Design Theories of Ship and Offshore Plant

Part I. Ship Design

Ch. 4 General Arrangement Design

Fall 2016

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Contents

Ch. 4 General Arrangement Design

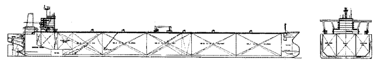
4.1 Concept of General Arrangement Design

Arrangement Design

- ☑ 'Design' is a kind of 'Arrangement'.
- ☑ Arrangement design of a ship includes
  - Compartment arrangement ➡ General arrangement design
  - Equipment and piping arrangement ➡ Outfitting design
  - Structural member arrangement ➡ Structural design

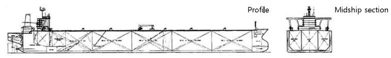
General Arrangement (G/A)

- ☑ Sketch G/A: Arrangement of ship's compartments and tanks
  - Compartment arrangement: Maximization of volumes of cargo holds and tanks 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.

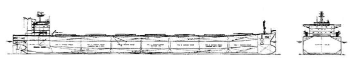


Example of General Arrangement

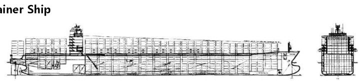
Tanker (VLCC)



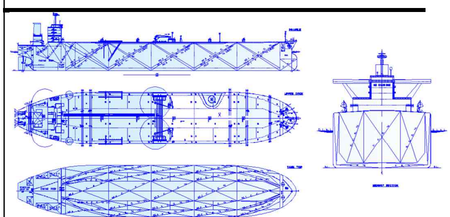
Bulk Carrier (Panamax)



Container Ship



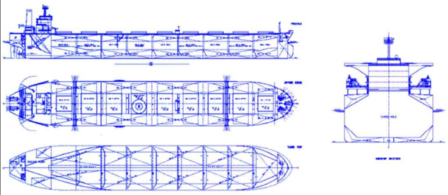
G/A of a 320K VLCC



Principal Dimensions		Capacities	
LOA	332.0 m	Cargo tank	357,000 m³
LBP	320.0 m	Water ballast	101,500 m³
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	16.0 knots	No. of cargo segregation	Three (3)
at NCR with 15% sea margin		Cruising range	26,500 N/M

* Reference: DSME

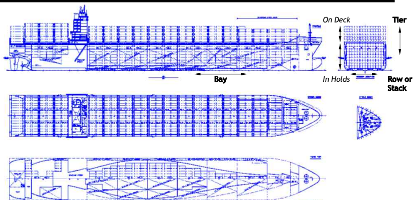
G/A of a 173K Bulk Carrier



Principal Dimensions		Capacities	
LOA	289.0 m	Cargo holds	192,000 m³
LBP	279.0 m	Water ballast	76,000 m³
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

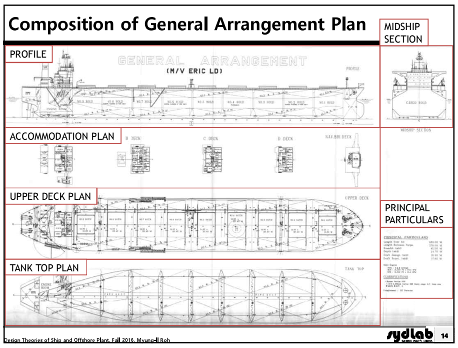


Principal Dimensions		Container Capacities	
LOA	300.0 m	Total	6,456 TEU
LBP	286.56 m	On deck	3,398 TEU
B	40.0 m	In hold	3,058 TEU
D	24.2 m	Reefer container (on deck)	500 FEU
Td / Ts	12.0 / 14.5 m		
Deadweight at Ts	78,100 ton	Main Engine	B&W 12K98MC-C
Service speed at Td at NCR with 15% sea margin	27.0 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

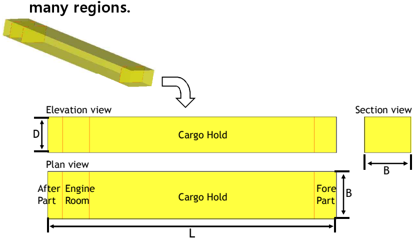
4.2 Reading the G/A Drawing

Composition of General Arrangement Plan



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.



Concept of Compartment Arrangement

☑ To maximize cargo hold space ➡ "Index of owner's profit"

- 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

☑ To minimize supporting spaces (engine room, deck house, fuel oil tank, ballast water ➡ Minimization of length and breadth of engine room, length of AFT and FPT

☑ 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.

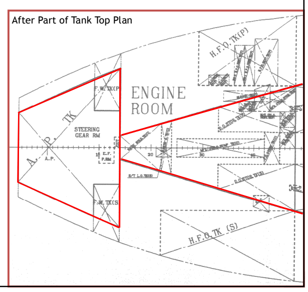
☑ Determination of hull form considering resistance / propulsion, maneuvering, stability, vibration, etc.

