Determination of Regression Formulas for Main Dimensions of Tankers and Bulk Carriers based on IHS Fairplay data

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On the following pages are shown the results of the analysis of IHS Fairplay data for tankers and bulk carriers. All possible outliers have been left out (obvious errors in data and vessels having unusual dimensions) as described in following document:


Tankers have been categorized in following 7 groups:

1. Small tankers (< 10000 DWT)
2. Handysize tankers (10000 - 25000 DWT)
3. Handymax tankers (25000 - 55000 DWT)
4. Panamax tankers (55000 - 80000 DWT)
5. Aframax tankers (80000 - 120000 DWT)
6. Suezmax tankers (120000 - 170000 DWT)
7. VLCC (170000 - 330000 DWT)

The equations found by regression analysis are shown for each individual ship sub type. The equations are basis for the generic ship design model for determination of main dimensions and propulsion characteristics for all types of tankers and bulk carriers – in the following called ‘DTU and SDU model’.

There are no tankers in the range from 170000 DWT to 250000 DWT, but in this area a linear interpolation has been carried out in order to establish equations for the whole deadweight range from 1000 to 330000 DWT.

Regression equations for tankers can be found in App. A-G, bulk carriers in App. H-O and finally comments about water plane area coefficient and scantling and design draught in in app P.

Common Structural Rules

Most of the ships in the statistical analysis have been built before the introduction of Common Structural Rules (CSR) for tankers and bulk carriers for tankers longer than 150 m and bulk carriers longer than 90 m. These rules will increase the steel weight most probably by 5 – 10 %.

In order to take the CSR rules into account, all lightweight formulas has been corrected, such that the lightweight for tankers longer than 150 m for and bulk carriers longer than 90 m has been increased by 5 %, by adding a factor 1.05 to the formulas for the lightweight coefficient as these coefficient formulas represent the outcome of the actual ship data of which most of them are not constructed according to the relatively new CSR rules effective after 2005.

The resulting block coefficient and length displacement ratio in all the figures in this report have been determined after addition of the extra 5 % lightweight.
Fig. 1 Length between pp as function of DWT

Fig. 2 Breadth as function of DWT

Fig. 3 Depth as function of DWT

Fig. 4 Maximum draught as function of DWT

Fig. 5 Lightweight as function of DWT

Fig. 6 Lightweight coefficient as function of DWT
Fig. 7 Block coefficient as function of DWT

Fig. 8 Length displacement ratio as function of DWT
Appendix A - Small tankers (< 10000 DWT)

Length pp = 6.809 * DWT^{0.3048}

Breadth = 1.406 * DWT^{0.285}

Depth = 4.4 + 0.000681 * DWT

Draught = 0.33 * DWT^{0.343}

Lightweight/Lpp/B/D = 0.2096 - 0.00000724 * DWT

Fig. A1 Length between pp as function of DWT

Fig. A2 Breadth as function of DWT

Fig. A3 Depth as function of DWT

Fig. A4 Maximum draught as function of DWT
Fig. A5 Block coefficient as function of DWT

Fig. A6 Length displacement ratio as function of DWT

Fig. A7 Lightweight coefficient as function of DWT
Appendix B - Handysize tankers (10000 - 25000 DWT)

Length pp
\[ = 3.9537 \times \text{DWT}^{0.3684} \]

Breadth
\[ = 8.99 + 0.000874 \times \text{DWT} \]

Depth
\[ = 7.56 + 0.0002405 \times \text{DWT} \]

Draught
\[ = 7 + 0.0000523 \times \text{DWT} \]

Lightweight/Lpp/B/D
\[ = 0.1584 - 0.00000145 \times \text{DWT} \]

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**Fig. B1** Length between pp as function of DWT

**Fig. B2** Breadth as function of DWT

**Fig. B3** Depth as function of DWT

**Fig. B4** Maximum draught as function of DWT
Fig. B5 Block coefficient as function of DWT

Fig. B6 Length displacement ratio as function of DWT

Fig. B7 Lightweight coefficient as function of DWT
Appendix C – Handymax tankers (25000 - 55000 DWT)

