Innovative Ship and Offshore Plant Design

Part I. Ship Design

Ch. 9 General Arrangement (G/A) Design

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1. Concept of General Arrangement Design

Arrangement Design

☑ 'Design' is a kind of 'Arrangement'.

☑ Arrangement design of a ship includes

➡ General arrangement design

- Equipment and piping arrangement ➡ Outfitting design
- Structural member arrangement ➡ Structural design

General Arrangement (G/A)

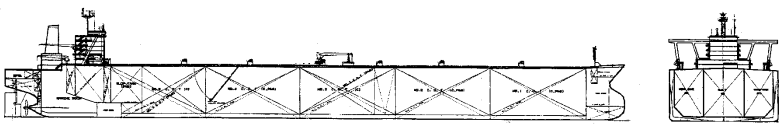
☑ Sketch G/A: Arrangement of ship's compartments and tanks

- Compartment arrangement:
  under the given condition

➡ Optimal compartment arrangement design

☑ Full General Arrangement

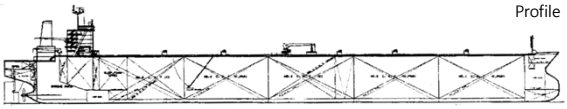
- Includes detailed arrangement of deck house, loading and unloading equipment, mooring and anchoring equipment, communication equipment, etc.



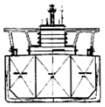
Example of General Arrangement

Tanker (VLCC)

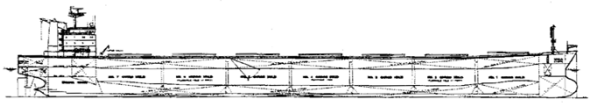
Profile

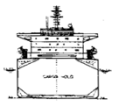


Midship section

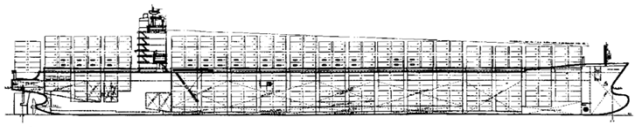


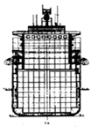
Bulk Carrier (Panamax)



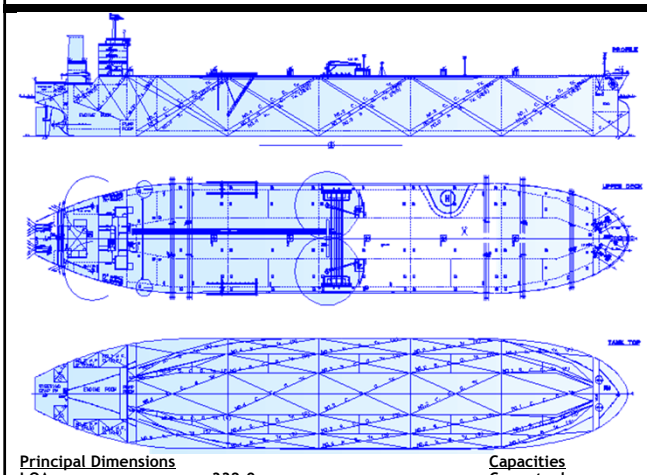


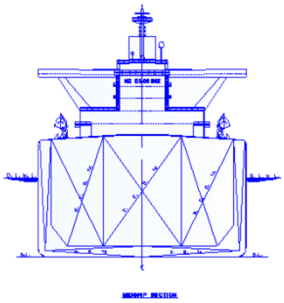
Container Ship





G/A of a 320K VLCC

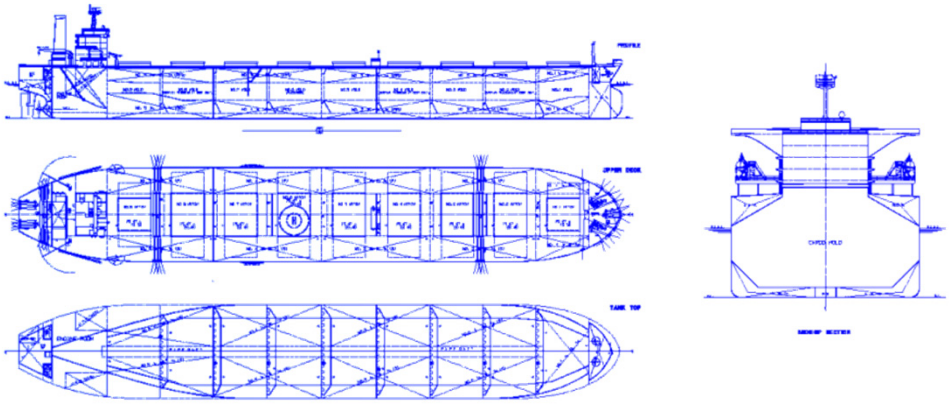




Principal Dimensions		Capacities	
LOA	332.0 m	Cargo tank	357,000 m^3
LBP	320.0 m	Water ballast	101,500 m^3
B	60.0 m		
D	30.5 m	Main Engine	SULZER 7RTA84T-D
Td / Ts	21.0 / 22.5 m	MCR	39,060 PS x 76.0 rpm
Deadweight at Ts	320,000 ton	NCR	35,150 PS x 73.4 rpm
Service speed at Td at NCR with 15% sea margin	16.0 knots	No. of cargo segregation	Three (3)
		Cruising range	26,500 N/M

* Reference: DSME

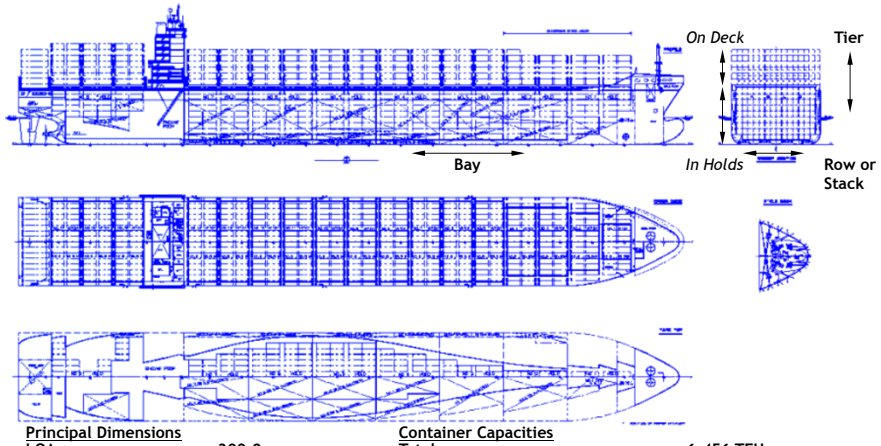
G/A of a 173K Bulk Carrier



Principal Dimensions		Capacities	
LOA	289.0 m	Cargo holds	192,000 m^3
LBP	279.0 m	Water ballast	76,000 m^3
B	45.0 m		
D	24.2 m	Main Engine	B&W 6S70MC
Td / Ts	16.5 / 17.8 m	MCR	22,920 PS x 91.0 rpm
Deadweight at Ts	172,900 ton	NCR	19,480 PS x 86.2 rpm
Service speed at Td at NCR with 15% sea margin	15.0 knots	Cruising range	20,000 N/M

* Reference: DSME

G/A of a 6,500 TEU Container Ship

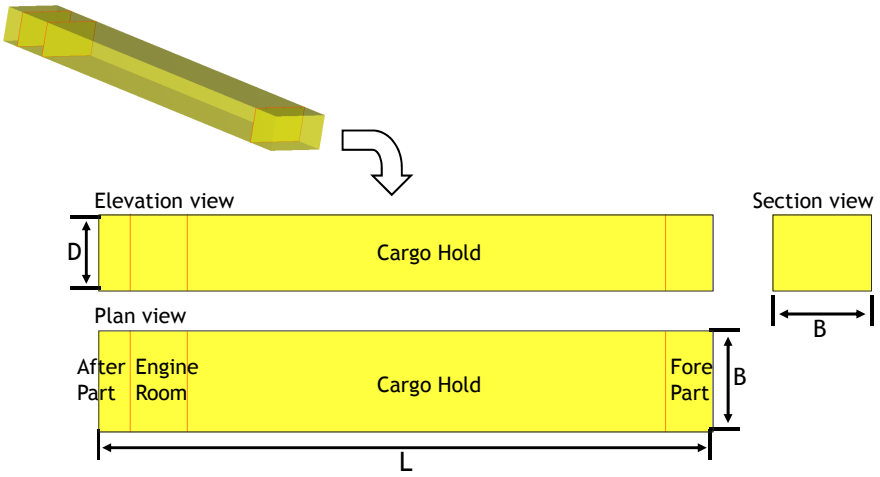


Principal Dimensions		Container Capacities	
LOA	300.0 m	Total	6,456 TEU
LBP	286.56 m	On deck	3,398 TEU
B	40.0 m	In hold	3,058 TEU
D	24.2 m	Reefer container (on deck)	500 FEU
Td / Ts	12.0 / 14.5 m		
Deadweight at Ts	78,100 ton	Main Engine	B&W 12K98MC-C
Service speed at Td at NCR with 15% sea margin	27.0 knots	MCR	93,120 PS x 104.0 rpm
		NCR	83,810 PS x 100.4 rpm
		Cruising range	23,500 N/M

* Reference: DSME

Compartment Arrangement of Ship

☑ The compartment arrangement is to secure suitable spaces in a cuboid of L, B, and D by subdividing it into many regions.



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Concept of Compartment Arrangement

➡ " "

■ In the case of VLCC, it means the arrangement to maximize cargo hold space by satisfying rules and regulation such as tank capacity and arrangement by MARPOL, SBT (Segregated Ballast Tank), PL (Protective Location), double bottom height and double side breadth of double hull tanker

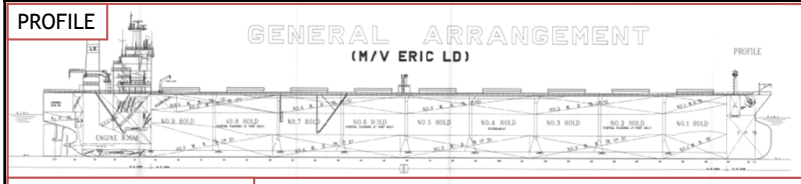
(engine room, deck house, fuel oil tank, ballast water ➡

☑ To maximize sectional area of cargo hold ➡ Investigation of satisfaction of rules and regulation for midship section, double bottom height, FPT length, etc.
☑ Suitable arrangement of hopper tank and wing tank
☑ Consideration for frame, web, and longitudinal stiffener (longi.)
☑ Consideration for anchoring, mooring, rudder, etc.
☑ Determination of hull form considering resistance / propulsion, maneuvering, stability, vibration, etc.

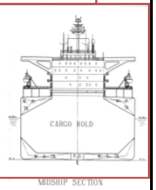
2. Reading the G/A Drawings

Composition of General Arrangement Plan

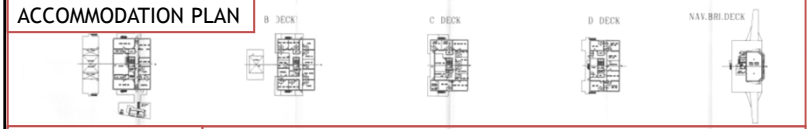
PROFILE



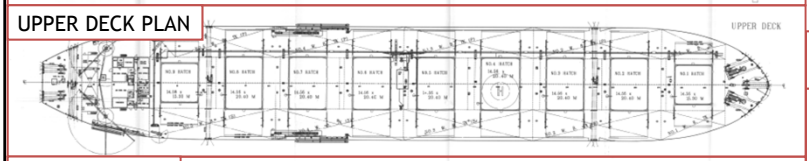
MIDSHIP SECTION



ACCOMMODATION PLAN

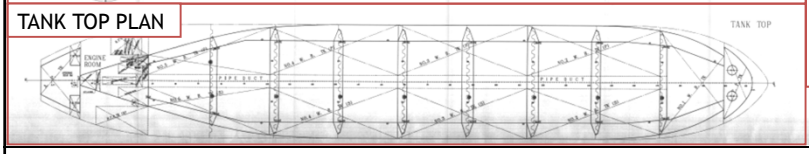


UPPER DECK PLAN



PRINCIPAL PARTICULARS

TANK TOP PLAN



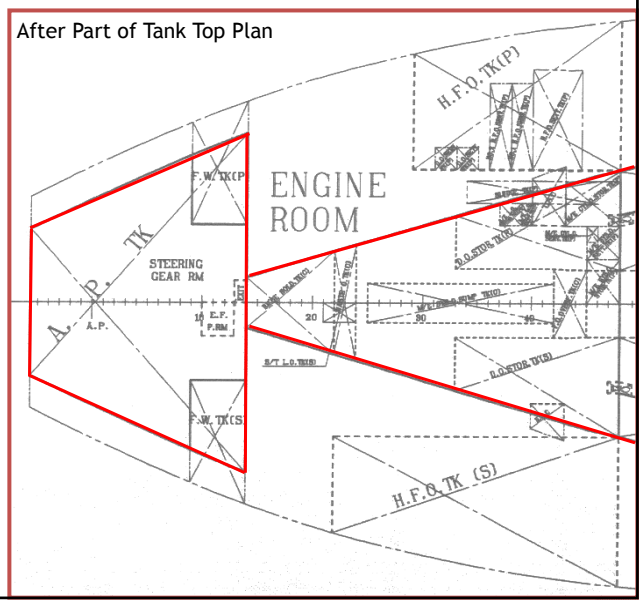
Reading the General Arrangement Drawings (1/3)

- Meaning of lines in G/A

① ——————

(solid line): outer boundary of cutting plane

After Part of Tank Top Plan



Reading the General Arrangement Drawings (2/3)

- Meaning of lines in G/A

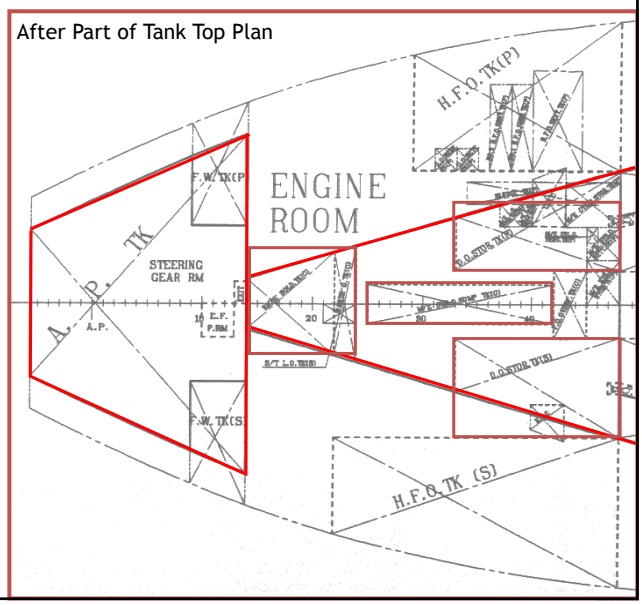
① ——————

(solid line): outer boundary of cutting plane

② – – – – – – –

(dashed line): located below cutting plane

After Part of Tank Top Plan



Reading the General Arrangement Drawings (3/3)