Reading the General Arrangement Plan (1/3)

- Meaning of lines in G/A

① ―――――

(solid line) : outer boundary of cutting plane



Reading the General Arrangement Plan (2/3)

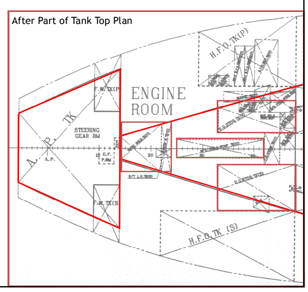
- Meaning of lines in G/A

① ―――――

(solid line) : outer boundary of cutting plane

② - - - - - - -

(dashed line) : located below cutting plane



Reading the General Arrangement Plan (3/3)

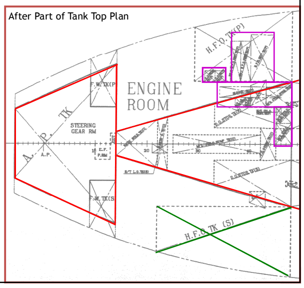
- Meaning of lines in G/A

① ————— (solid line) : outer boundary of cutting plane

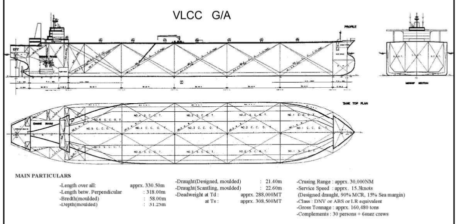
② - - - - - - - (dashed line) : located below cutting plane

③ — · — · — · (alternated long and short dash line) : tank compartment

④ — ·· — ·· — (alternate long and two short dashes line) : located above cutting plane



General Arrangement (G/A) of a VLCC



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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)

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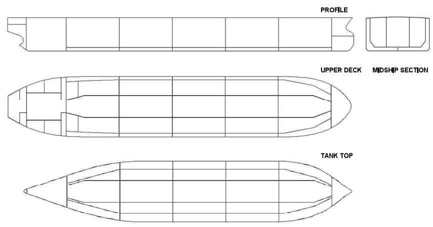
Compartment Arrangement of a VLCC

Sketch G/A



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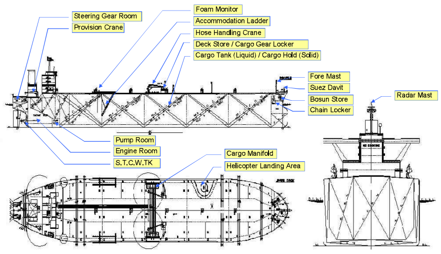
G/A of a VLCC



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

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4.3 Arrangement Design of Tanker

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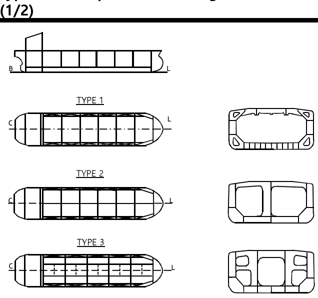
Various Types of Compartment Arrangements of Tankers (1/2)



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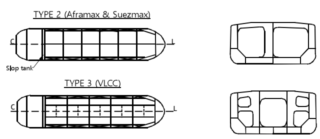
Various Types of Compartment Arrangements of Tankers (2/2)



General arrangement of compartments

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

* 1: 80,000~120,000 DWT Tanker (Large Range 2 Tanker), 2: 120,000~180,000 DWT, 3: 200,000~320,000 DWT Tanker

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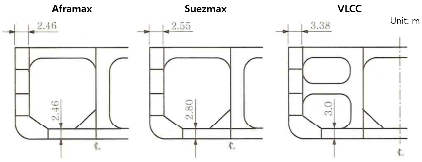
Double Bottom Height and Wing Tank Width of Various Types of Tankers

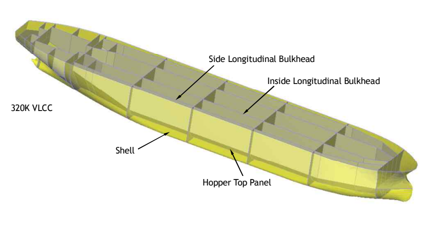


General values of double bottom height and wing tank width

Ship Size	D/B Height [m]	Wing Tank Width [m]
Aframax	2.46	2.46
Suezmax	2.80	2.55
VLCC	3.00	3.38

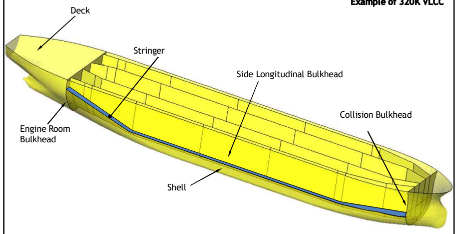
Compartment Arrangement Model of a VLCC (1/2)

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 Double Hull (MARPOL 73/78)***

- Inner hull including slop tank should have distance of about 2.0 m 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)

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

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

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

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

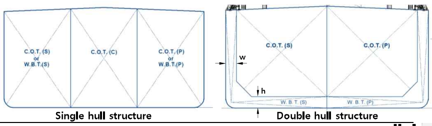
☑ **Protection of Fuel Oil Tanks (MARPOL 73/78)**

- Fuel oil tanks having an aggregate capacity of over 600 m³ 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

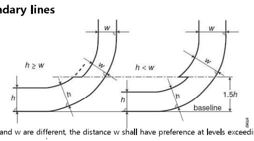
Item	Requirement	
Double bottom height	Over 5,000 DWT	h = B / 15 (m) or h = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m
	Less than 5,000 DWT	h = B / 15 (m) with a minimum value of 0.76 m
Wing tank width	Over 5,000 DWT	w = 0.5 + DWT / 20,000 (m) or w = 2.0 m, whichever is the lesser,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



