots	14.0		14.0	14.0	14.0	14.0	14.0
SMCR power	kW	5,950		6,280	7,340	8,200	8,620	9,080
Main engine options	1.	5S50MC-C / 5S50ME-C		5S50MC-C / 5S50ME-C	5S50MC-C/ME-C	6S50MC-C/ME-C	5S60MC-C/ME-C	5S60MC-C/ME-C
	2.	5S50MC		5S50MC	6S50MC	6S50MC	5S60MC	5S60MC
	3.	5S46MC-C		5S46MC-C	6S46MC-C	6S50MC-C/ME-C	6S50MC-C/ME-C	7S50MC
Average design ship speed + 0.5 kn	Knots	15.0		15.0	15.0	15.0	15.0	15.0
SMCR power	kW	7,610		8,210	9,620	10,600	11,050	11,640
Main engine options	1.	5S50MC-C / 5S50ME-C		6S50MC-C / 6S50ME-C	7S50MC-C/ME-C	7S50MC-C/ME-C	5S60MC-C/ME-C	6S60MC-C/ME-C
	2.	5S50MC		6S50MC	7S50MC	5L60MC-C	6S60MC	6S60MC
	3.	6S46MC-C		7S46MC-C	8S46MC-C	6L60MC	7S50MC-C/ME-C	8S50MC-C/ME-C

(Note: the 82,000 dwt Kamsarmax column continues the SMCR values: Average design ship speed 14.5 kn, SMCR 10,780 kW, options 1. 5S60MC-C/ME-C, 2. 6S60MC, 3. 7S50MC-C/ME-C; – 0.5 kn 14.0 kn, SMCR 9,530 kW, options 1. 5S60MC-C/ME-C, 2. 5S60MC, 3. 7S50MC; + 0.5 kn 15.0 kn, SMCR 12,200 kW, options 1. 6S60MC-C/ME-C, 2. 6S60MC, 3. 8S50MC-C/ME-C.)

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

Bulk carrier class

Bulk carrier class		Capesize				VLBC		
Ship size (at scantling draught)	dwt	80,000	100,000	150,000	175,000 (Dunkirkmax)	205,000 (Setouchmax)	230,000	320,000
Scantling draught	m	13.1	13.6	17.3	18.4	18.7	18.6	22.8
Length overall	m	225.0	235.0	270.0	289.0 (max)	299.9 (max)	320.0	332.0
Length between pp	m	217.0	226.0	260.0	279.0	289.0	308.0	320.0
Breadth	m	37.0	43.0	44.0	45.0 (max)	50.0	53.0	58.0
Design draught	m	12.1	12.6	16.0	17.0	16.1 (max)	17.2	21.0
Sea margin	%	15	15	15	15	15	15	15
Engine margin	%	10	10	10	10	10	10	10
Average design ship speed	Knots	14.5	14.5	14.5	14.7	14.7	14.7	14.7
SMCR power	kW	11,230	12,790	14,950	16,800	18,500	20,260	24,680
Main engine options	1.	5S60MC-C/ME-C	6S60MC-C/ME-C	5S70MC-C/ME-C	6S70MC-C/ME-C	6S70MC-C/ME-C	6S80MC-C/ME-C	7S80MC-C/ME-C
	2.	6S60MC	7S60MC	6S70MC	6S70MC	7S70MC	6S80MC	7S80MC
	3.	8S50MC-C/ME-C	5S65ME-C	6S65ME-C	6S65ME-C	7S65ME-C		
Average design ship speed - 0.5 kn	Knots	14.0	14.0	14.0	14.2	14.2	14.2	14.2
SMCR power	kW	9,920	11,300	13,350	15,000	16,580	18,180	22,190
Main engine options	1.	5S60MC-C/ME-C	5S60MC-C/ME-C	5S70MC-C/ME-C	5S70MC-C/ME-C	6S70MC-C/ME-C	5S80MC	6S80MC-C/ME-C
	2.	5S60MC	6S60MC	5S70MC	6S70MC	6S70MC	6S80MC-C/ME-C	7S80MC
	3.	7S50MC-C/ME-C	6S60MC-C/ME-C	5S65ME-C	6S65ME-C	6S65ME-C	6S80MC	
Average design ship speed + 0.5 kn	Knots	15.0	15.0	15.0	15.2	15.2	15.2	15.2
SMCR power	kW	12,710	14,280	16,740	18,660	20,660	22,560	27,160
Main engine options	1.	6S60MC-C/ME-C	7S60MC-C/ME-C	6S70MC-C/ME-C	6S70MC-C/ME-C	7S70MC-C/ME-C	6S80MC-C/ME-C	7S80MC-C/ME-C
	2.	7S60MC	7S60MC	6S70MC	7S70MC	8S70MC	7S80MC	8S80MC
	3.		5S65ME-C	6S65ME-C	7S65ME-C	8S65ME-C		6S90MC-C/ME-C