- Meaning of lines in G/A

① ——————

(solid line): outer boundary of cutting plane

② – – – – – – –

(dashed line): located below cutting plane

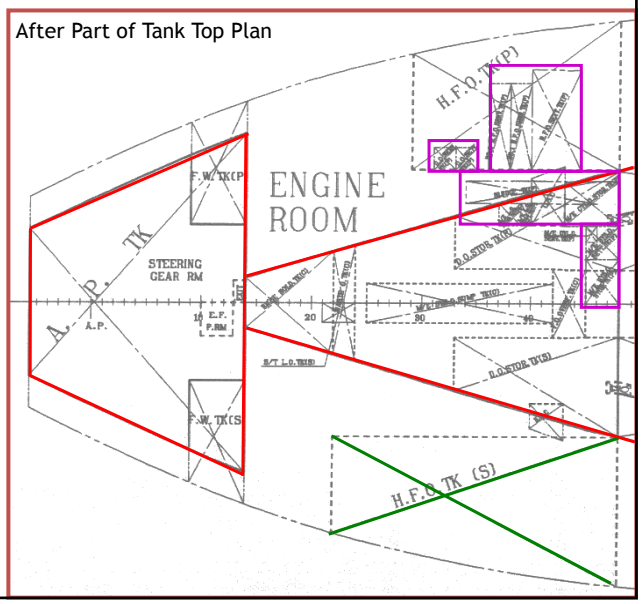
③ — · — · — · — · —

(alternated long and short dash line) : tank compartment

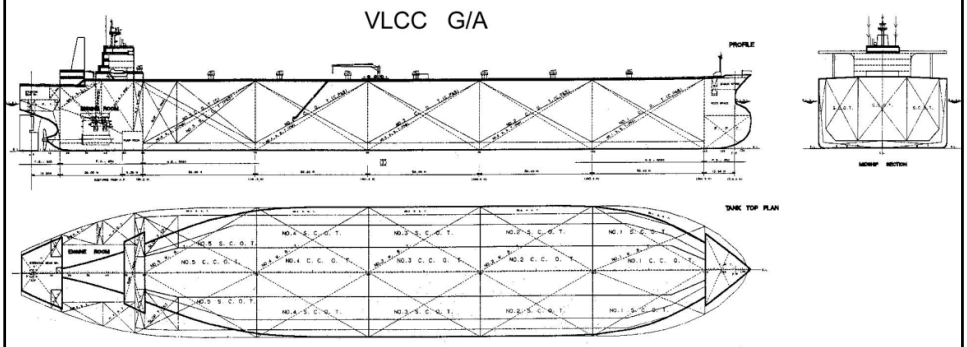
④ — · · — · · —

(alternate long and two short dashes line) : located above cutting plane

After Part of Tank Top Plan



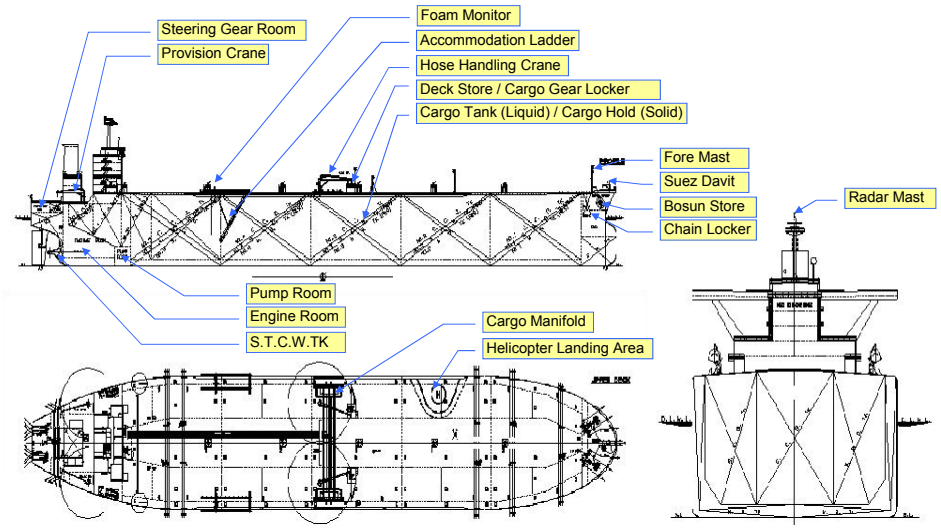
General Arrangement (G/A) of a VLCC



MAIN PARTICULARS

-Length over all:	apprx. 330.50m	-Draught(Designed, moulded)	: 21.40m	-Crusing Range : apprx. 30,000NM	
-Length betw. Perpendicular	: 318.00m	-Draught(Scantling, moulded)	: 22.60m	-Service Speed : apprx. 15.3knots	
-Breath(moulded)	: 58.00m	-Deadweight at Td :	apprx. 288,000MT	(Designed draught, 90% MCR, 15% Sea margin)	
-Depth(moulded)	: 31.25m	at Ts :	apprx. 308,500MT	-Class : DNV or ABS or LR equivalent	
				-Gross Tonnage : apprx. 160,480 tons	
				-Complements : 30 persons + 6suez crews	

G/A of a VLCC



* S.T.C.W. TK: Stern Tube Cooling Water Tank
* Reference: DSME

3. Arrangement Design of Tanker

VLCC (Very Large Crude oil Carrier)

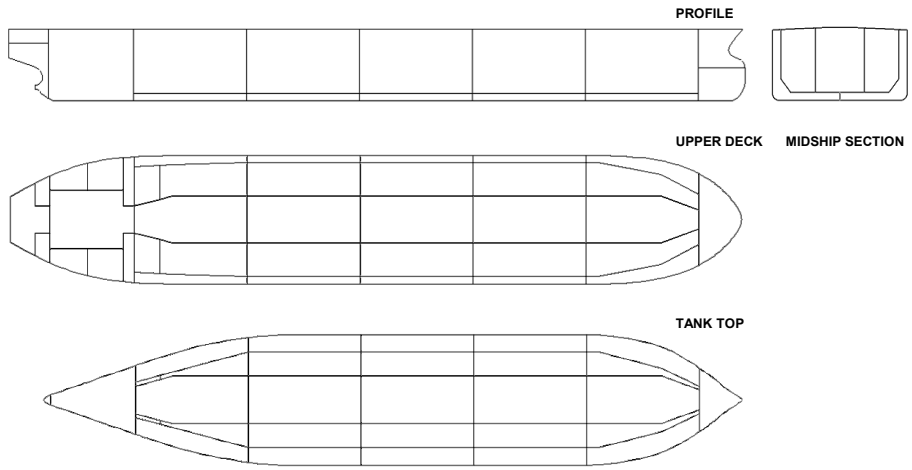
- ☑ Types: Crude oil tanker, product carrier, chemical Tanker
- ☑ Speed: 14~15 knots (about 26~27 km/h)
- ☑ VLCC: DWT 280,000~310,000 ton
- ☑ 40 days required per one voyage from Persian Gulf to Korea (speed 15~16 knots)

442,000ton DWT
ULCC(Ultra Large Crude Oil Carrier)

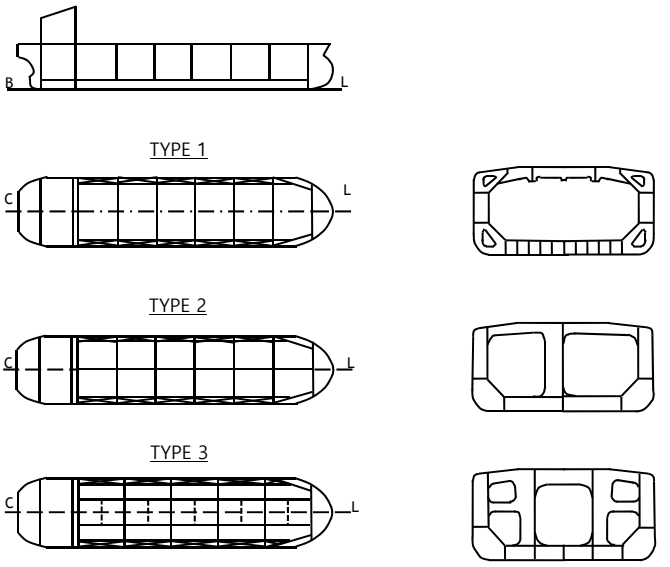
300,000ton DWT VLCC

Compartment Arrangement of a VLCC

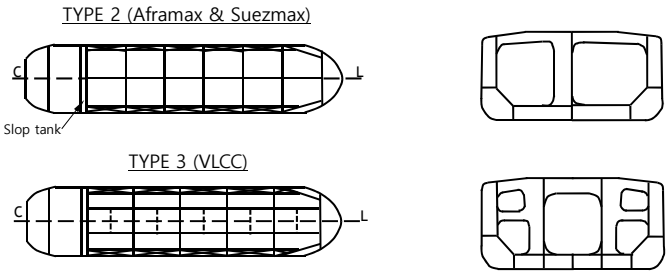
Sketch G/A



Various Types of Compartment Arrangements of Tankers (1/2)



Various Types of Compartment Arrangements of Tankers (2/2)



General arrangement of compartments

Ship Size	Cargo Hold	Ballast Tank	Slop Tank*	Tank Arrangement in Midship
Aframax	6 pairs	4 pairs	2 EA	2 pairs (port & starboard) in transverse direction, 1 longitudinal bulkhead
Suezmax	6 pairs	4 pairs	2 EA	2 pairs (port & starboard) in transverse direction, 1 longitudinal bulkhead
VLCC	5 center 5 pairs	5 pairs	2 EA	3 pairs (center, port & starboard) in transverse direction, 2 longitudinal bulkheads

* Slop tank: Tank for storing polluted ballast water and cleansing water for tank

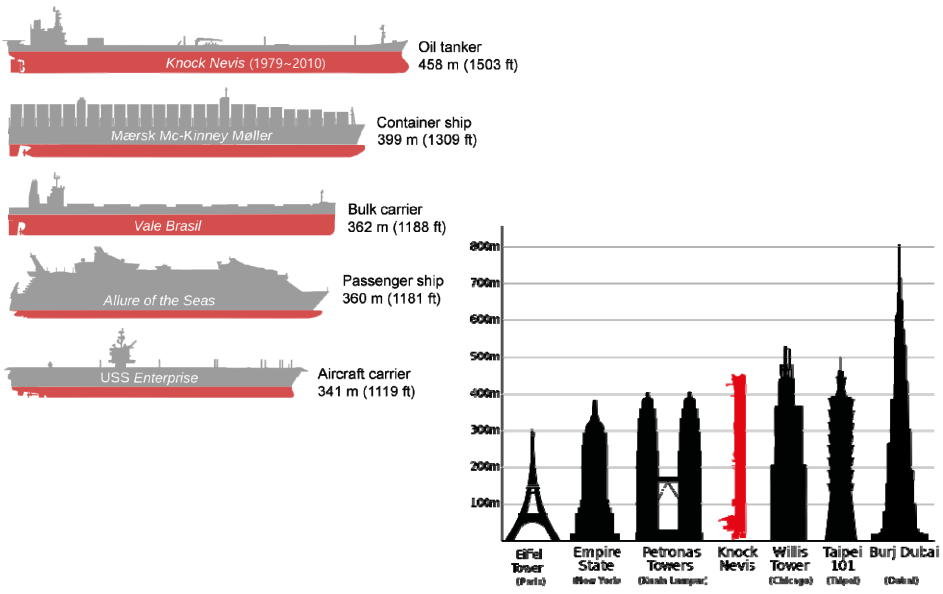
[Reference] Category of Oil Tanker Size

AFRA[1] Scale		Flexible Market Scale	
Class	Size in DWT	Class	Size in DWT
General Purpose Tanker	10,000~24,999	Seawaymax	10,000~60,000
Medium Range Tanker	25,000~44,999	Panamax	60,000~80,000
LR1 (Large Range 1)	45,000~79,999	Aframax	80,000~120,000
LR2 (Large Range 2)	80,000~159,999	Suezmax	120,000~200,000
VLCC	160,000~319,999	VLCC	200,000~320,000
ULCC	320,000~549,999	ULCC	320,000~550,000

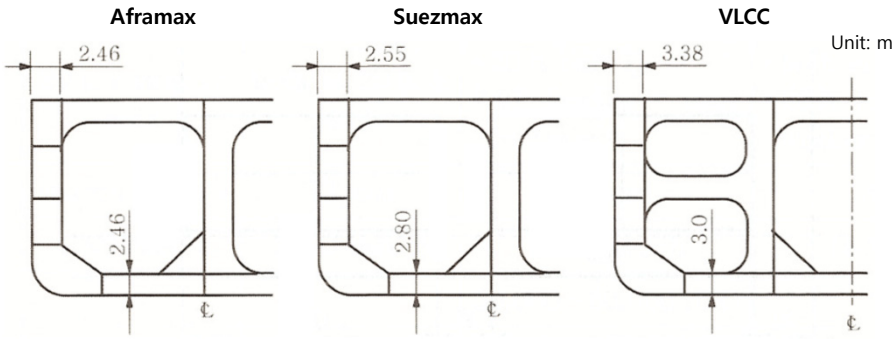
Class	Typical Length	Typical Breadth	Typical Draft
Seawaymax	226 m	24 m	7.92 m
Panamax	228.6 m	32.3 m	12.6 m
Aframax	253.0 m	44.2 m	11.6 m
Suezmax	-	-	16 m
VLCC	330 m	60 m	20 m
ULCC	-	-	-

1: Average Freight Rate Assessment system which classifies tankers of different sizes developed by Shell Oil in 1954

[Reference] Longest Oil Tanker Ever Built



Double Bottom Height and Wing Tank Width of Various Types of Tankers

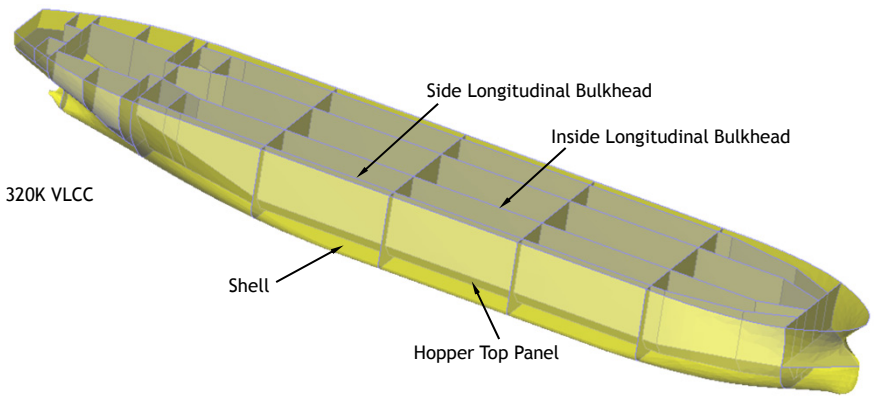


General values of double bottom height and wing tank width

Ship Size (Deadweight)	D/B Height [m]	Wing Tank Width [m]
Aframax (80~120K)	2.46	2.46
Suezmax (120~180K)	2.80	2.55
VLCC (280~320K)	3.00	3.38