Double Hull Structure (2/2)

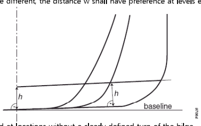
Cargo tank boundary lines

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)	$C \le 200{,}000\ m^3$	$O_M \le 0.015$
	$200{,}000\ m^3 \le C \le 400{,}000\ m^3$	$O_M \le 0.012 + (0.003 / 200{,}000) \cdot (400{,}000 - C)$
	$400{,}000\ m^3 \le C$	$O_M \le 0.012$

* C: Total volume of cargo oil, in m³, 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

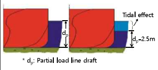
Limitations of Size and Arrangement of Cargo Tank (3/4)

☑ 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)

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

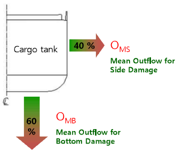
where,

$$O_{MS} = C_3 \sum_{1}^{n} P_{S(i)} \cdot O_{S(i)} \; [m^3]$$

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

$$O_{MB(0)} = \sum_{1}^{n} P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \; [m^3] \;\; for\ 0\ m\ tide$$

$$O_{MB(2.5)} = \sum_{1}^{n} P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \; [m^3] \;\; for\ -2.5\ m\ tide$$



Note)
i: Each 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

Slop Tank

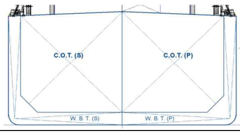
☑ Target: Oil tankers delivered on or after [31 December 1979]
☑ Regulation: MARPOL Annex I, Reg. 29
☑ Purpose: To store polluted ballast water and cleansing water for tank
- When void cargo hold at ballast condition is filled with sea water in an emergency, oil from dirty water generated by tank washing 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 ≥ 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

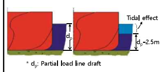
Fuel Oil Tanks (2/6)

☑ 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

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

Fuel Oil Tanks (3/6)

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

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

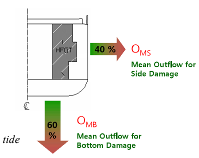
where,

$$O_{MS} = \sum_{1}^{n} P_{S(i)} \cdot O_{S(i)} \; [m^3]$$

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

$$O_{MB(0)} = \sum_{1}^{n} P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \; [m^3] \;\; for\ 0\ m\ tide$$

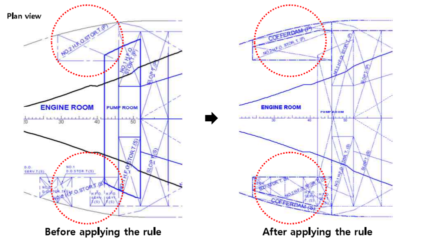
$$O_{MB(2.5)} = \sum_{1}^{n} P_{B(i)} \cdot O_{B(i)} \cdot C_{DB(i)} \; [m^3] \;\; for\ -2.5\ m\ tide$$



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

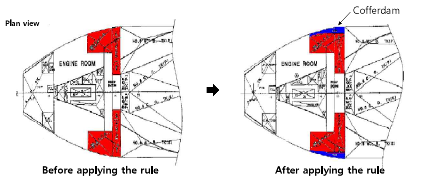
Fuel Oil Tanks (4/6)

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



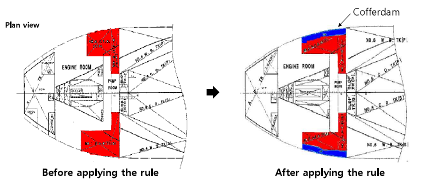
Fuel Oil Tanks (5/6)

☑ Application to Aframax Tanker
- The reduced volume of HFO was allocated at the cargo tank (decrease of cargo volume).



Fuel Oil Tanks (6/6)

☑ Application to Suezmax Tanker
- The reduced volume of HFO was allocated at engine room (rearrangement of engine room).



Arrangement Design of Cargo Hold

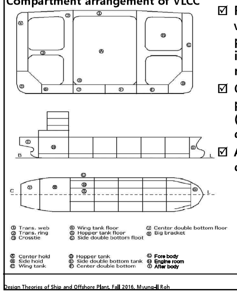
Cargo Hold Compartment Arrangement Design

☑ Compartment arrangement of cargo hold
- Tanker
- Container ship
- Bulk carrier

☑ Watertight bulkhead
☑ Frame space
☑ Double bottom height and wing tank width
☑ Cofferdam
☑ Miscellaneous

Compartment Arrangement by Watertight Transverse and Longitudinal Bulkheads (1/2)

Compartment arrangement of VLCC



☑ First, arrange compartments which have influence on basic performance of ship and then investigate the satisfaction of rules and regulation
☑ Cargo hold, engine room, fore peak tank (FPT), after peak tank (APT), miscellaneous compartments
☑ Adjustment according to the change of cargo hold volume

Compartment Arrangement by Watertight Transverse and Longitudinal Bulkheads (2/2)

☑ General concept
- Maximize the length of cargo tank as soon as possible to secure large cargo capacity
- Even the length of cargo tank
- Simplify the structure of cargo tank