Length pp  \[= 41.647 \times \text{DWT}^{0.133}\]
Breadth  \[= \text{MIN}[15.04 + 0.000369 \times \text{DWT}; 32.2]\]
Depth  \[= 9.69 + 0.000188 \times \text{DWT}\]
Draught  \[= 7.41 + 0.000106 \times \text{DWT}\]
Lightweight/Lpp/B/D  \[= 1.05 \times (0.1765 - 0.00000175 \times \text{DWT})\]
Fig. C5 Block coefficient as function of DWT

Fig. C6 Length displacement ratio as function of DWT

Fig. C7 Lightweight coefficient as function of DWT
Appendix D - Panamax tankers (55000 - 75000 DWT)

Length pp = 193.26 + 0.000353 * DWT
Breadth = 32.06 + 0.0000023 * DWT
Depth = 6.14 + 0.000196 * DWT
Draught = 2.76 + 0.000156 * DWT
Lightweight/Lpp/B/D = 1.05 * (0.0924 + 0.000000084 * DWT)

![Fig. D1 Length between pp as function of DWT](image1)

![Fig. D2 Breadth as function of DWT](image2)

![Fig. D3 Depth as function of DWT](image3)

![Fig. D4 Maximum draught as function of DWT](image4)
Fig. D5 Block coefficient as function of DWT

Fig. D6 Length displacement ratio as function of DWT

Fig. D7 Lightweight coefficient as function of DWT
Appendix E - Aframax tankers (75000 - 120000 DWT)

Length pp = 187.92 + 0.000431 * DWT
Breadth = 1.5658 * DWT\(^{0.285}\)
Depth = 13.97 + 0.000067 * DWT
Draught = 0.0848 * DWT\(^{0.4454}\)
Lightweight/Lpp/B/D = 1.05 * (0.0859 - 0.0000000235 * DWT)

Fig. E1 Length between pp as function of DWT
Fig. E2 Breadth as function of DWT
Fig. E3 Depth as function of DWT
Fig. E4 Maximum draught as function of DWT
Fig. E5 Block coefficient as function of DWT

Fig. E6 Length displacement ratio as function of DWT

Fig. E7 Lightweight coefficient as function of DWT
Appendix F - Suezmax tankers (120000 - 170000 DWT)

Length pp = 222.41 + 0.000263 * DWT
Breadth = 23.95 + 0.000153 * DWT
Depth = 22.61 + 0.000004647 * DWT
Draught = 0.2476 * DWT^{0.353}
Lightweight/Lpp/B/D = 1.05 * (0.1296 - 0.000000308 * DWT)

Fig. F1 Length between pp as function of DWT
Fig. F2 Breadth as function of DWT
Fig. F3 Depth as function of DWT
Fig. F4 Maximum draught as function of DWT
Fig. F5 Block coefficient as function of DWT

Fig. F6 Length displacement ratio as function of DWT

Fig. F7 Lightweight coefficient as function of DWT
Appendix G - VLCC (170000 - 250000 DWT)

Length pp = 267.12 + (DWT - 170000) * 0.0005975
Breadth = 49.96 + (DWT - 170000) * 0.00009219
Depth = 23.4 + (DWT - 170000) * 0.0000825
Draught = 17.38 + (DWT - 170000) * 0.00002147
Lightweight/Lpp/B/D = 1.05 * (0.0772 - (DWT - 170000) * 0.0000001574)

The above mentioned equations have been created based on a linear interpolation between tankers having a deadweight of 170000 t and 250000 t respectively.

VLCC (250000 - 330000 DWT)

Length pp = 293.67 + 0.000085 * DWT
Breadth = 49.01 + 0.0000333 * DWT
Depth = 30 m
Draught = 6.85 + 0.000049 * DWT
Lightweight/Lpp/B/D = 1.05 * (0.01912+0.00000018212 * DWT)

Fig. G1 Length between pp as function of DWT
Fig. G2 Breadth as function of DWT
Fig. G3 Depth as function of DWT

Fig. G4 Maximum draught as function of DWT

Fig. G5 Block coefficient as function of DWT

Fig. G6 Length displacement ratio as function of DWT

Fig. G7 Lightweight coefficient as function of DWT
Appendix H – All bulk carriers – summary of regression analysis

Bulk carriers have been categorized in following 6 groups:

1. Small bulk carriers (< 10000 DWT)
2. Handysize bulk carriers (10000 - 25000 DWT)
3. Handymax bulk carriers (25000 - 55000 DWT)
4. Panamax bulk carriers (55000 - 85000 DWT)
5. Capesize bulk carriers (85000 - 200000 DWT)
6. VLBC (200000 - 330000 DWT)

The equations found by regression analysis are shown for each individual ship sub type. The equations are basis for the generic ship design model for determination of main dimension and propulsion characteristics for all types of bulk carriers – in the following called ‘DTU and SDU model’.