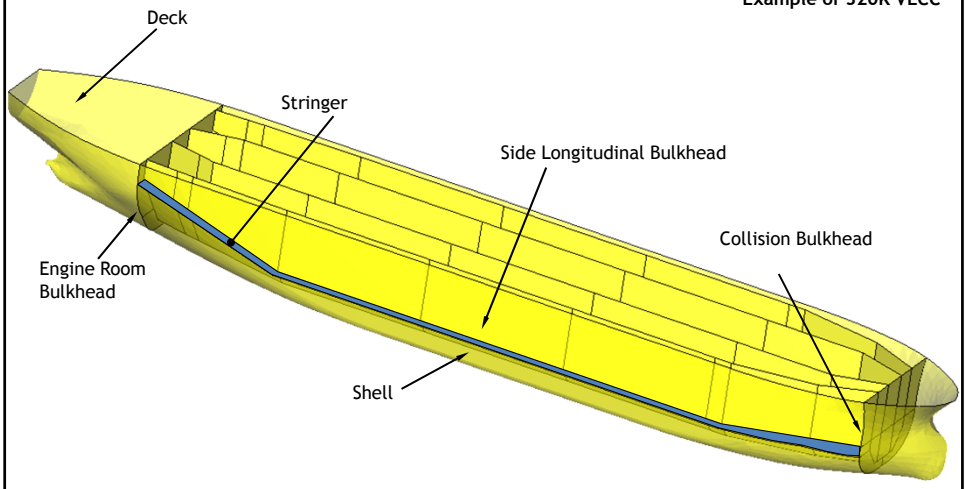
Compartment Arrangement Model of a VLCC (1/2)

Example of 320K VLCC



Compartment Arrangement Model of a VLCC (2/2)

Example of 320K VLCC



Check Points for Compartment Arrangement of Tanker (1/2)

☑ **Requirements for (MARPOL 73/78)***

- Inner hull including slop tank should have distance of from outer hull.

☑ **Limitations of Size and Arrangement of Cargo Tank (MARPOL 73/78)**

- Check whether the requirement (length and volume of tank) is satisfied or not after calculating PL (Protective Location) & SBT (Segregated Ballast Tanks).
  - PL of SBT: The ballast tanks are positioned where the impact of a collision or grounding is likely to be greatest. In this way the amount of cargo spilled after such an accident will be greatly reduced.
  - For oil tankers delivered before [1 January 2010], Annex I, Reg. 26 should be considered.
- Oil tankers delivered on or after [1 January 2010] should satisfy a new regulation for "Accidental Oil Outflow Performance" (Annex I, Reg. 23).

* Background: The Exxon Valdez oil spill occurred in Prince William Sound, Alaska, on March 24, 1989.

Check Points for Compartment Arrangement of Tanker (2/2)

☑ **Slop Tank (MARPOL 73/78)**

- Oil tankers delivered on or after [31 December 1979] should have a sufficient slop tank to
  . (over 3% of total cargo tank)

☑ **Segregated Ballast Tanks (SBT) (MARPOL 73/78)**

- Oil tankers over 20,000 DWT delivered on or after [1 June 1982] should have a sufficient, segregated ballast tanks for ballast condition.

☑ **Protection of Fuel Oil Tanks (MARPOL 73/78)**

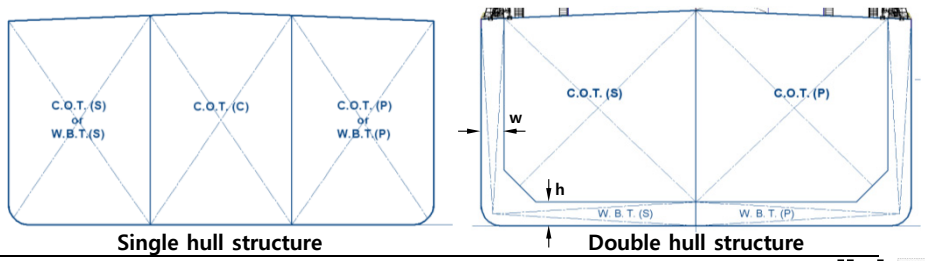
- Fuel oil tanks having an aggregate capacity of over 600 m^3 of oil tankers delivered on or after [1 August 2010] should be properly protected.

Double Hull Structure (1/2)

☑ Target: Oil tankers over 600 DWT delivered on or after [6 July 1996]

☑ Regulation: MARPOL Annex I, Reg. 19

Item	Requirement	
Double bottom height	Over 5,000 DWT	h = B / 15 (m) or h = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m
	Less than 5,000 DWT	h = B / 15 (m) with a minimum value of 0.76 m
Wing tank width	Over 5,000 DWT	w = 0.5 + DWT / 20,000 (m) or w = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m
	Less than 5,000 DWT	w = 0.4 + 2.4 * DWT / 20,000 (m) with a minimum value of 0.76 m

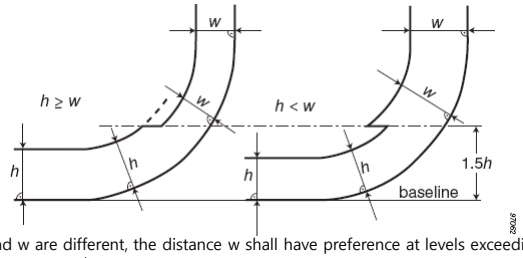


Single hull structure Double hull structure

Double Hull Structure (2/2)

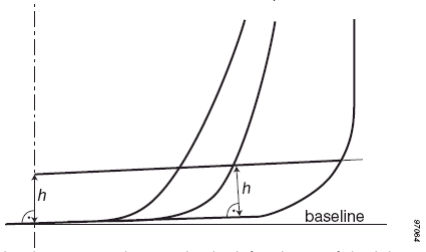
Cargo tank boundary lines

Over 5,000 DWT



When the distances h and w are different, the distance w shall have preference at levels exceeding 1.5h above the baseline .

Less than 5,000 DWT



In the turn of the bilge area and at locations without a clearly defined turn of the bilge, the cargo tank boundary line shall run parallel to the line of the midship flat bottom

Limitations of Size and Arrangement of Cargo Tank (1/4)

- ☑ **Target: Oil tankers delivered on or after [1 January 2010]**
- ☑ **Objective: To provide adequate protection against oil pollution in the event of collision or stranding**
- ☑ **Regulation: MARPOL Annex I, Reg. 23 (Accidental Oil Outflow Performance)**

For over 5,000 DWT, the mean oil outflow parameter shall be as follows:

Item	Requirement	
Mean oil outflow parameter (O_M)	C ≤ 200,000 m³	$O_M \leq 0.015$
	200,000 m³ ≤ C ≤ 400,000 m³	$O_M \leq 0.012 + (0.003 / 200{,}000) \cdot (400{,}000 - C)$
	400,000 m³ ≤ C	$O_M \leq 0.012$

* C: Total volume of cargo oil, in m^3, at 98% tank filling

Limitations of Size and Arrangement of Cargo Tank (2/4)

For less than 5,000 DWT, the length of each cargo tank shall not exceed 10 m or one of the following values, whichever is the greater.

Item			Calculation formula
No longitudinal bulkhead inside cargo tanks			(0.5 bi/B + 0.1)L, but not to exceed 0.2L
Centerline longitudinal bulkhead inside the cargo tanks			(0.25 bi/B + 0.15)L
Two or more longitudinal bulkheads	Wing cargo tanks		0.2L
	Center cargo tanks	bi/B ≥ 0.2L	0.2L
		bi/B < 0.2L	(0.5 bi/B + 0.1)L ; no centerline longitudinal bulkhead (0.25 bi/B + 0.15)L ; centerline longitudinal bulkhead

* b_i: The minimum distance from the ship's side to the outer longitudinal bulkhead of the tank in question measured inboard at right angles to the centerline at the level corresponding to the assigned summer freeboard

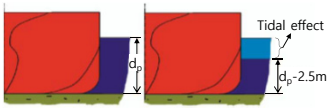
Limitations of Size and Arrangement of Cargo Tank (3/4)

☑ **Calculation of Mean Oil Outflow Parameter (O_M)**

$$O_M = (0.4\ O_{MS} + 0.6\ O_{MB}) / C$$

$O_{MS} = C_3 \sum P_{s(i)} O_{s(i)}$; **Side Damage**

i: Each cargo tank under consideration
$P_{s(i)}$: The probability of penetrating cargo tank i from side damage
$O_{s(i)}$: The outflow from side damage to cargo tank i;
Assumed equal to the total volume in cargo tank i at 98% filling



* d_p: Partial load line draft

$O_{MB} = 0.7\ O_{MB(0)} + 0.3\ O_{MB(2.5)}$; **Bottom Damage**

$O_{MB(0)}$: Mean outflow for 0 m tide condition (m^3)
$O_{MB(2.5)}$: Mean outflow for -2.5 m tide condition (m^3)

* C: Total volume of cargo oil, in m^3, at 98% tank filling

Limitations of Size and Arrangement of Cargo Tank (4/4)

☑ **Calculation of Mean Oil Outflow Parameter (O_M) (Detailed)**

$$O_M = \left(0.4O_{MS} + 0.6O_{MB}\right) / C$$

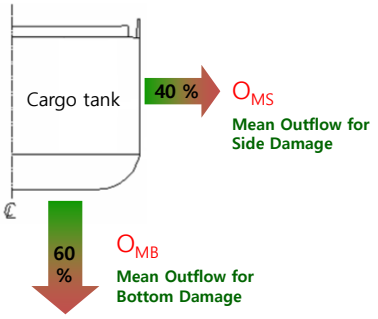
where,

$$O_{MS} = C_3 \sum_1^n P_{S(i)} \cdot O_{S(i)} \ [m^3]$$

$$O_{MB} = 0.7O_{MB(0)} + 0.3O_{MB(2.5)}$$

$$O_{MB(0)} = \sum_1^n P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \ [m^3] \quad for\ 0\ m\ tide$$

$$O_{MB(2.5)} = \sum_1^n P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \ [m^3] \quad for\ -2.5\ m\ tide$$



Note)
i: Each cargo tank under consideration
n: Total number of cargo tanks
O_{MS}: Mean outflow for side damage, in m^3
O_{MB}: Mean outflow for bottom damage, in m^3
$O_{MB(0)}$: Mean outflow for 0 m tide condition
$O_{MB(2.5)}$: Mean outflow for minus 2.5 m tide condition, in m^3
$P_{S(i)}$: The probability of penetrating cargo tank i from side damage
$O_{S(i)}$: The outflow, in m^3, from side damage to cargo tank i, which is assumed equal to the total volume in oil fuel tank i at 98% filling
C_3: 0.77 for ships having two longitudinal bulkheads inside the cargo tanks, provided these bulkheads are continuous over the cargo block. 1.0 for all other ships
$P_{B(i)}$: The probability of penetrating cargo tank i from bottom damage
$O_{B(i)}$: The outflow from cargo tank i, in m^3 (after tidal change for $O_{MB(2.5)}$)
$C_{DB(i)}$: Factor to account for oil capture

37

Slop Tank

☑ **Target: Oil tankers delivered on or after [31 December 1979]**

☑ **Regulation: MARPOL Annex I, Reg. 29**

☑ **Purpose: To store polluted ballast water and cleansing water for tank**

- When void cargo hold at ballast condition is filled with sea water in an emergency, oil from dirty water generated by tank washing is separated and stored in slop tank.

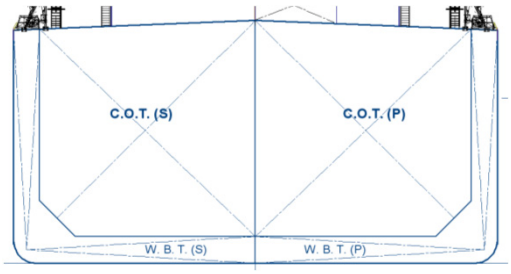
☑ **Capacity: Over 3% of total cargo tank, except that the Administration may accept:**

- 2% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system;
- 2% where segregated ballast tanks or dedicated clean ballast tanks are provided in accordance with regulation 18 of this Annex, or where a cargo tank cleaning system using crude oil washing is fitted in accordance with regulation 33 of this Annex. This capacity may be further reduced to 1.5% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system; and
- 1% for combination carriers where oil cargo is only carried in tanks with smooth walls. This capacity may be further reduced to 0.8% where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system.

Segregated Ballast Tanks (SBT)

- ☑ Target: Oil tankers over 20,000 DWT delivered on or after [1 June 1982]
- ☑ Regulation: MARPOL Annex I, Reg. 18
- ☑ Requirements: The capacity of the segregated ballast tanks shall be so determined that the ship may operate safely on ballast voyages (ballast condition) without recourse to the use of cargo tanks for water ballast.