☑ Considerations

Item	Regulation	Design Point
Number of cargo tanks	-	- Total number of cargo tanks - Slop tank - Cargo segregation group
Length of cargo tank	MARPOL Annex I, Reg. 23	- Maximum rule length - Maximum volume of cargo tank - Consideration of loading condition
Web spacing	-	- Structural strength - Lightweight and manufacturability - Consideration of design trend

Watertight Bulkhead

☑ Factor for determining the number and length of cargo hold
- Ship length
- Damage stability
- Structural strength

☑ Watertight bulkhead
- Watertight bulkhead: bulkhead which is watertight against water pressure
- The cargo hold is divided into several compartments by watertight bulkheads.
- To minimize disasters in ship
- Regulation of classification societies

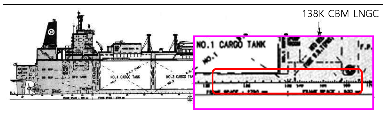
Criteria for Determining the Number of Transverse Bulkheads of Classification Societies

Ship Length (m)	ABS (No. of Cargo Hold BHD) E/R AMID	ABS (No. of Cargo Hold BHD) E/R AFT	LR E/R AMID	LR E/R AFT	DNV E/R AMID	DNV E/R AFT	BV	GL	KR	Ship Length (m)
65			4	3	4	3	4	3		65
66			4	4	4	4		4		66
67 85									4	67 85
86			5	5	5	4				86
87 88 89 90 91 101	1	2					5	4 + 1/20 m	5	87 88 89 90 91 101
102 103 104 105	2	3					6		6	102 103 104 105
106 115			6	5	6	5				106 115
116 122			6	6						116 122
123 124 125							7		7	123 124 125
126 142			7	6	7	6				126 142
143										143
144 145							8		8	144 145
146 164			8	7	8	7				146 164
165							9			165
166 185			9	8	9	8			9	166 185
186 190									As determined by the society in each case	186 190
191 197					10	9				191 197
198 225	3	4								198 225
226					Specially considered					226

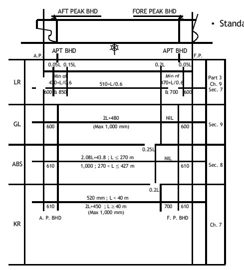
Frame Spacing

☑ Considerations for determining frame spacing
- Standardized frame space by classification societies
- Arrangement of web floor in double bottom
- Arrangement of transverse stiffeners in top side and deck
- Even spacing
- The frame number for cargo hold is determined by considering hull structure and strength, size of lower stool, manufacturability, etc.

138K CBM LNGC



Standardized Frame Space by Classification Societies

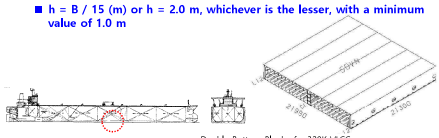


- Standard Longitudinal Frame Spacing: 2L + 550 [mm]

Double Bottom Height

☑ Considerations for determining double bottom height
- Structural strength (SWBM* control)
- Cargo hold capacity (volume)
- Ballast water capacity
- Manufacturability
  - Workable height (about 2.8 m) in double bottom tank without work platform

☑ Regulation: MARPOL Annex I, Reg. 19
- h = B / 15 (m) or h = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m



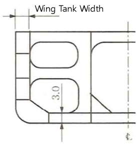
Double Bottom Block of a 320K VLCC

* SWBM: Still Water Bending Moment

Wing Tank Width

☑ Considerations for determining double bottom height
- Structural strength (SWBM control)
- Cargo hold capacity (volume)
- Ballast water capacity

☑ Regulation: MARPOL Annex I, Reg. 19
- w = 0.5 + DWT / 20,000 (m) or w = 2.0 m, whichever is the lesser, with a minimum value of 1.0 m



Cofferdam (1/2)

☑ Cofferdam
- Space for fire prevention by installing between cargo hold and E/R
- Watertight space between two watertight bulkhead, which can be empty or use for ballast

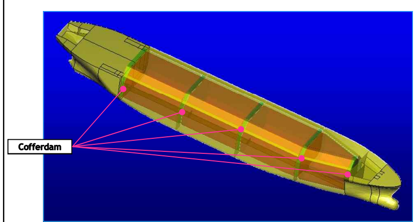
☑ Installation position of cofferdam

- Between L.O.T and F.O.T
- Between water tank and oil tank
- Between heated tank and grain store
- When F.O.T end deck and lower part of deck is space for other equipment or E/R
- Between E/R and emergency generator room
- Near M/E L.O sump tank
- Etc. required for isolation

Cofferdam (2/2)

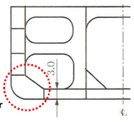
☑ Regulation Related to Cofferdam Installation of Classification Societies
- LR (Lloyd) in England
  - A cofferdam should be installed at forward and after end of oil cargo space. It should be able to cover whole area of end bulkhead of cargo space.
  - A pump room, oil fuel bunker or water ballast tank can be regarded as cofferdam.
  - A cofferdam should be also installed between cargo oil tanker and convenience space, and between cargo oil tank and the space where electric equipment is installed.
- GL (Germanischer Lloyd) in Germany
  - A product tanker should have a cofferdam between cargo tank and fuel oil tank. However, a ship which carry non-dangerous liquid having flash point over 60°C does not have a cofferdam. At this time, this should be stated at its certificate.
- The minimum breadth of cofferdam is over 760 mm for LR and BV (Bureau Veritas), over 600 mm for GL and DNV (Det Norske Veritas), and not available for ABS (American Bureau of Shipping).