Fig. H1 Length between pp as function of DWT

Fig. H2 Breadth as function of DWT
Appendix I - Small bulk carriers (< 10000 DWT)

Length pp  = 5.582 * DWT^{0.329}
Breadth     = 11+ 0.001 * DWT - 0.00000001675 * DWT^{2}
Depth       = 5.22 + 0.000485 * DWT
Draught     = 0.529 * DWT^{0.285}
Lightweight/Lpp/B/D = 0.831 * DWT^{-0.2}

Fig. I1 Length between pp as function of DWT
Fig. I2 Breadth as function of DWT
Fig. I3 Depth as function of DWT
Fig. I4 Maximum draught as function of DWT
Fig. I5 Block coefficient as function of DWT

Fig. I6 Length displacement ratio as function of DWT

Fig. I7 Lightweight coefficient as function of DWT
Appendix J – Handysize bulk carriers (10000 - 25000 DWT)

Length pp = 5.463 * DWT^{0.3285}
Breadth = 14.86 + 0.00045 * DWT
Depth = 7.84 + 0.000232 * DWT
Draught = 6.2 + 0.000141 * DWT
Lightweight/Lpp/B/D = 1.05 * (0.153 - 0.00000158 * DWT)

Fig. J1 Length between pp as function of DWT
Fig. J2 Breadth as function of DWT
Fig. J3 Depth as function of DWT
Fig. J4 Maximum draught as function of DWT
Fig. J5 Block coefficient as function of DWT

Fig. J6 Length displacement ratio as function of DWT

Fig. J7 Lightweight coefficient as function of DWT
Appendix K - Handymax bulk carriers (25000 - 55000 DWT)

Length pp = 25.66 * DWT^{0.1813}

Breadth = MIN(18.93 + 0.000272 * DWT; 32.2)

Depth = 9.32 + 0.000158 * DWT

Draught = 6.84 + 0.000101 * DWT

Lightweight/Lpp/B/D = 1.05 * (0.151 - 0.00000127 * DWT)

Fig. K1 Length between pp as function of DWT

Fig. K2 Breadth as function of DWT

Fig. K3 Depth as function of DWT

Fig. K4 Maximum draught as function of DWT
Fig. K5 Block coefficient as function of DWT

Fig. K6 Length displacement ratio as function of DWT

Fig. K7 Lightweight coefficient as function of DWT
Appendix L - Panamax bulk carriers (55000 - 85000 DWT)

Length pp
\[
\begin{align*}
\text{for DWT < 60000} & \quad = 107.00 + 0.0014 \times \text{DWT} \\
\text{for 60000 <= DWT <= 69000} & \quad = 31.00 + 0.00267 \times \text{DWT} \\
\text{for DWT > 85000} & \quad = 180.50 + 0.0005 \times \text{DWT}
\end{align*}
\]

Breadth = 32.23

Depth
\[ \text{Draught} = 13.47 + 0.0000777 \times \text{DWT} \]

Draught
\[ \text{Lightweight/Lpp/B/D} = 1.05 \times 0.079 \]

Fig. L1 Length between pp as function of DWT

Fig. L2 Breadth as function of DWT

Fig. L3 Depth as function of DWT

Fig. L4 Maximum draught as function of DWT
Fig. L5 Block coefficient as function of DWT

Fig. L6 Length displacement ratio as function of DWT

Fig. L7 Lightweight coefficient as function of DWT
Appendix M - Capesize bulk carriers (85000 - 200000 DWT)

Length pp = 5.705 * DWT^{0.322}

Breadth = 27.80 + 0.00012 * DWT for DWT < 110000
          = 32.75 + 0.000075 * DWT for DWT => 110000

Depth  = 1.126 * DWT^{0.2545}

Draught = 0.179 * DWT^{0.3814}

Lightweight/Lpp/B/D = 0.0817 – 0.0000000486 * DWT

Fig. M1 Length between pp as function of DWT
Fig. M2 Breadth as function of DWT
Fig. M3 Depth as function of DWT
Fig. M4 Maximum draught as function of DWT
Fig. M5 Block coefficient as function of DWT