Item	Requirement
Moulded draft amidships (d_m)	$d_m \geq 2.0\ m + 0.02L$
Trim by stern	Less than 0.015L
Propeller	Full immersion



Fuel Oil Tanks (1/6)

- ☑ Target: Oil tankers having an aggregate fuel oil capacity of over 600 m^3 delivered on or after [1 August 2010]
- ☑ Regulation: MARPOL Annex I, Reg. 12A
- ☑ Impact: Decrease of fuel oil volume, Reduction of cruising range

Item		Requirement
Capacity of individual fuel oil tank		Less than 2,500 m^3 (at 98% filling)
Distance from bottom		h = B / 20 (m) or h = 2.0 m, whichever is the lesser, with a minimum value of 0.76 m
Distance from side	600 ~ 5,000 m^3	w = 0.4 + 2.4 C / 20,000 (m) with a minimum value of 1.0 m. However for individual tanks with an oil fuel capacity of less than 500 m^3 the minimum value is 0.76 m.
	Over 5,000 m^3	w = 0.5 + C / 20,000 (m) or w = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m
Mean oil outflow parameter (O_M)	600 ~ 5,000 m^3	$O_M < 0.0157 - 1.14 \cdot 10^{-6} \cdot C$
	Over 5,000 m^3	$O_M < 0.010$

* C: Total fuel oil volume, in m^3, at 98% tank filling

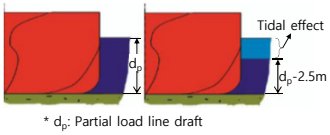
Fuel Oil Tanks (2/6)

☑ **Calculation of Mean Oil Outflow Parameter (O_M)**

$$O_M = (0.4\ O_{MS} + 0.6\ O_{MB}) / C$$

$O_{MS} = \sum P_{s(i)} O_{s(i)}$; **Side Damage**

i: Each fuel oil tank under consideration
$P_{s(i)}$: The probability of penetrating fuel oil tank i from side damage
$O_{s(i)}$: The outflow from side damage to fuel oil tank i;
Assumed equal to the total volume in fuel oil tank i at 98% filling



* d_p: Partial load line draft

$O_{MS} = 0.7\ O_{MB(0)} + 0.3\ O_{MB(2.5)}$; **Bottom Damage**

$O_{MB(0)}$: Mean outflow for 0 m tide condition (m^3)
$O_{MB(2.5)}$: Mean outflow for -2.5 m tide condition (m^3)

Fuel Oil Tanks (3/6)

☑ **Calculation of Mean Oil Outflow Parameter (O_M) (Detailed)**

$$O_M = (0.4O_{MS} + 0.6O_{MB}) / C$$

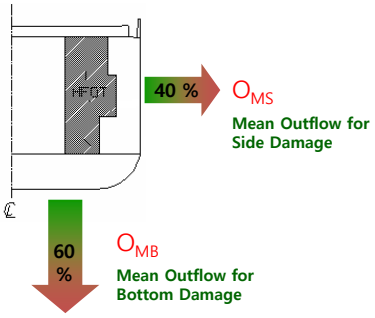
where,

$$O_{MS} = \sum_1^n P_{S(i)} \cdot O_{S(i)}\ [m^3]$$

$$O_{MB} = 0.7O_{MB(0)} + 0.3O_{MB(2.5)}$$

$$O_{MB(0)} = \sum_1^n P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)}\ [m^3]\ \ for\ 0\ m\ tide$$

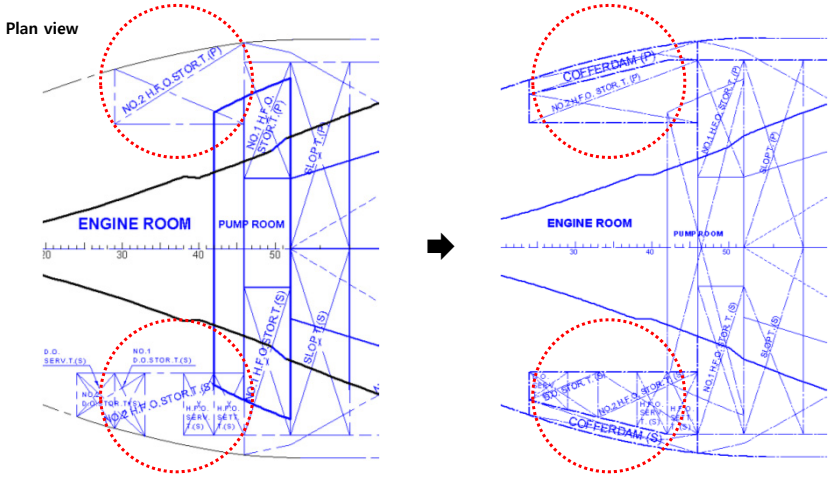
$$O_{MB(2.5)} = \sum_1^n P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)}\ [m^3]\ \ for\ -2.5\ m\ tide$$



Note)
i: Each fuel oil tank under consideration
n: Total number of fuel oil tanks
O_{MS}: Mean outflow for side damage, in m^3
O_{MB}: Mean outflow for bottom damage, in m^3
$O_{MB(0)}$: Mean outflow for 0 m tide condition
$O_{MB(2.5)}$: Mean outflow for minus 2.5 m tide condition, in m^3
$P_{S(i)}$: The probability of penetrating fuel oil tank i from side damage
$O_{S(i)}$: The outflow, in m^3, from side damage to fuel oil tank i, which is assumed equal to the total volume in fuel oil tank i at 98% filling
$P_{B(i)}$: The probability of penetrating fuel oil tank i from bottom damage
$O_{B(i)}$: The outflow from fuel oil tank i, in m^3 (after tidal change for $O_{MB(2.5)}$)
$C_{DB(i)}$: Factor to account for oil capture

Fuel Oil Tanks (4/6)

☑ **Impact: Decrease of fuel oil volume, Reduction of cruising range**



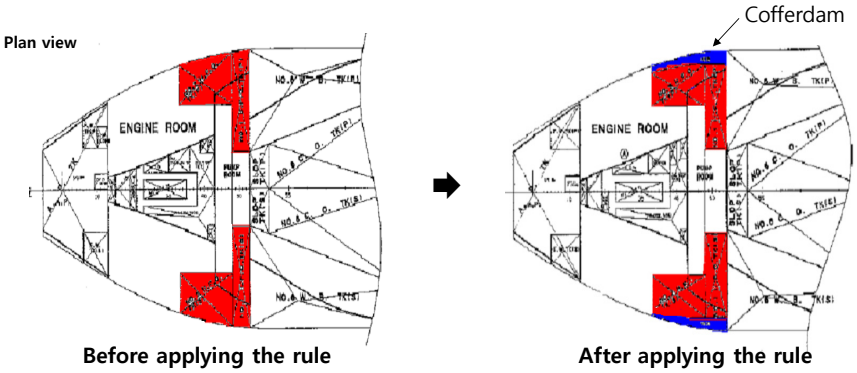
Before applying the rule

After applying the rule

Fuel Oil Tanks (5/6)

☑ **Application to Aframax Tanker**

- **The reduced volume of HFO was allocated at the cargo tank (decrease of cargo volume).**



Before applying the rule

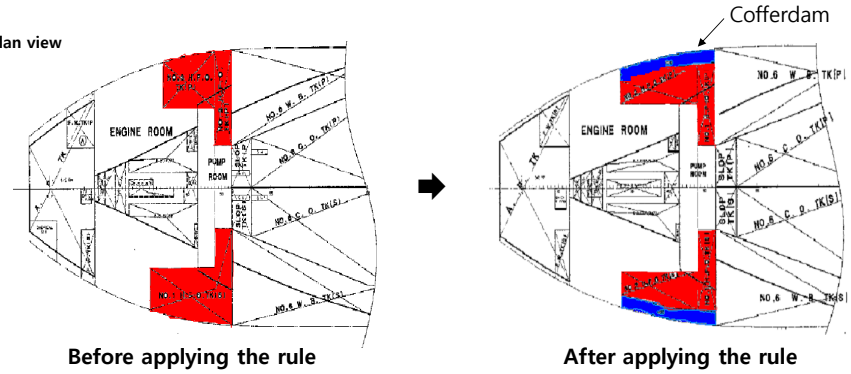
After applying the rule

Fuel Oil Tanks (6/6)

☑ **Application to Suezmax Tanker**

- **The reduced volume of HFO was allocated at engine room (rearrangement of engine room).**

Plan view

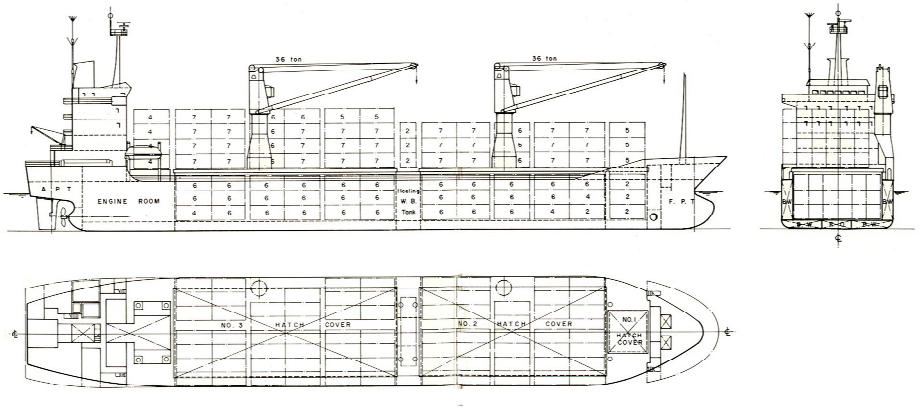


Before applying the rule

After applying the rule

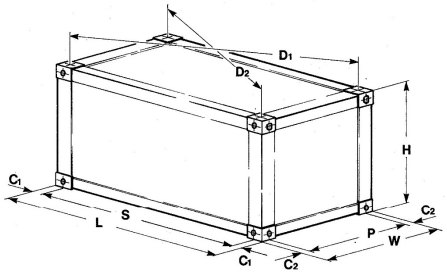
4. Arrangement Design of Container Ship

400 TEU Semi-Container Ship (Multi Purpose Container Vessel)



LOA	: 121.50 m	Dmld	: 8.50 m	Deadweight at designed draft	: 7,418 ton
LBP	: 111.70 m	Td	: 6.45 m	Service Speed (85% MCR, 15% SM)	: 13.35 knots
Bmld	: 19.20 m	Ts	: 6.50 m	Complement	: 22 persons

Size and Weight of Different Container Types

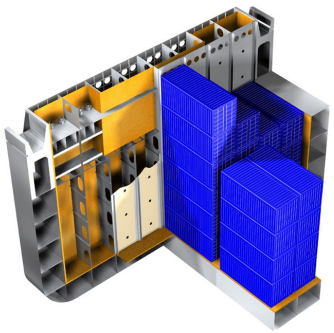


Type	Height (H)		Width (W)		Length (L)		Max Weight (kg)
	mm	ft-in	mm	ft-in	mm	ft-in	
1A	2,438	8'	2,438	8'	12,192	40'	30,480
1AA (FEU)	2,591	**8'-6"**	2,438	**8'**	12,192	**40'**	30,480
1B	2,438	8'	2,438	8'	9,152	29'-11 1/4"	25,400
1C	2,438	8'	2,438	8'	6,058	19'-10 1/2"	20,320
1CC (TEU)	2,591	**8'-6"**	2,438	**8'**	6,058	**19'-10 1/2"**	20,320
1D	2,438	8'	2,438	8'	2,991	9'-9 3/4"	10,160

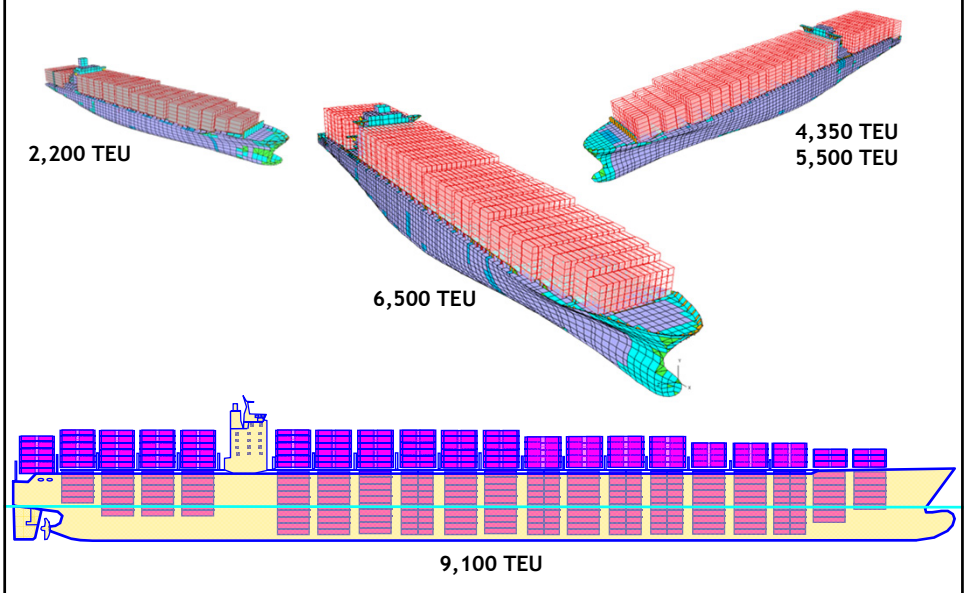
Large Container Ship

☑ Korean shipyards have the superiority of large size container ship.

- Beyond 10,000 TEU construction, under construction for 19,000 TEU, design completion for 22,000 TEU in Korea
- In Korea, 12 cycle engine is being applied and pod system is under examination.



Various Sizes of Container Ship



* Reference: DSME

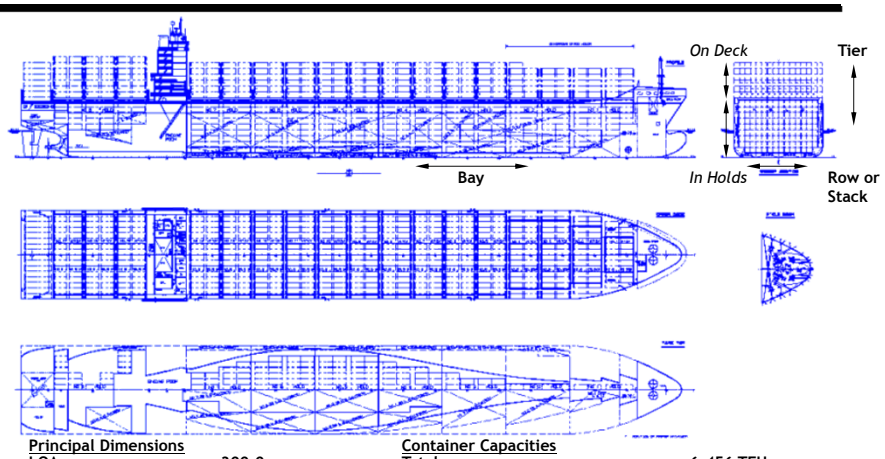
Examples of Large Size Container Ship

13,800 TEU Container Ship by HHI

18,270 TEU Container Ship by DSME

* Reference: HHI and DSME

G/A of a 6,500 TEU Container Ship



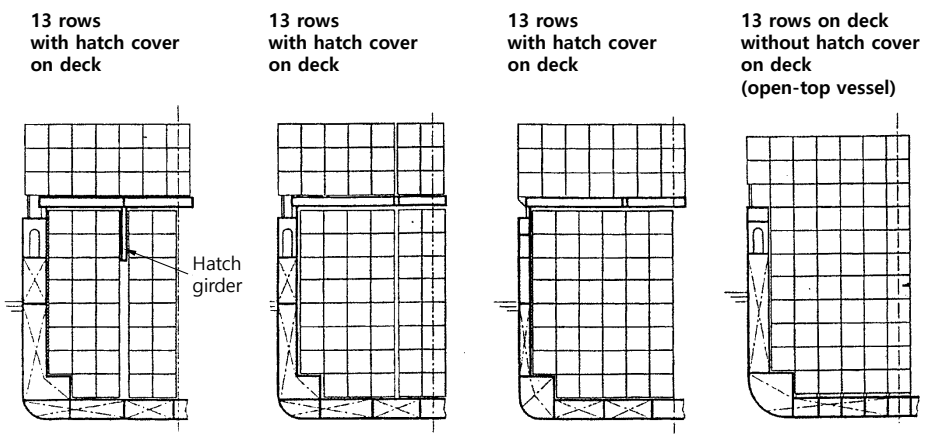
Principal Dimensions	
LOA	300.0 m
LBP	286.56 m
B	40.0 m
D	24.2 m
Td / Ts	12.0 / 14.5 m
Deadweight at Ts	78,100 ton
Service speed at Td at NCR with 15% sea margin	27.0 knots