Example of Cofferdam Installed between Cargo Tank in 160,000 CBM LNG Carrier

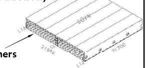


Miscellaneous Item Related to Midship Section

☑ Considerations for determining hopper size and angle
- Structural strength
- Cargo hold capacity (volume)
- Manufacturability (Number of stringers)
- Hull form angle
- Hopper angle: In general, abt. 40~45 deg


Hopper

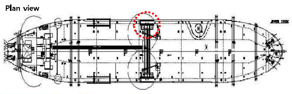
☑ Considerations for determining longi. spacing
- Structural strength
- Manufacturability (Lightweight control, M/H reduction)


Space between longitudinal stiffeners

Cargo Manifold (1/2)

☑ Equipment for loading and unloading cargo (one of cargo handling equipment)

Plan view



Manifold mark

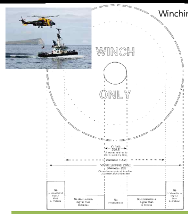
* Reference: VisTechnologies

2017-06-16

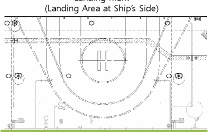
Helicopter Landing/Winching Mark (2/3)

- This specification is option of ship owner.
- Large ship or ship having no propulsor: Landing/Winching mark
- Small ship: Winching mark only

Winching Mark



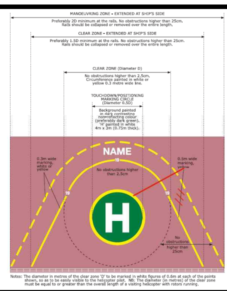
Landing Mark
(Landing Area at Ship's Side)



Requirements of Landing Area	Requirements of Winching Area
- Aiming circle: 0.5D (No obstructions higher than 0.1 m) - Clear zone (and Extended): D (1.5D) (No obstructions higher than 0.25 m) - Maneuvering zone (and Extended): 1.3D (2D) (No obstructions higher than 1.25 m)	- Clear zone: D (minimum 5 m) (No obstructions) - 1.5D area (No obstructions higher than 3 m) - Maneuvering zone: 2D (No obstructions higher than 6 m)

Helicopter Landing/Winching Mark (3/3)

Helicopter Landing Mark



* References: ICS, Guide to Helicopter/Ship Operations

2017-06-16

Cargo Manifold (2/2)

☑ Regulation: Standard for Tanker Manifolds and Associated Equipment by OCIMF*

☑ Tonnage Categories

Category	A	B	C	D
Deadweight	16,000~25,000	25,000~60,000	60,000~160,000	Over 160,000

☑ Requirements

Item	Requirement
Manifold Position	Amidship of LOA, ± 3 m
Distance form Ship Side	4.6 m
Height from Upper Deck	Not exceed 2.1 m
Spacing of Manifolds	A: 1.5, B: 2.0, C: 2.5, D: 3.0 (m)
Spill Tank Size	Width: 1,800 mm, Depth: 300 mm Vertical positioning: 900 mm

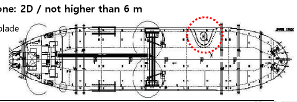
* Oil Companies International Marine Forum

Helicopter Landing/Winching Mark (1/3)

☑ Regulation: Guide to Helicopter/Ship Operations by ICS (International Chamber of Shipping)

☑ Requirements
- Landing area
  - Aiming (or touchdown) circle: 0.5D / not higher than 0.1 m
  - Clear zone (and Extended): D (1.5D) / not higher than 0.25 m
  - Maneuvering zone (and Extended): 1.3D (2D) / not higher than 1.25 m
- Winching area: All helicopter operations to and from a ship should normally involve landing on a deck; however, where operations are infrequent or the configuration of the ship precludes installation of a helicopter deck, then facilities for winching may be provided.
  - Clear zone: D (minimum 5 m) / no obstruction
  - 1.5D area: not higher than 3 m
  - Maneuvering zone: 2D / not higher than 6 m

* D: LOA of helicopter including blade



2017-06-16

Arrangement Design of Fore Part

Fore Part Compartment Arrangement Design

☑ General
☑ Collision bulkhead
☑ F.P.T. (Fore Peak Tank)
☑ F'cle (Forecastle) Deck
☑ Bosun Store
☑ Bulwark

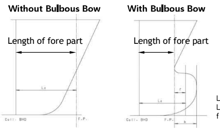
General

☑ Considerations
- Collision bulkhead (firstly)
- F.P.T. (Fore Peak Tank) capacity
- Mooring equipment

☑ Frame spacing of fore part
- In general, same to those of after part and engine room

Collision Bulkhead (1/2)

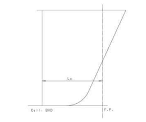
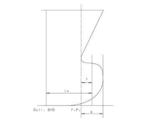
☑ Transverse bulkhead between F.P.T. and cargo hold
☑ The most strong and forward bulkhead of the ship, which has a very important safety feature
☑ Min and max distance required by classification societies
☑ Maximize cargo hold space ➡ Minimize the length of fore part
☑ Consideration for mooring, anchor chain, etc.
☑ Sometimes, the length of fore part becomes long to decrease fore trim when it is excessive.