Fig. M6 Length displacement ratio as function of DWT

Fig. M7 Lightweight coefficient as function of DWT
Appendix N - VLBC (200000 - 330000 DWT)

Length pp
= 230.00 + 0.00032 * DWT for DWT < 250000
= 250.625 + 0.0002375 * DWT for DWT => 250000

Breadth = MIN(57.5, 20 + 0.00015 * DWT)

Depth = MIN(6.86 + 0.0000857 * DWT, 30)

Draught
= 14.95 + 0.000015 * DWT for DWT < 230000
= 7.82 + 0.000046 * DWT for DWT => 230000

Lightweight/Lpp/B/D = 1.05 * (0.076 – 0.0000000261 * DWT)

Fig. N1 Length between pp as function of DWT
Fig. N2 Breadth as function of DWT
Fig. N3 Depth as function of DWT
Fig. N4 Maximum draught as function of DWT
Fig. N5 Block coefficient as function of DWT

Fig. N6 Length displacement ratio as function of DWT

Fig. N7 Lightweight coefficient as function of DWT
Appendix O – Water plane area coefficient and draught change

The waterplane area coefficient, $C_w$, for tankers and bulk carriers is shown in Fig. O1.

$C_w$ depends on the block coefficient, $C_b$, as follows:

$$C_w = 0.24 + 0.81 C_b$$

where $C_w$ and $C_b$ are calculated on basis of the length between pp.

In Fig. O2 is shown the waterplane area coefficient as function of the relative displacement. Based on the results in Fig. O2, the waterplane area coefficient at a displacement $\Delta_2$ can be approximated as follows:

$$C_w(\Delta_2) = C_w(\Delta_1) - 0.08 \cdot \left(1 - \frac{\Delta_2}{\Delta_1}\right) = [0.24 + 0.81 \cdot C_b(\Delta_1)] - 0.08 \cdot \left(1 - \frac{\Delta_2}{\Delta_1}\right)$$

Scantling draught and design draught

All data presented in this report are presented as function of the maximum deadweight.

Normally two draughts are specified for tankers and bulk carriers, namely the design draught and the scantling draught. The design draught is the draught at which the ship is expected to operate normally, while the scantling draught is the maximum permissible draught according to the class rules. Comparison of scantling draught data (Significant Ships, 1990 – 2010) with summer load line draught data (denoted maximum draught in this report) shows that the summer load line draught is nearly identical with the scantling draught (Fig. O3 and O4).

The design deadweight and the scantling deadweight are shown in Fig. O5 as the ratio between design deadweight and scantling deadweight for 229 ships (181 tankers and 58 bulk carriers). The
ratio depends on the ship size, but the scatter is relatively large so a design to scantling deadweight ratio of 90% is assumed.

The design draught can be calculated according to this approximate formula:

\[
T_{design} = T_{scantling} - \frac{Dw_{scantling} - Dw_{design}}{[Cw_{scantling} - 0.04 \cdot (1 - \frac{\Delta_{scantling}}{\Delta_{design}})] \cdot Lpp \cdot B \cdot \rho_{salt\ water}}
\]
Appendix P Service speed for tankers and bulk carriers

The speed for tankers according IHS Fairplay and Significant Ships are presented in Fig. P1.

Based on a regression analysis of the IHS Fairplay data, following speed assumptions have been made for calculation of a default service speed:

If deadweight (DWT) \( \leq 150000 \) t: \[ \text{Speed} = 9.5 \cdot \text{DWT}^{0.043}, \text{but not more than } 15 \text{ knots} \]
If deadweight > 150000 t: \[ \text{Speed} = 15 + (\text{DWT} - 150000) \cdot 0.000003 \]

The speed for bulk carriers according IHS Fairplay and Significant Ships are presented in Fig. P2. Based on a regression analysis of the IHS Fairplay data, following speed assumption has been made for calculation of a default service speed:

\[ \text{Speed} = 0.613 \cdot \ln(\text{DWT}) + 7.74), \text{but not more than } 15 \text{ knots} \]
Bulk carriers (1990 - 2010)

\[ y = 0.613 \ln(x) + 7.74 \]

Fig. P2  Speed for bulk carriers