Container Capacities	
Total	6,456 TEU
On deck	3,398 TEU
In hold	3,058 TEU
Reefer container (on deck)	500 FEU

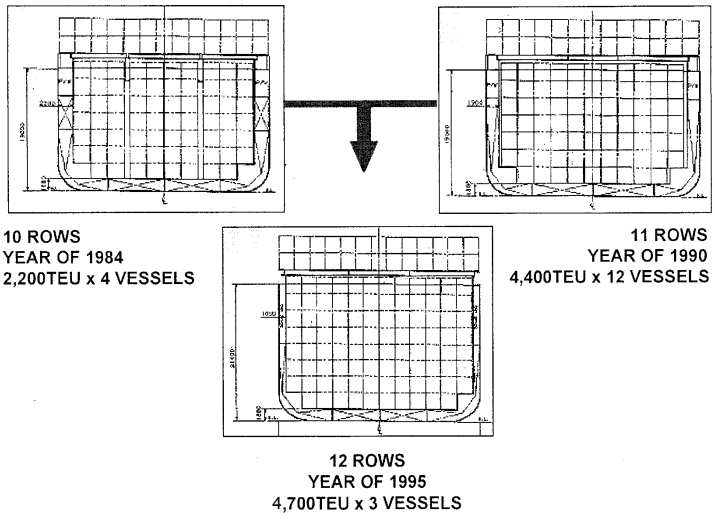
Main Engine	B&W 12K98MC-C
MCR	93,120 PS x 104.0 rpm
NCR	83,810 PS x 100.4 rpm
Cruising range	23,500 N/M

* Reference: DSME

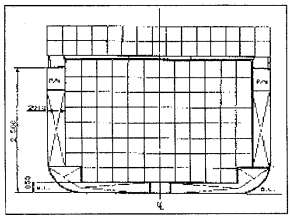
Various Container Arrangement in Midship Section



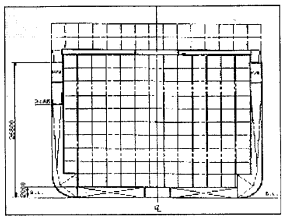
Increased Rows of a PAX (Panamax) Beam Container Ship



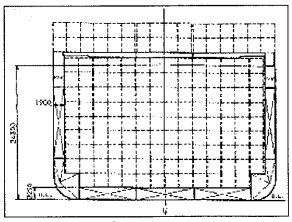
Increased Rows of a POSTPAX (Post Panamax) Beam Container Carrier



12 ROWS
YEAR OF 1990
B = 37.1 m



13 ROWS
YEAR OF 1992
B = 38.0 m

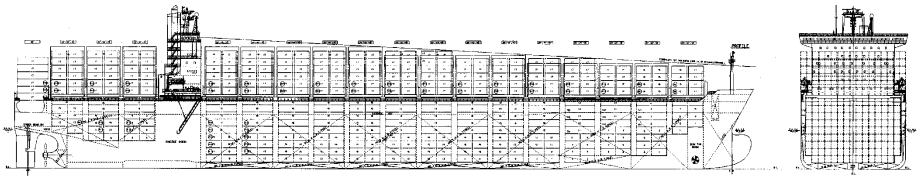


14 ROWS
YEAR OF 1995
B = 40.0 m

15 ROWS
YEAR OF 1995
B = 42.8 m

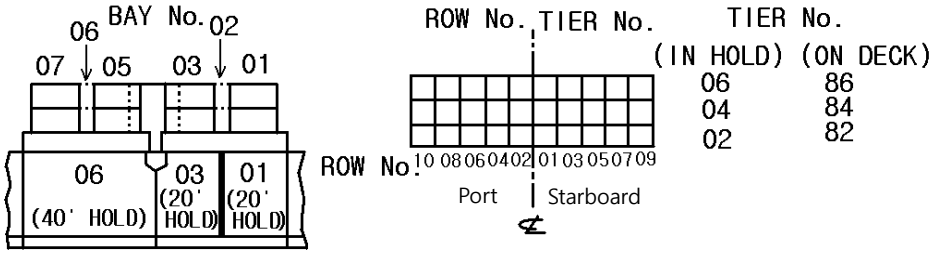
* Allowable dimensions for Panama Canal (Post Panama)
- Length = 294.13 m (about 366 m)
- Breadth = 32.31 m (about 49 m)
- Draft = 12.04 m (about 15 m)
- Container Capacity = 4,400 TEU (14,000 TEU)

G/A (Profile & Midship) of a POSTPAX Beam Container Ship

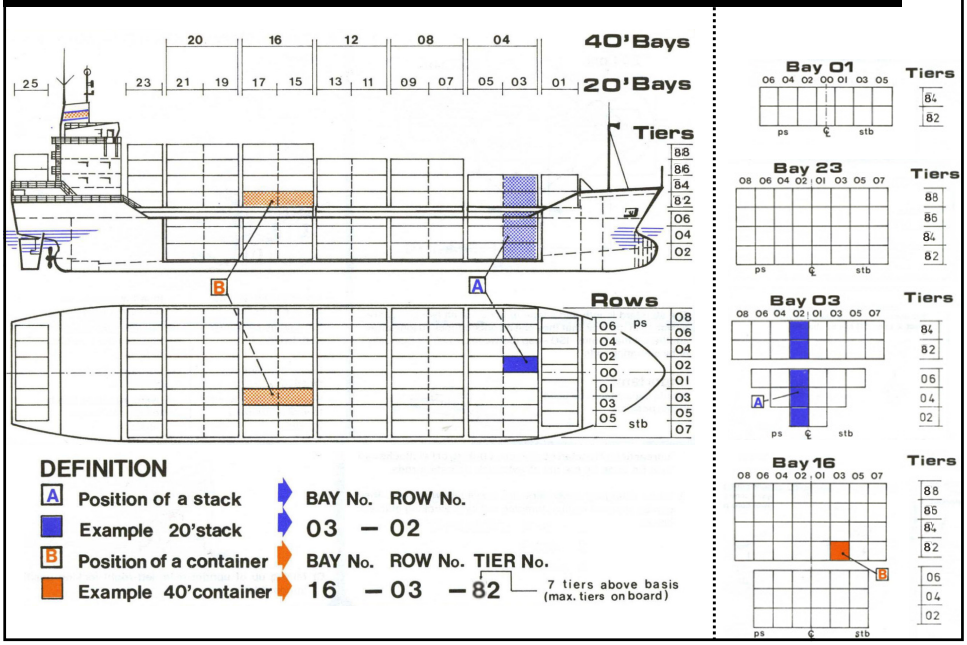


Code of the Container Position (1/2)

- ☑ Each container loaded on the container ship has its own position for loading, and thus specific codes are given to the position for loading convenience.
- ☑ The codes represent longitudinal ( ), transverse ( ), and vertical location ( ) for the position.
- ☑ The coding method is different from shipping companies and one example is as follows.
  - For 20 ft container, the bay number is given as an odd from stem. For 40 ft container, the bay number is given as the next even number.
  - The tier number in holds is an even. The tier number on deck starts from 82.
- ☑ The code is marked to available space near cargo holds or hatch covers, as shown in the figure.
- ☑ Cell guides are generally fixed and thus 40 ft containers can not be loaded at the position where 20 ft containers will be loaded due to cell guides. In some cases, 40 ft containers can be loaded at the position for 20 ft containers by removing the cell guides.

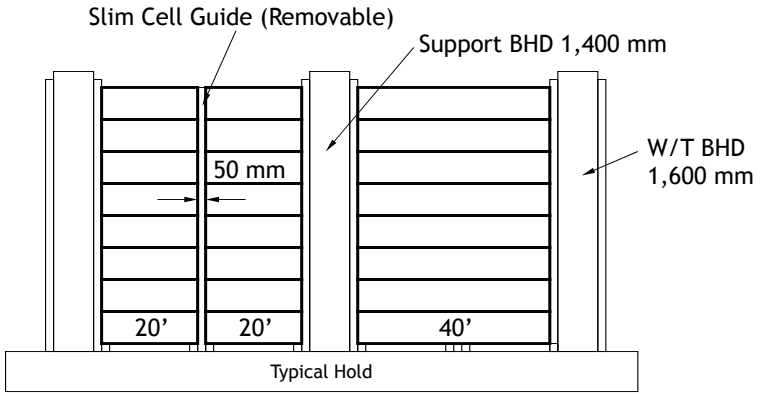


Code of the Container Position (2/2)



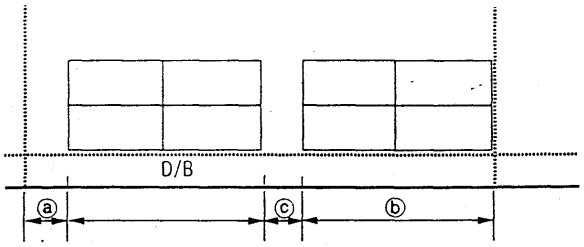
Container Arrangement in Hold

- ☑ **Install slim cell guide of 50 mm between 20′ (feet) container.**
- ☑ **Support BHD has generally 1.4 m space for human access.**
- ☑ **For only 20′ container loading, slim cell guide is installed but for 20′ and 40′ container loading, it is not installed.**

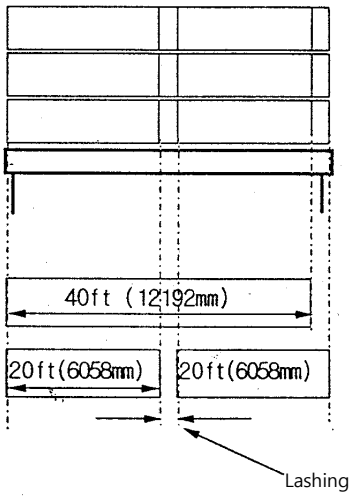


Criteria for Container Arrangement in Hold

- ☑ **Since 20 ft and 40 ft containers are generally loaded in holds, the standard length for ⓑ is as follows.**
  - **Over 4,000 TEU ➡ 12.72 m**
  - **Under 4,000 TEU ➡ 12.64 m**
- ☑ **The space ⓐ and ⓒ which represent hold space are used as hold access space, and the standard lengths for them are 1.60 m and 1.40 m, respectively.**
  - **In the case of reefer container hold, the lengths for ⓐ and ⓒ are 1.8 m by considering reefer socket and ventilation space and but if there is ship owner's requirements about this, the lengths can change by consulting with a captain.**
  - **When cargo cranes are installed on deck, the length for ⓐ or ⓒ is 3.4 m.**
- ☑ **For new designed ship above guidance can be used but if a parent ship can be used for a new ship, hold spaces can follow the parent ship.**

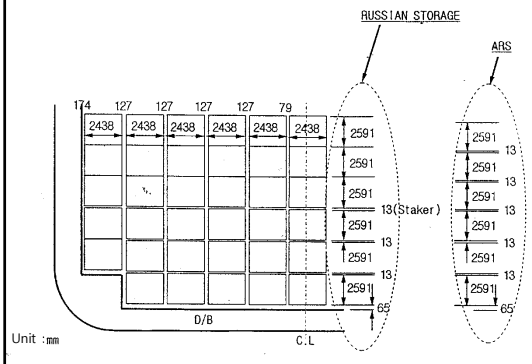


Criteria for Container Arrangement on Deck



- ☑ **The arrangement of on deck containers can change according to ship owner. If there is no requirement, the arrangement in the left figure can be the standard.**
- ☑ **20 ft and 40 ft containers can be all loaded on hatch cover.**

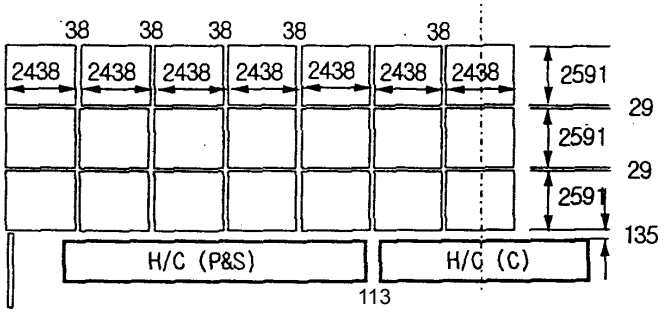
Criteria for Container Loading in Hold



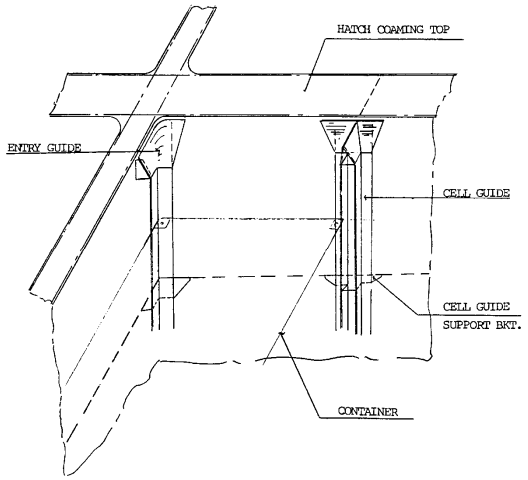
- ☑ **The container arrangement in holds can be a basis of G/A, VCG of cargo in trim & stability calculation, and the check point of cargo in holds. Thus, it should be confirmed in early stage.**
- ☑ **For Russian storage (20 ft containers are loaded without slim cell guides in holds and 40 ft containers are loaded on the 20 ft containers), containers are loaded in holds up to four tiers. Thus stackers of 13 mm between the tiers for in holds and no stacker for on deck should be considered.**
- ☑ **For ARS type, stackers of 13 mm up to top tier should be considered.**
- ☑ **In the case of 20 ft only hold, a stacker is unnecessary due to slim cell guide.**
- ☑ **The standard height of container is 8 ft 6 inch but container of 9 ft 6 inch can be loaded on top tier. When determining the height of deck and hatch coaming, it should be considered.**

Criteria for Container Loading on Deck

- ☑ **On deck containers are loaded as the following figure. Here, the height of hatch cover is related to the arrangement of on deck containers and thus it should be confirmed by ship owner (or captain).**
- ☑ **The arrangement of on deck reefer containers should be made with ship owner (or captain) after the confirmation of initial scheme.**

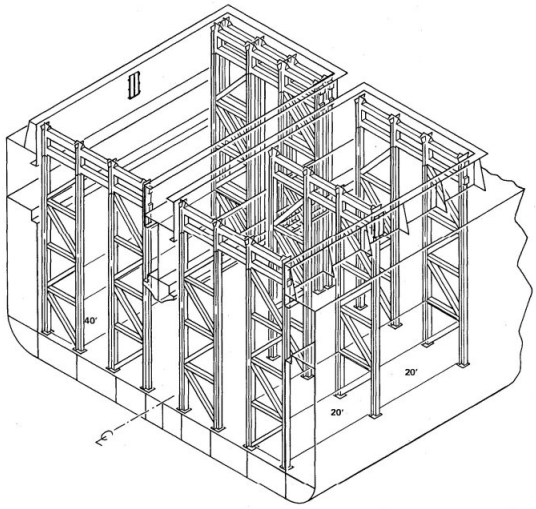


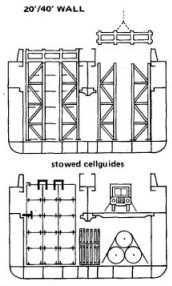
Cell Guide System of Container Carrier (1/2)



* Reference: CONVER

Cell Guide System of Container Carrier (2/2)





CHARACTERISTICS

- adjustable cellguide system for 20'/40' Cont.
- dismantable and to be stowed in containers to be located under longitudinal bulkhead in centre-line
- combined cell/blockstowage for 20' Cont.