Fig. 13: Ship particulars and propulsion SMCR power demand, Capesize and VLBC bulk carriers
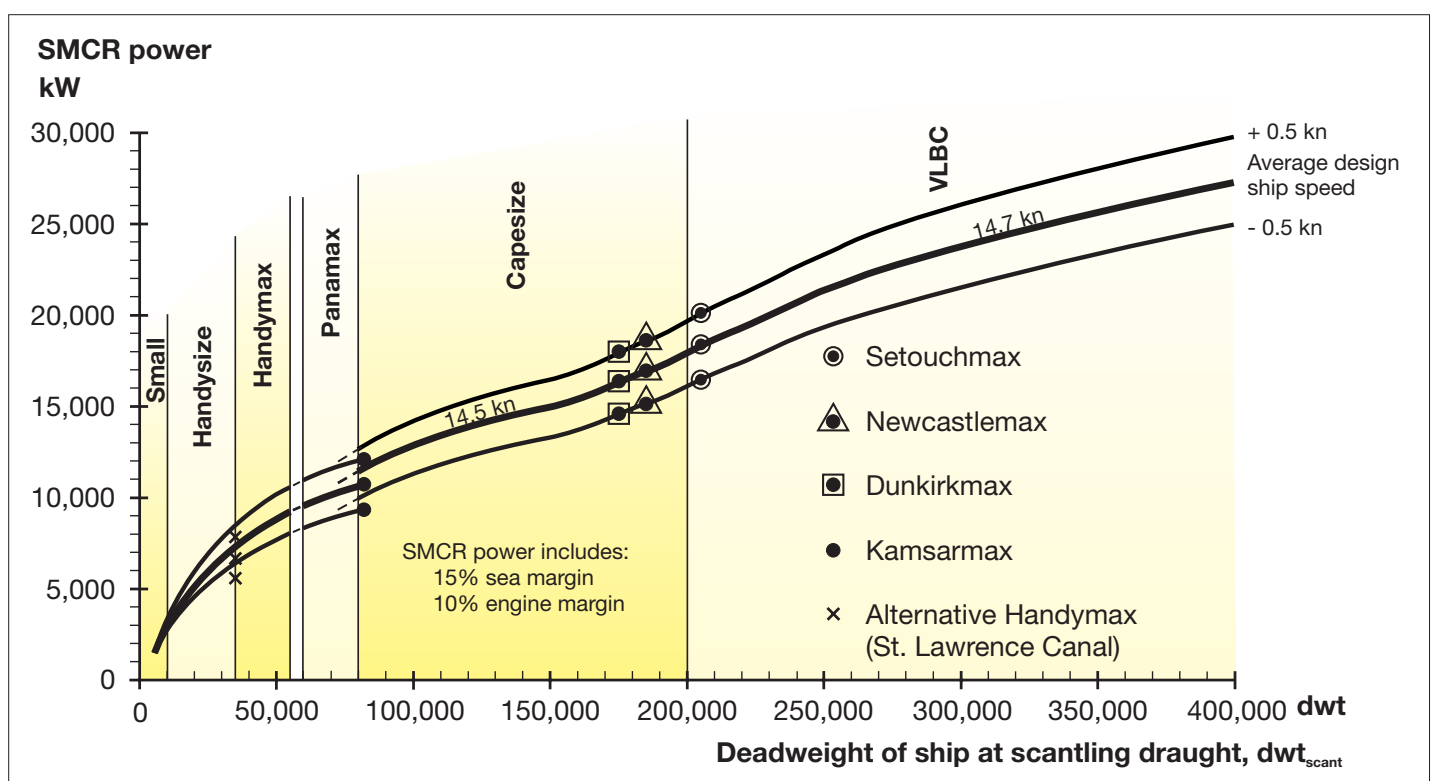