Lc: Distance from collision bulkhead to FP or bulbous bow
L: Freeboard length (Lf)
f = Minimum (Bulb length (b) / 2, 0.015L, 3 m)

Collision Bulkhead (2/3)

☑ Regulation: SOLAS Chapter II-1, Reg. 12 (2006 amendment) from Reg. 11 (1989/1990 Amend)
☑ Requirements
- Vertical: Watertight from base line to freeboard deck
- Longitudinal

Item	Without Bulbous Bow	With Bulbous Bow
Profile		
Rule Length	Min (0.05Lf or 10m) < Lc < Max (0.08Lf or 0.05Lf + 3 m)	

Lc: Distance from collision bulkhead to FP or bulbous bow
Lf: Freeboard length
f = Min (Bulb length (b) / 2, 0.015Lf, 3 m)

Collision Bulkhead (3/3)

☑ In the initial design stage, the following table can be used to determine the position of collision bulkhead.

Ship Type	LBP ≥ 250	LBP ≤ 250	Remark
Bulk carrier	0.03 L + 3.0	0.02 L + 5.5	L: Rule Length
Tanker	0.03 L + 3.5	0.02 L + 6.0	
Container ship	0.03 L + 4.0	0.02 L + 6.5	

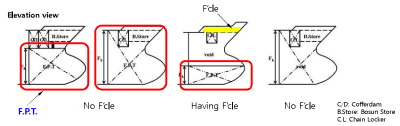
* Rule Length (Scantling Length)
- Basis of structural design and equipment selection
- Intermediate one among (0.96 Lwl at Ts, 0.97 Lwl at Ts, Lbp at Ts)

- Position of collision bulkhead of actual ship

Ship Type	Panamax Container	Panamax B/C	Aframax Tanker	Suezmax Tanker	VLCC
Coll. BHD~F.P [m]	11.8	9.7	10.12	12.92	13.0

F.P.T. (Fore Peak Tank) (1/2)

☑ It is advantageous to minimize F.P.T. capacity under allowable loading.
☑ In the aspect of structural optimization and amount of paint, it is advantageous to determine the position of F.P.T. as lower as possible.



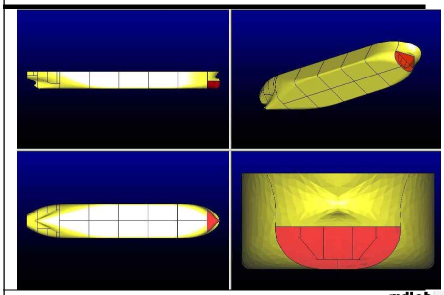
F.P.T. (Fore Peak Tank) (2/2)

☑ Generals
- Included to ballast tank required by MARPOL
- However, the purpose is trim and strength control as compared with general tanks.
- Thus, optimum design for its capacity is required.

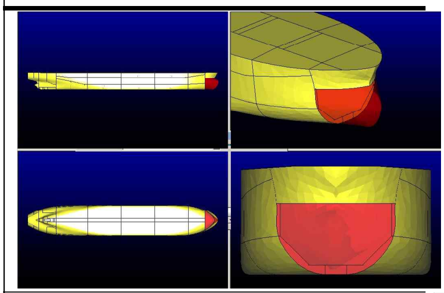
☑ Design Point
- Trim control, Strength control, Stability control, Ballast exchange control, Cost and maintenance

☑ Design Guidance
- Top level of tank: Ts (scantling draft) + 0.5~0.7 m

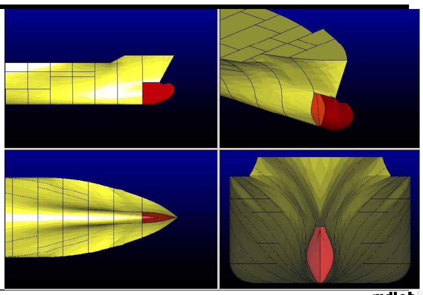
Fore Peak Tank of a 320K VLCC



Fore Peak Tank of a 182K Bulk Carrier



Fore Peak Tank of a 9,000 TEU Container Ship



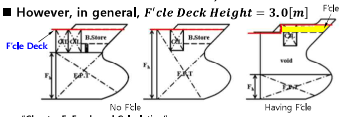
F'cle (Forecastle) Deck

☑ Freeboard regulation of the length of F'cle deck

- $F'cle\ Deck\ Length \geq 0.07L_f$ * L_f: Freeboard Length

☑ Freeboard regulation of the height of F'cle deck

- $F'cle\ Deck\ Height = 2.3[m]\ for\ L_f \geq 125[m]$
- However, in general, $F'cle\ Deck\ Height = 3.0[m]$



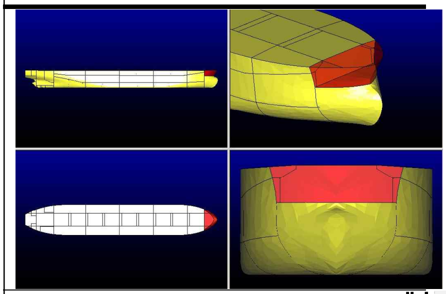
No F'cle Having F'cle

Reference: "Chapter 5. Freeboard Calculation"