POSSIBLE ALTERATIONS

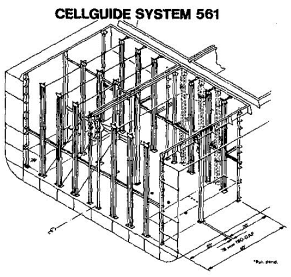
- 35' WALLS
- cellguide system fixed welded at 20' or 40' area (35')

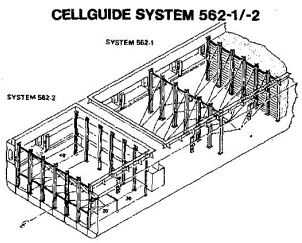
SPECIFICATION

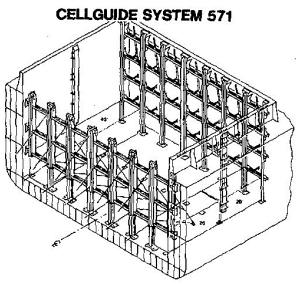
- Material : in accordance with the Classification Society
- Finish : upon client's request
- Class. approval : All items can be supplied with the approval of any Classification Society upon client's request

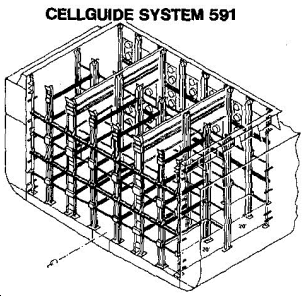
* Reference: CONVER

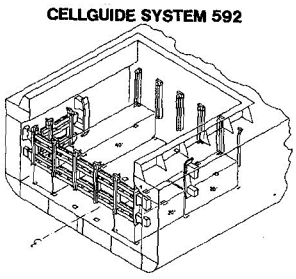
Various Cell Guide Systems

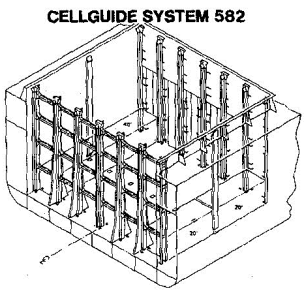






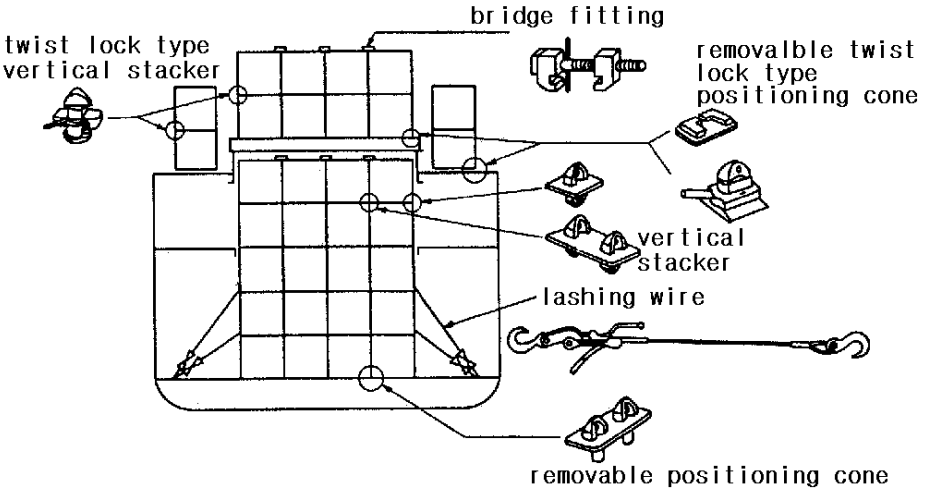






* Reference: CONVER

Various Container Fittings (1/2)



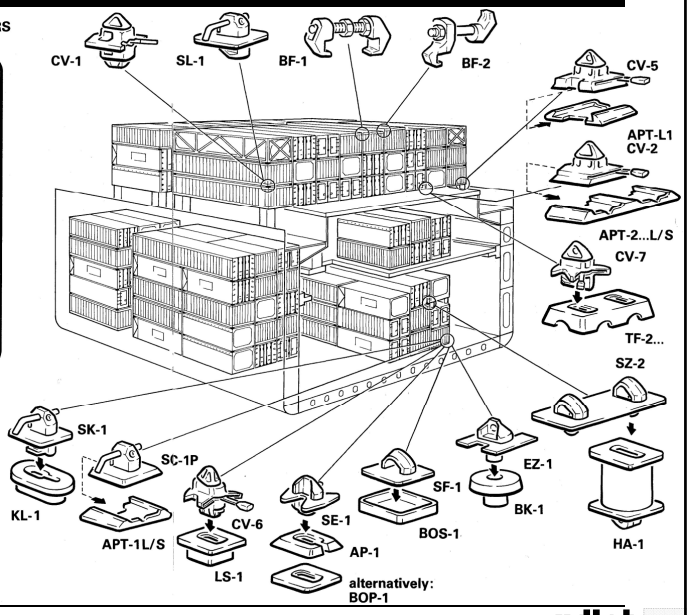
* Reference: CONVER

Various Container Fittings (2/2)

3 INTERMEDIATE & BOTTOM STACKERS
TWISTLOCKS/BRIDGE FITTINGS

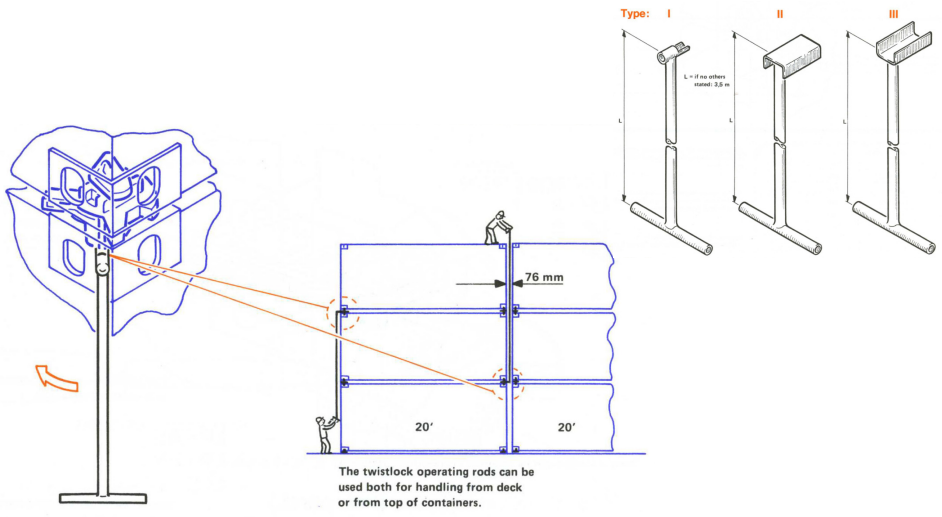
	DESCRIPTION	TYPE
3.1	INTERBRIDGE STACKING CONES SPECIAL STACKING CONES	SZ-... SZ-2-Y/-V/-CV
3.2	LEVELLING TYPES OF STACKING CONES	HA-1 HA-V/-CV
3.3	REMOVABLE CONE PLATES	EPZ-... EZ-1
3.4	BOTTOM STACKING CONES LOCKABLE STACKING CONES	SF-1/SFP-1/SE-1 SC-1/SL-1/SK-1
3.5	'SLIDE'-LOCKS SEPARATE CONES/ISO-SEA-LAND'	AC-1/AL-1 I/III/AK-P/L/IS-1/-2
3.6	BOTTOM TWISTLOCKS	CV 2 CV-5
3.7	TWISTLOCKS	CV-1 CV-1A
3.8	TWISTLOCKS FIXED BASE TWISTLOCKS	CV-3 CV-7/CV-7R
3.9	TWISTLOCKS	CV-6 CV-6-35'
3.10	TWISTLOCK ADAPTERS TWISTLOCK OPERATING RODS	LP-.../PA-... TYP I/II/III
3.11	TWISTLOCK OPERATIONS	
3.12	BRIDGE FITTINGS	BF-1/-2/-4 BF-3/BF-SR

Remark:
Corresponding bottom foundations please see Sect. 2



* Reference: CONVER

Twistlock Operating Rods

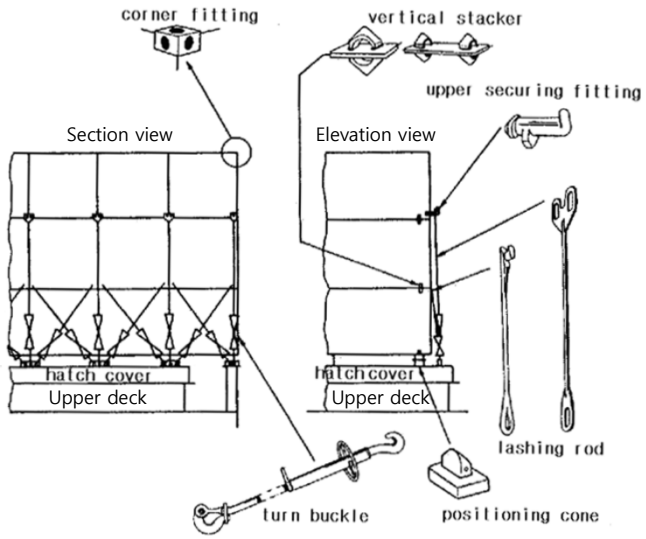


NOTE: These are three types of actuator poles. Special types can be designed and manufactured on request. When ordering, please state the length of the actuator pole and the types of twistlocks (with or without plastic cap). Material: Steel-tube, on request: Al-tube.

* Reference: CONVER

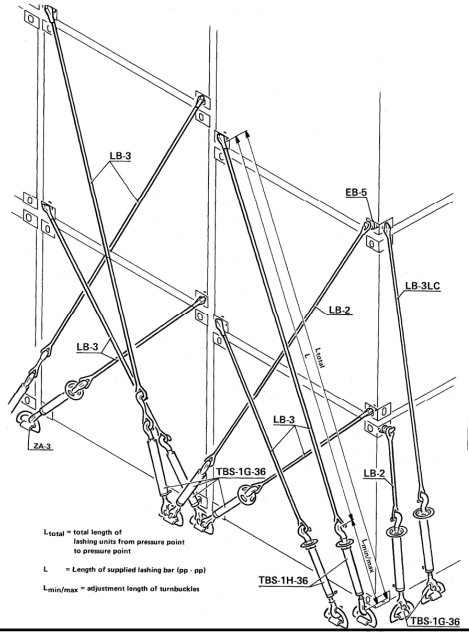
Container Lashing Equipment on Deck (1/2)

Example of lashing equipment for exposed containers



* Reference: CONVER

Container Lashing Equipment on Deck (2/2)



LB: Lashing Bar
TBS: Turn Buckle

* Reference: CONVER

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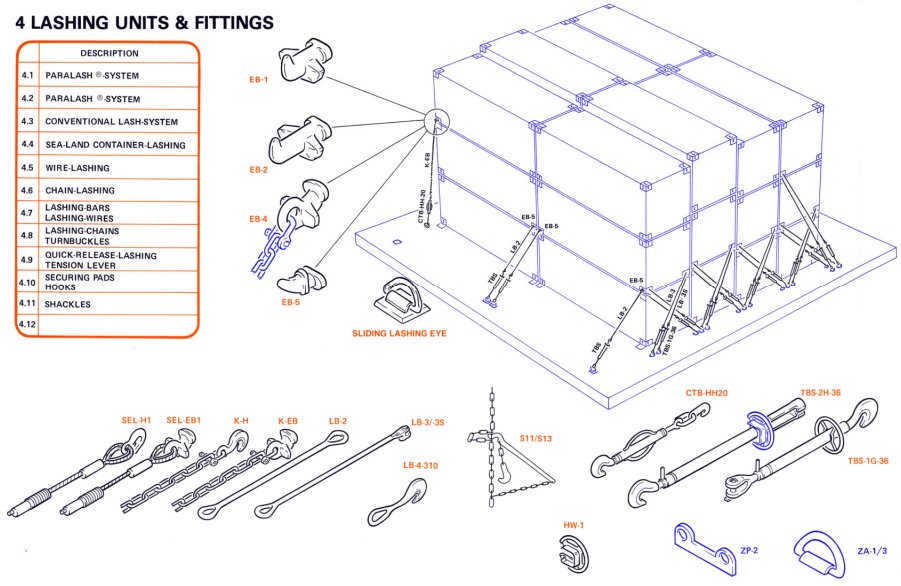
Lashing Units & Fittings

4 LASHING UNITS & FITTINGS

	DESCRIPTION
4.1	PARALASH ®-SYSTEM
4.2	PARALASH ®-SYSTEM
4.3	CONVENTIONAL LASH-SYSTEM
4.4	SEA-LAND CONTAINER-LASHING
4.5	WIRE-LASHING
4.6	CHAIN-LASHING
4.7	LASHING-BARS LASHING-WIRES
4.8	LASHING-CHAINS TURNBUCKLES
4.9	QUICK-RELEASE-LASHING TENSION LEVER
4.10	SECURING PADS HOOKS
4.11	SHACKLES
4.12	