Fig. 14: Propulsion SMCR power demand of an average bulk carrier

SMCR power kW

- 1A Super
- VLBC
- Capesize
- Panamax
- 1A
- Normal SMCR power for average bulk carriers without ice class notation
- Handymax
- Handysize
- Small
- 14.7 kn
- 1B
- 1A Super
- 14.5 kn
- 1A
- 1C
- 1B
- 1C
- × Alternative handymax (St. Lawrence Canal)

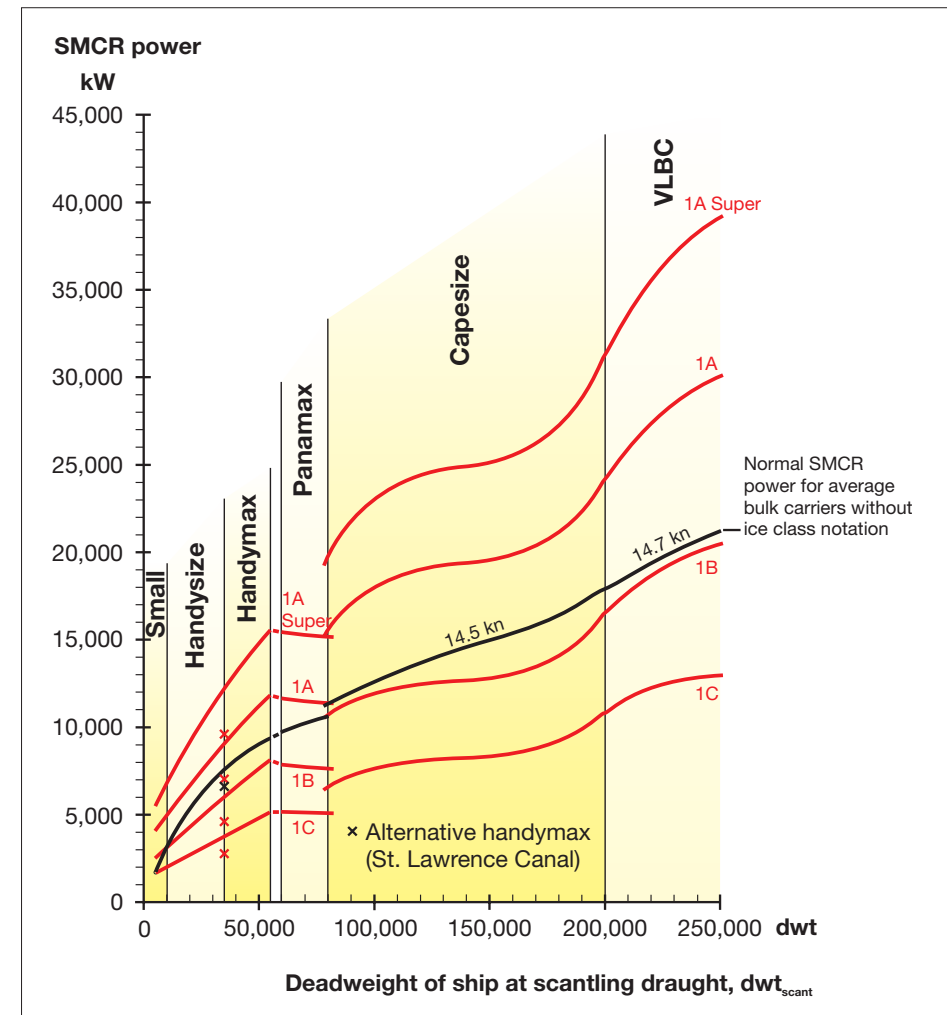**Deadweight of ship at scantling draught, dwt$_{scant}$**

Fig. 15: Minimum required propulsion SMCR power demand (CP-propeller) for average-size bulk carriers with Finnish-Swedish ice class notation (for FP-propeller add +11%)

hull design could be corresponding to an about 55,000 dwt single hull design.