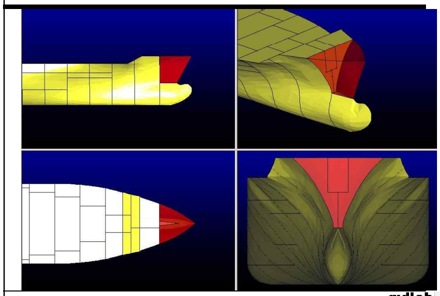
* The standard height of a superstructure shall be as given in the following table :

L_f (m)	Raised quarterdeck (m)	All other superstructures (m)
30 or less	0.90	1.80
75	1.20	1.80
125 or more	1.80	2.30

Bosun Store of a 182K Bulk Carrier



Bosun Store of a 9,000 TEU Container Ship



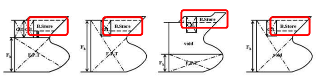
Bosun Store

☑ It is used as warehouse of fore part or deck.

☑ Position

- Ship with f'cle: in the f'cle
- Ship with no f'cle: under the upper deck

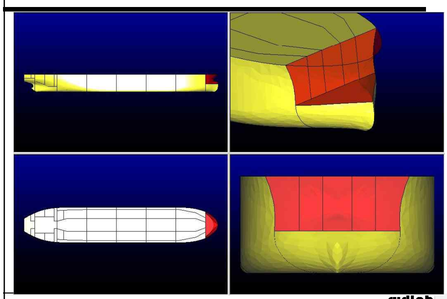
☑ The passages for bosun store are installed in port side for smoothly running of mooring equipment.



No F'cle Having F'cle No F'cle

C/D: Cofferdam
B.Store: Bosun Store
C.L: Chain Locker

Bosun Store of a 320K VLCC



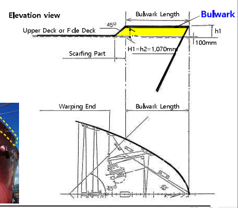
Bulwark

☑ A kind of breakwater

☑ Installed in the front of warping end

☑ Angle of inclination: 45 [deg]

☑ Height: 1.1 [m]



* Reference: Samsung Heavy Industries

Arrangement Design of Engine Room (E/R)

Engine Room (E/R) Arrangement Design

☑ General
☑ Selection of main engine
☑ Length of engine room
☑ Height of engine room
☑ Room sizing in E/R
☑ Hull tank arrangement in E/R

Selection of Main Engine

☑ Criteria for determining main engine
- Optimum power and RPM range
- Size and unit weight
- Initial cost and operational cost (e.g., fuel oil consumption)
- Reliability and maintenance
- Consideration for vibration (major cause of noise and vibration of ship)

☑ Check points for determining main engine
- Ship speed
- Power (MCR x RPM)
- Propeller diameter
- Length / breadth of M/E
- Weight of M/E
- M/E cost
- SFOC[1] / DFOC[2] at NCR
- Exciting force[3]

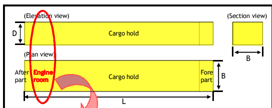
* 1: Specific Fuel Oil Consumption [g/kW·h], 2: Daily Fuel Oil Consumption [ton/day], 3: Force generated from main engine

General

☑ Objective
- Minimization of non-cargo loading space such as engine room, deck house, etc.
- Maximization of cargo hold

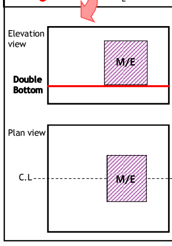
☑ Engine room arrangement and hull form
- If the ship speed becomes high
  - ➡ C_B becomes small.
  - ➡ The tank top area of engine room becomes small.
  - ➡ The allowable installation position goes forward.
  - ➡ The length of engine room becomes long.

☑ Frame spacing of engine room
- Consideration for vibration, web frame of engine room, the relation with deck house, etc.
- In the case of bulk carrier and tanker over 20,000 ton: 800~900 mm



Tanks in Engine Room

- Main Engine (M/E)



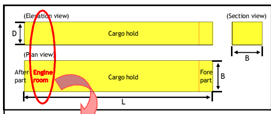
* H.F.O. STOR. TK ➡ SETT. TK ➡ SERV. TK ➡ M/E

- H.F.O. STOR. TK (Heavy Fuel Oil Storage Tank)
  : Tank for storing heavy fuel oil
- H.F.O. SETT. TK (Heavy Fuel Oil Settling Tank)
  : Tank for settling impurities in heavy fuel oil before using it
- H.F.O. SERV. TK (Heavy Fuel Oil Service Tank)
  : Tank for storing heavy fuel oil which is supplied from settling tank. The oil in service tank is supplied to main engine.