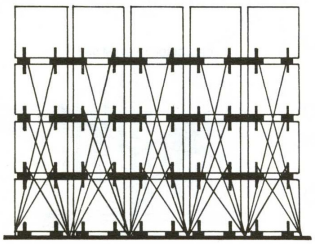


* Reference: CONVER

Lashing System

TWO GENERATIONS OF LASHINGS

CONVENTIONAL LASH-SYSTEM



Advantage of PARALASH®-SYSTEM

1.) 30-50% less lashing bars and turn-buckles

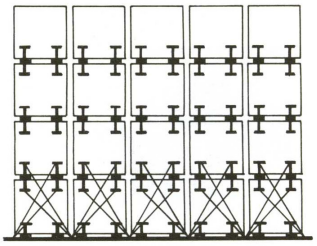
2.) same and partly higher stack load

3.) shorter lashing bars and thus better handling (weight)

4.) higher flexibility for stowage of 8' and 8'6" containers

5.) less investment and servicing costs

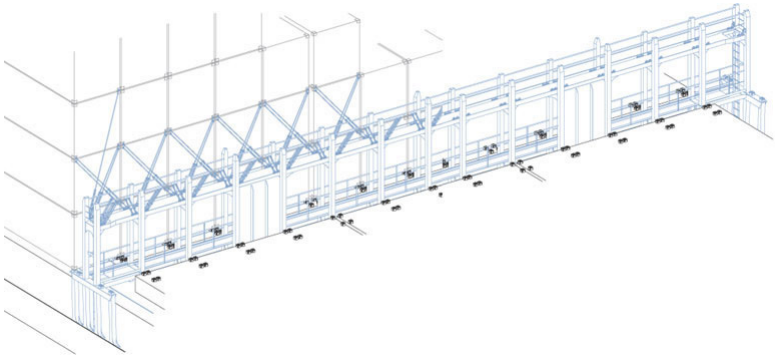
CONVER PARALASH®-SYSTEM



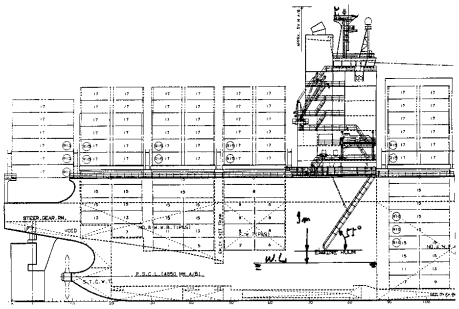
* Reference: CONVER

Lashing Bridge

- ☑ When the requested stackload for 40' containers is exceeding the limit of approx. 100 tons lashing from hatch cover level might no longer be sufficient.
- ☑ For this reason lashing bridges are installed between 40' hatches in order to realize more effective support by the lashings.

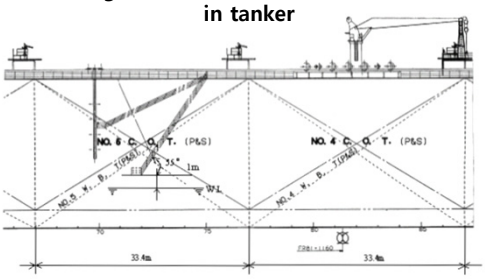


Accommodation Ladder

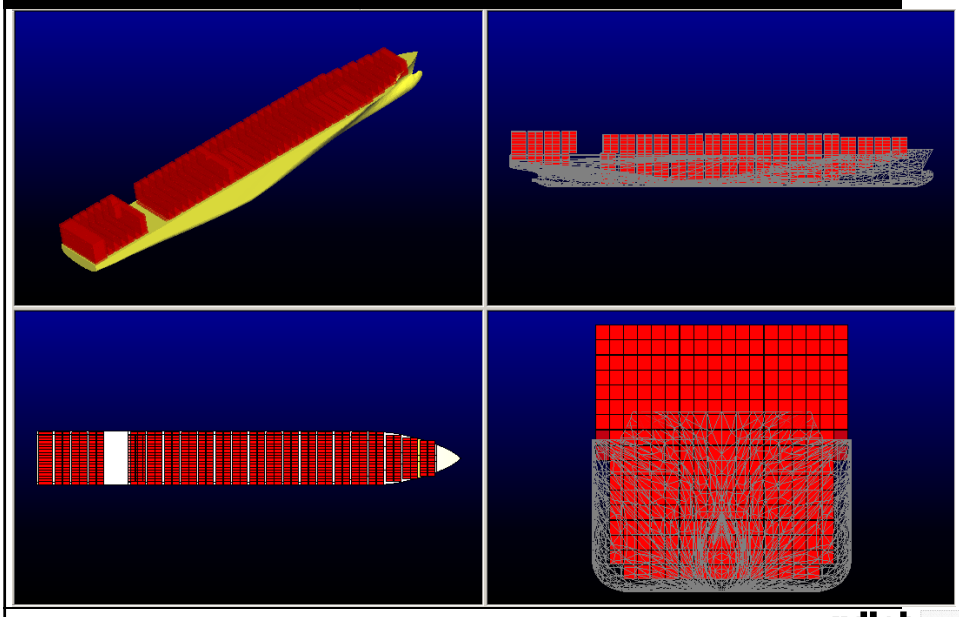


Arrangement of accommodation ladder in container ship

Arrangement of accommodation ladder in tanker

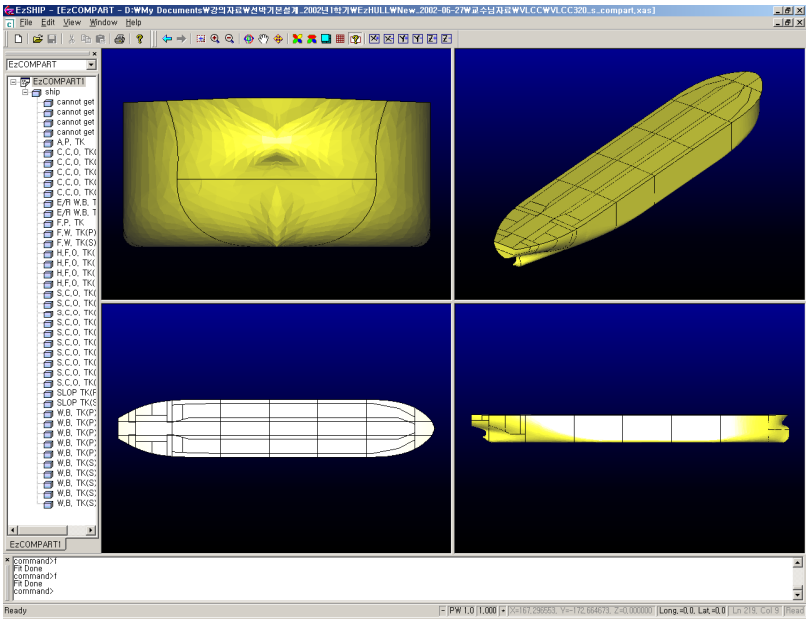


Example of the Container Loading of a 9,000 TEU Container Ship

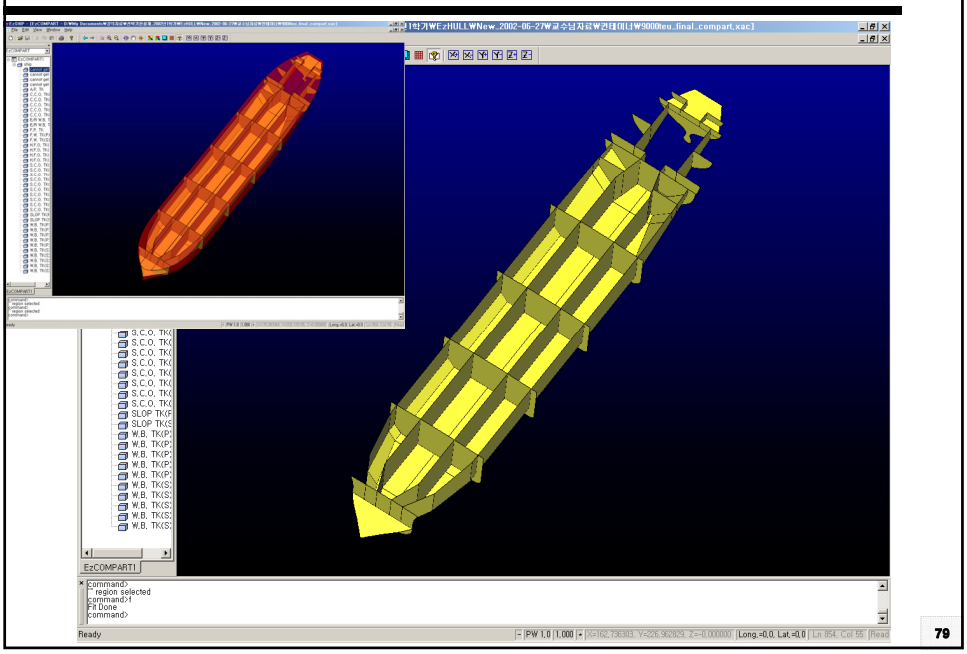


5. Examples of General Arrangement Design

General Arrangement Design of a 320K VLCC (1/3)



General Arrangement Design of a 320K VLCC (2/3)



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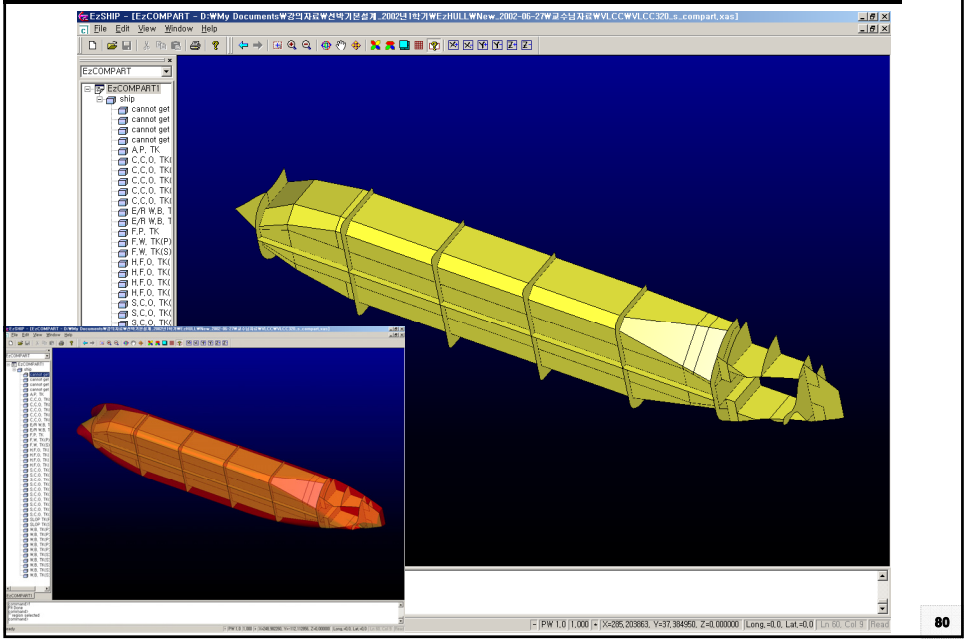
General Arrangement Design of a 320K VLCC (3/3)



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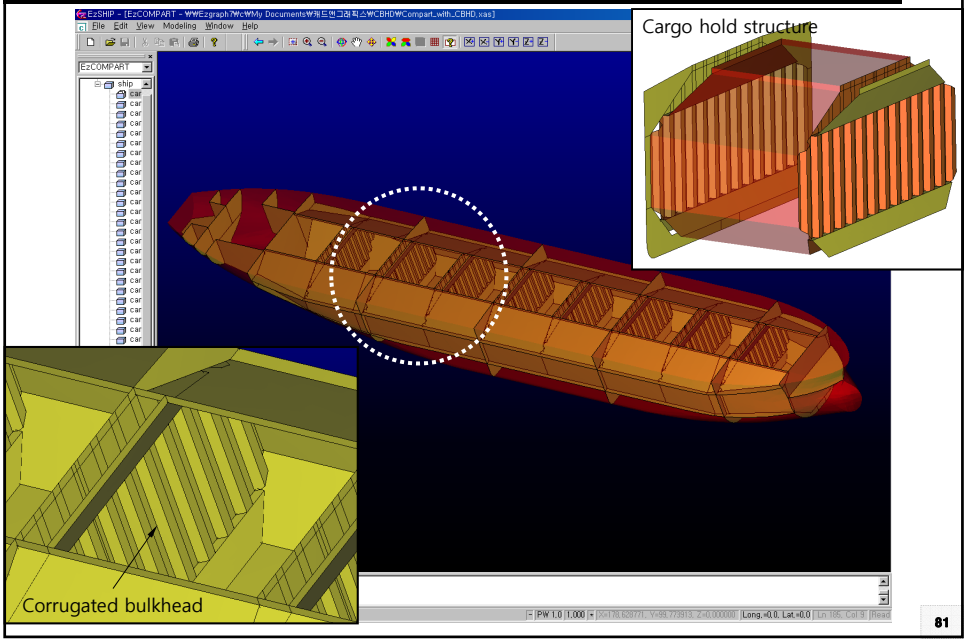
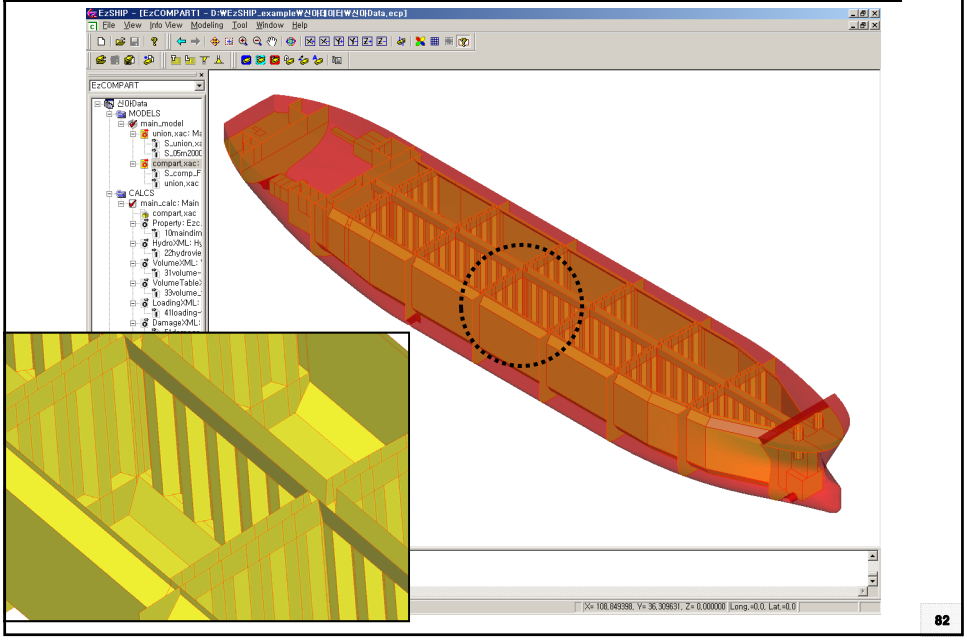
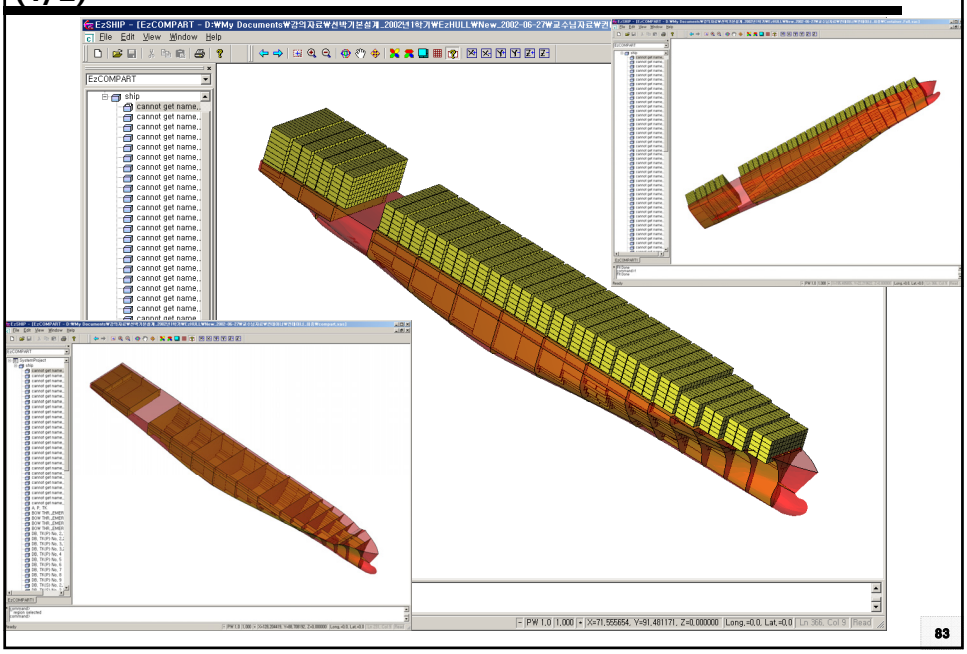
General Arrangement Design of a 182K Bulk Carrier