The graph in Fig. 14 shows the above-mentioned table figures of the specified engine MCR (SMCR) power needed for propulsion of an average bulk carrier without ice class notation. The SMCR power curves valid for +/-0.5 knot compared to the average design ship speed are also shown.

Average bulk carriers with ice class notation

When sailing in ice with a bulk carrier, 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 bulk carrier 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.

Based on the above-described bulk carriers, the minimum power demand of the ice classed ships, class 1A Super, 1A, 1B and 1C, have been estimated for all the bulk carrier classes up to 250,000 dwt and drawn-in in Fig. 15. In general, the lowest ice classes, 1B and 1C can – power-wise – 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 bulk carriers 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. Capesize bulk carriers longer than the max limitation for ship length stated in Annex 1 (65.0 m < L$_{oa}$ < 250.0 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.
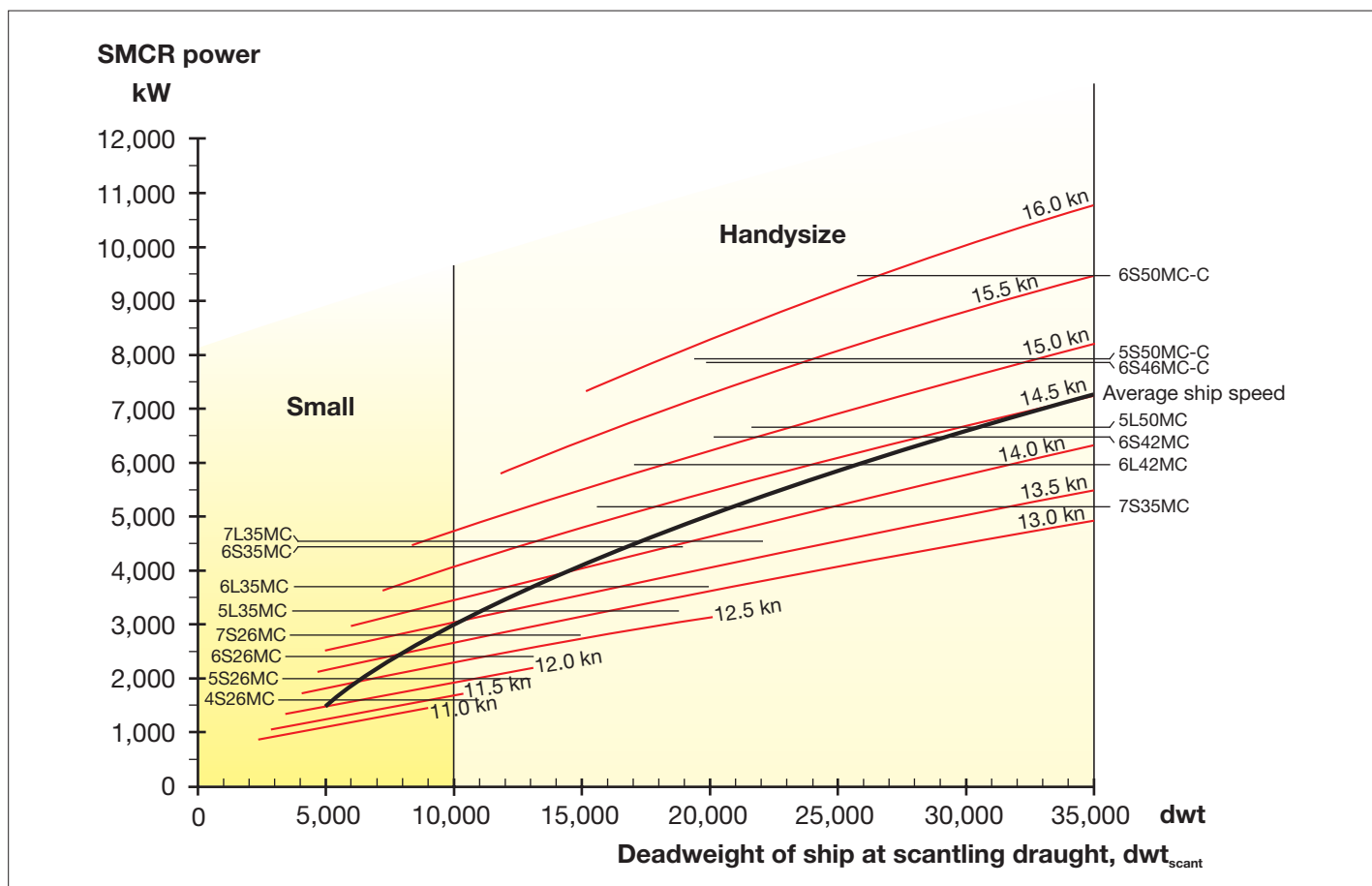
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Fig. 16: Propulsion SMCR power demand of Small and Handysize bulk carriers