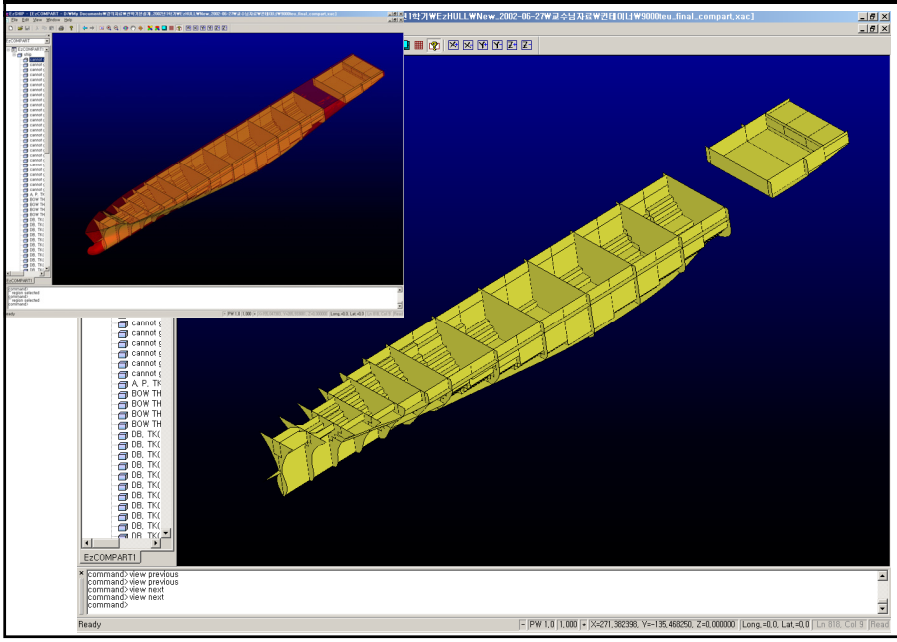
General Arrangement Design of a 40K Product/Chemical Carrier



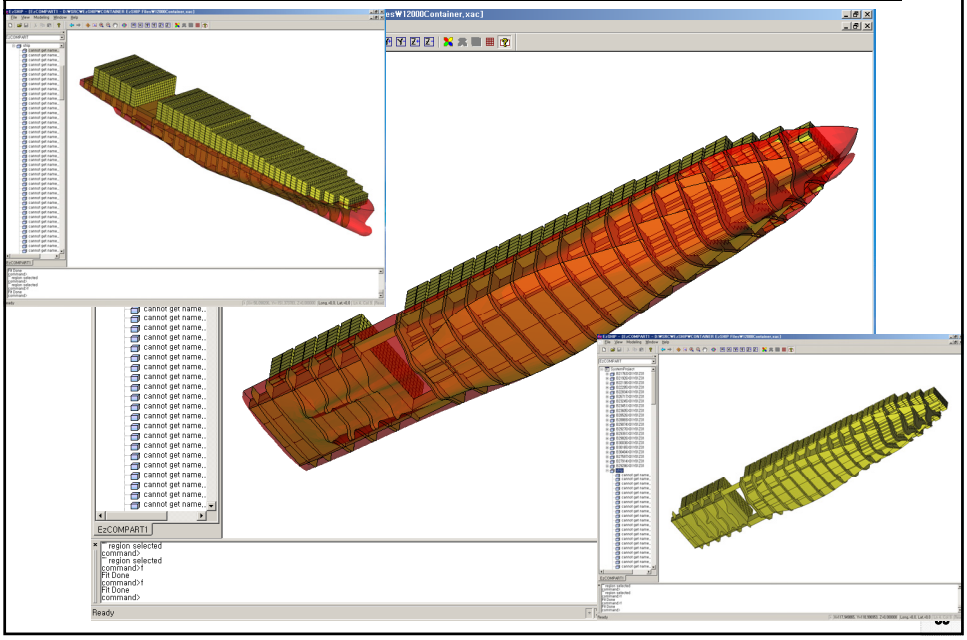
General Arrangement Design of a 9,000 TEU Container Ship (1/2)



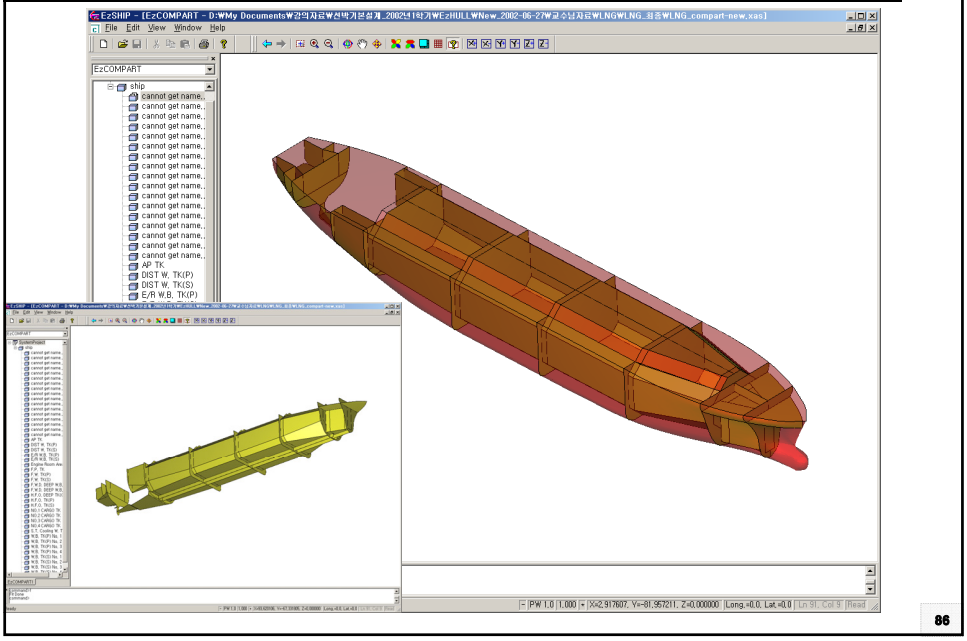
General Arrangement Design of a 9,000 TEU Container Ship (2/2)



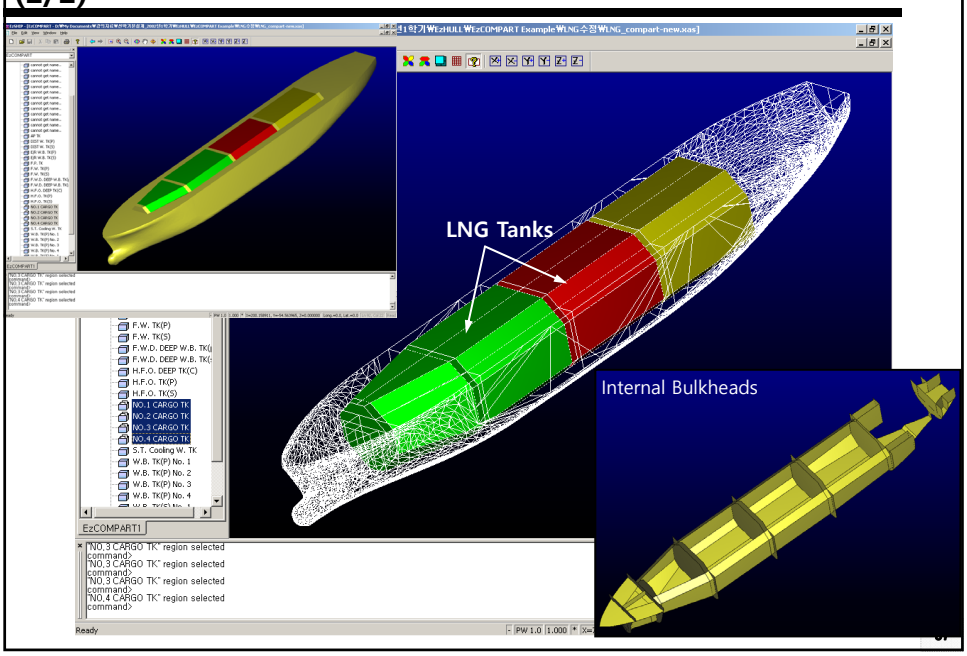
General Arrangement Design of a 12,000 TEU Container Ship



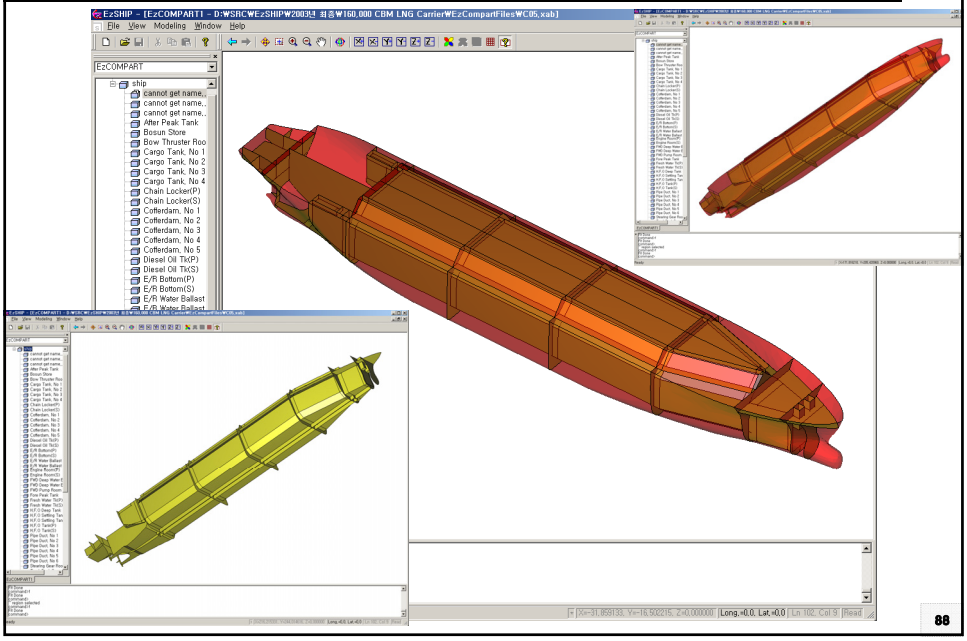
General Arrangement Design of a 145,000 CBM LNG Carrier (1/2)



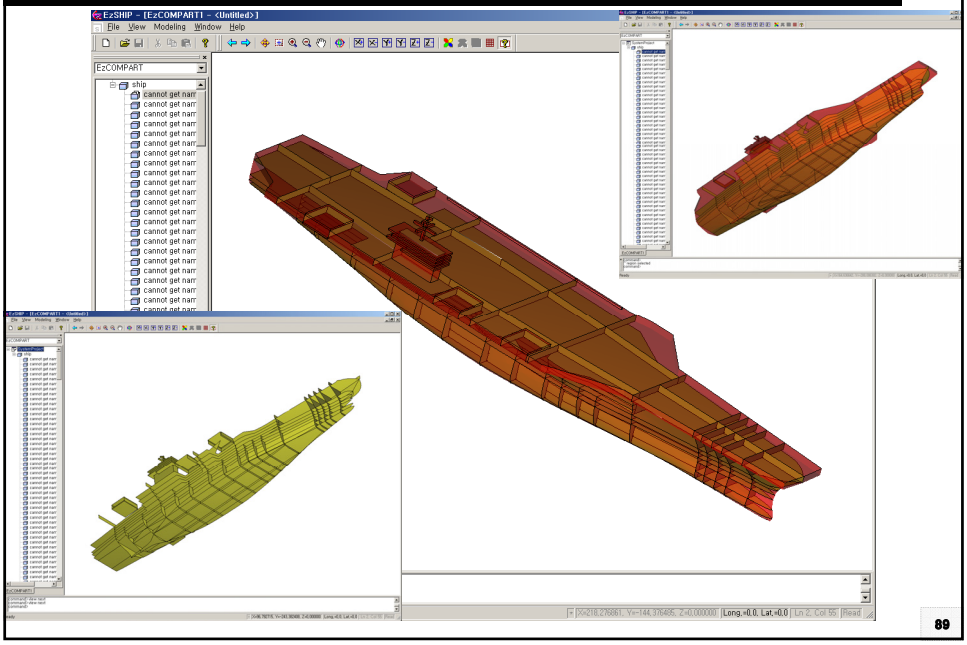
General Arrangement Design of a 145,000 CBM LNG Carrier (2/2)



General Arrangement Design of a 160,000 CBM LNG Carrier



General Arrangement Design of a 100,000 ton Nimitz Class Aircraft Carrier



General Arrangement Design of a 40,000 ton LHD (Landing Helicopter Dock)