Propulsion Power Demand of Average Bulk Carriers 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 particulars and average ship speed as the basis – is shown in detail in Figs. 16-18. See also the description below giving the results of the main engine selection for the different classes of bulk carriers.

If, to a required ship speed, the needed SMCR power for a given main engine is not sufficient, please note that the following relevant main engines used for bulk carriers also may be delivered in updated versions with mep = 20 bar (+ 5.3% more power output):

S46MC-C
S50MC-C/ME-C
S60MC-C/ME-C
S70MC-C/ME-C
S80MC-C/ME-C (+7.7%)

Small and Handysize bulk carriers

For Small and Handysize bulk carriers, see Fig. 16, the selection of main engines is not so distinct as for the large bulk carrier classes. Some owners and yards might prefer four-stroke engines, while others prefer and specify two-stroke engines. One owner/yard might prefer

an 8S35MC (5,920 kW at 173 r/min), and the other, a 6L42MC (5,970 kW at 176 r/min).

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

Handymax and Panamax bulk carriers

The main engines most often selected for Handymax bulk carriers, see Fig. 17, are the 5 and 6S50MC/MC-C/ME-C, with the 6S50 type being the optimum choice for meeting the power demand of all Handymax bulk carriers sailing up to 14.5 knots in service.
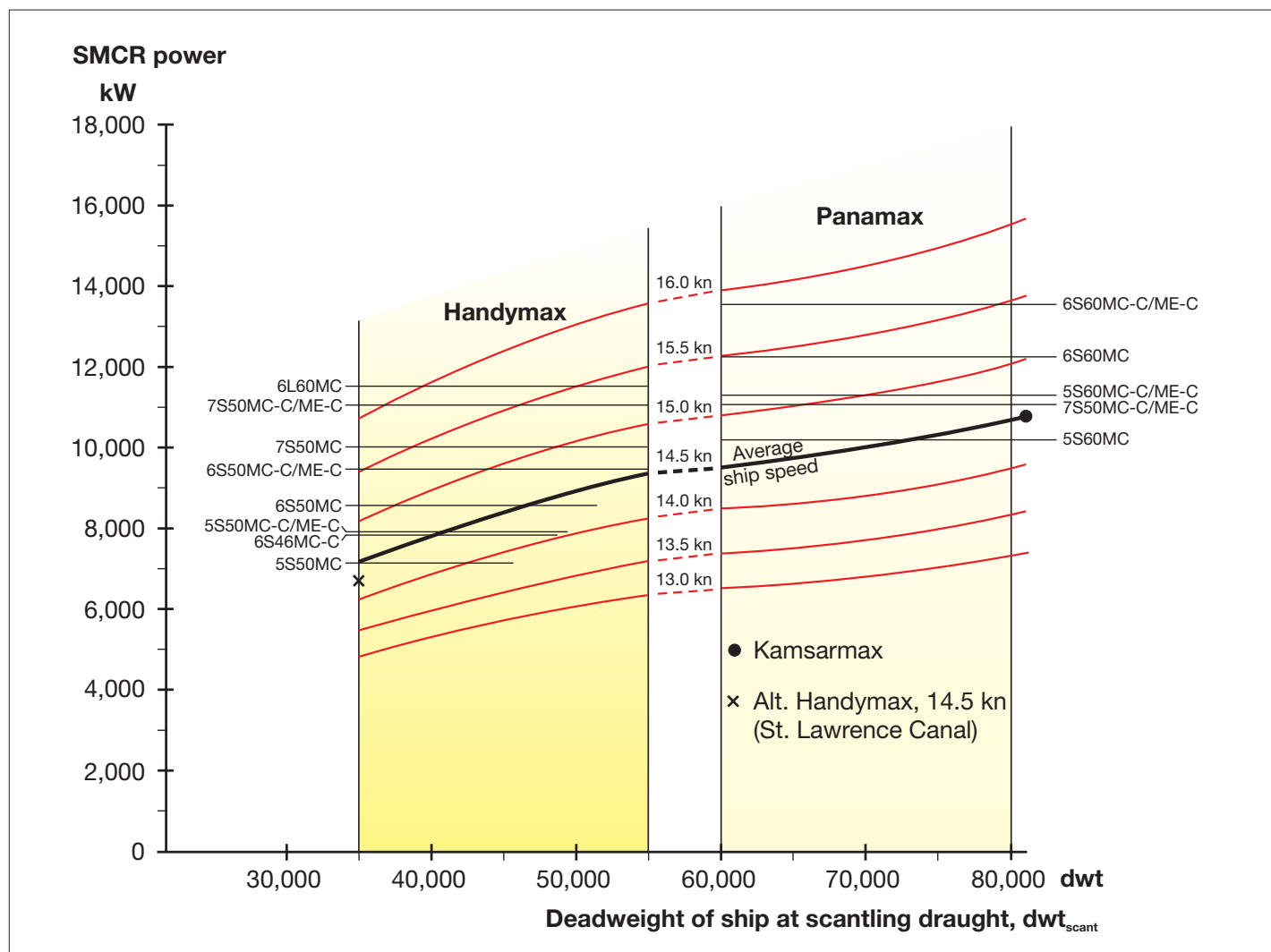
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Fig. 17: Propulsion SMCR power demand of Handymax and Panamax bulk carriers

The main engines used for Panamax bulk carriers, see Fig. 17, are mainly the 5 and 6S60MC/MC-C/ME-C, with the 6S60 type being the optimum choice for meeting the power demand for nearly all Panamax bulk carriers sailing up to 15.5 knots in service.

Capesize and VLBC bulk carriers

Today, in particular the 6S60MC/MC-C/ME-C and 6S70MC engines are used for propulsion of the Capesize bulk carriers, see Fig. 18. The recently developed S65ME-C is now also available, with 6 or 7 cylinder units being most suitable.

For VLBCs, the 6S70MC/MC-C/ME-C and 6S80MC-C/ME-C types are almost exclusively used as the main engine today, see Fig. 18. The recently developed S65ME-C is of course also available. For the larger VLBCs of the future, the 6 and 7S80MC-C/ME-C and the 6S90MC-C/ME-C will be most feasible.
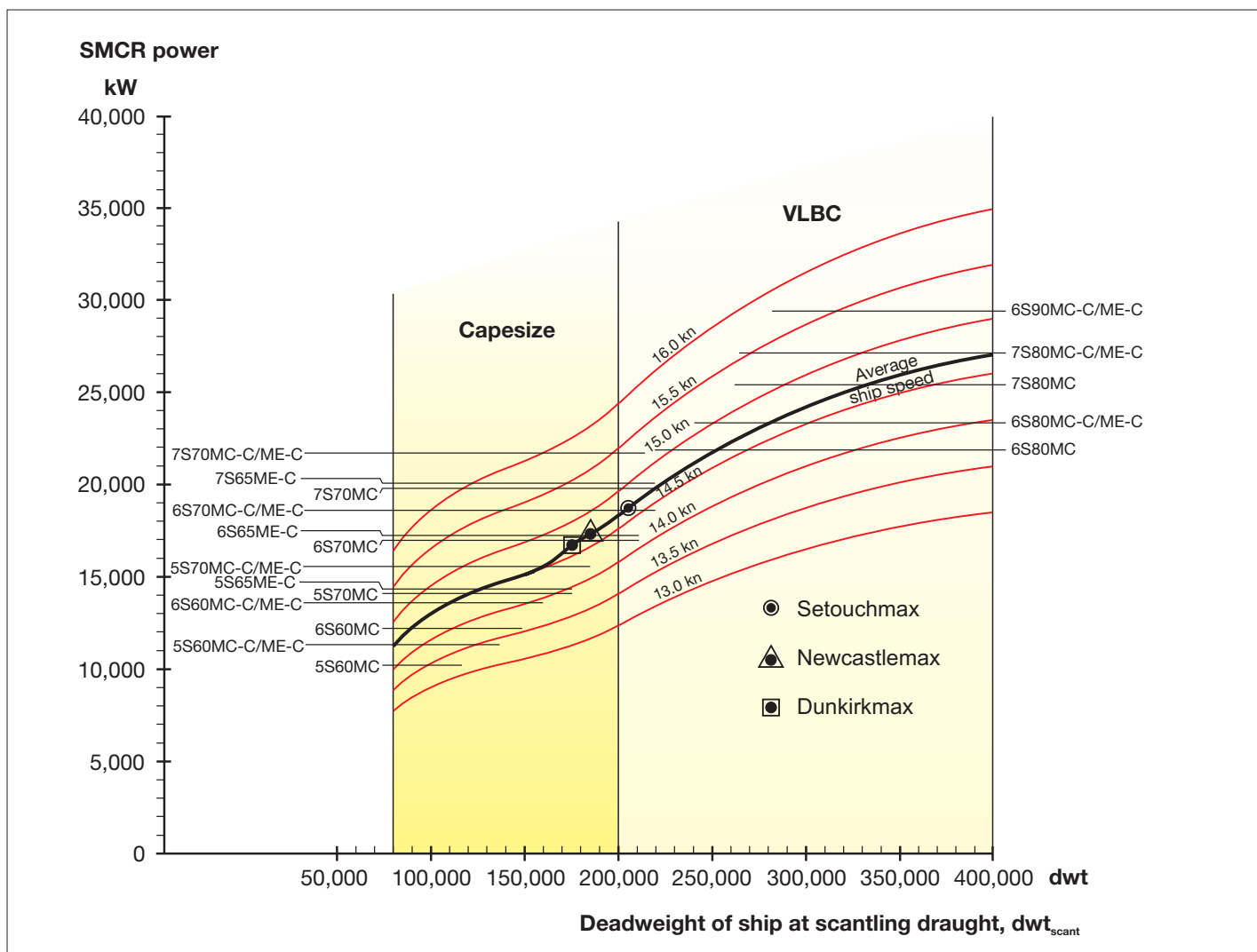
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Fig. 18: Propulsion SMCR power demand of Capesize and VLBC bulk carriers

Summary

The bulk carrier market is an increasingly important and attractive transport segment which, thanks to the ever increasing global market volume, is expected to continue to be of great importance.

Since its start in about 1950, the bulk carrier fleet, in terms of deadweight tonnage, has increased about 33% of the total world fleet operating today.

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 B&W Diesel is able to meet the engine power needs of any size or type of vessel in the modern bulk carrier fleet.

References

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

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[3] Side frame failure blamed in recent bulk carrier loss
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