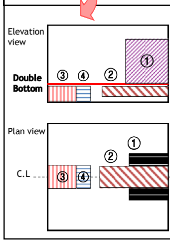
- D.O. STOR. TK (Diesel Oil Storage Tank)
  : Tank for storing diesel oil
- D.O. SETT. TK (Diesel Oil Settling Tank)
- D.O. SERV. TK (Diesel Oil Service Tank)

- L.O. SETT. TK (Lubrication Oil Settling Tank)
- L.O. SERV. TK

- CYL.O. SETT. TK (Cylinder Oil Settling Tank)
- CYL.O. SERV. TK



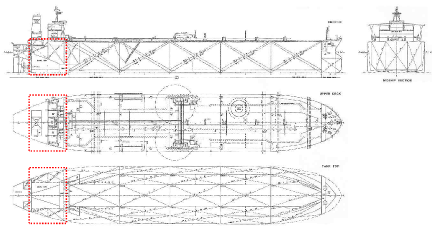
- C.F.W DRAIN TK (Cooling Fresh Water Drain Tank)
  : Tank for storing used cooling water
- HIGH S.C. (High Sea Chest)
  : Injection port of sea water for filling water ballast tank. Located in high part of side hull
- LOW S.C. (Low Sea Chest)
  : Same to HIGH S.C. Located in lower part of side hull



① Main Engine
② L.O. SUMP TK: Tank for storing lubrication oil to be already used in main engine
③ BILGE HOLDING TK: Tank for storing dirty water which gathers in bilge well
④ S/T L.O. DRAIN TK (Stern Tube Lubrication Oil Drain Tank)
: Tank for storing lubrication oil to be already used in stern tube
- F.O. OVERFLOW TK: Tank for storing an over flow from main engine during injection
- B/W (Bilge Well): Tank for storing dirty water including oil on the floor

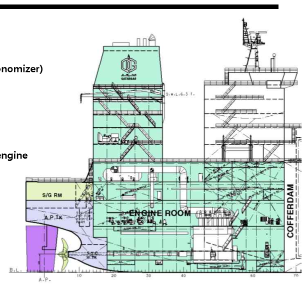
* Dirty water from ship ➡ Bilge Well ➡ Bilge Holding Tank

Position of Engine Room



Various Machinery Outfitting Equipment in E/R

☑ Main engine
☑ Auxiliary engine
☑ Boiler
☑ Exhaust gas boiler (economizer)
☑ Purifier
☑ Fresh water generator
☑ Compressed air system
☑ Pumps
☑ Heat exchangers
☑ Emergency generator engine
☑ Fire fighting
☑ Shafting
☑ Propeller
☑ Steering gear
☑ Rudder
☑ Ventilation fan
☑ Engine room crane
☑ Workshop equipment



Length of Engine Room (E/R) (1/5)

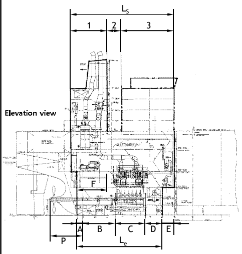
☑ Considerations for determining length of engine room
- Minimum space (Length minimized)
- Operating and maintenance space
- Space for auxiliary engine, boiler, and other equipment
- Accommodation and engine casing space
- Fuel oil tank space

Length of Engine Room (E/R) (2/5)

☑ Determination procedures

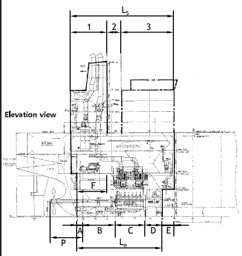
Step	Check Point	Remark
1	Distance between M/E bed and outer shell	Special web frame to be considered
2	Length of M/E	Dependent on M/E
3	Ballast pump and other space	about 5~6 frames
4	Installation space for cargo pump	about 4~5 frames
5	After space of M/E	
6	Option (if any)	e.g., Shaft generator
Final	Total summary and evaluation	

Length of Engine Room (E/R) (3/5)



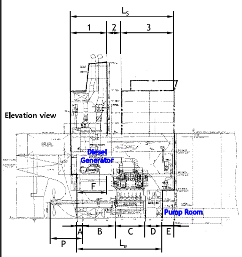
- ☑ P: Length of propeller shaft
- ☑ A: Distance from after bulkhead to end of propeller shaft
- ☑ B: Length of intermediate shaft
- ☑ C: Length of main engine (M/E)
- ☑ D: Distance from main engine to E/R bulkhead
- ☑ E: Space for pump room recess
- ☑ F: Distance for installing diesel generator
- ☑ Le: Distance from A to D (length of engine room)

Length of Engine Room (E/R) (4/5)



- ☑ A: The distance of 800~1,000 mm is required for connection of shaft flange and installation of stern tube forward seal
- ☑ B: If the shaft is pulled out to the inside of E/R, shaft length, M/E position, etc. should be considered. If the shaft is pulled out to after part, this distance can be short independently of shaft.
- ☑ A + B: The length for pulling the shaft out. The space for maintenance and inspection of shaft stern tube. This length should be longer than shaft length by 200~300 mm.

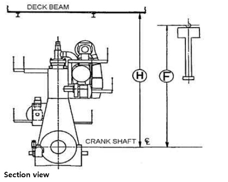
Length of Engine Room (E/R) (5/5)



- ☑ C: Determined by the length of M/E
- ☑ D: Space for arranging pipes and pumps in front of M/E. Different according to ship type but required for 3 m minimum
- ☑ E: Non-existence for bulk carrier and container ship due to non-existence of pump room
- ☑ F: The distance for installation of diesel generator
- ☑ Miscellaneous considerations
  - ■ Prevention of vibration through continuity of hull structure
  - ■ Trunk for emergency exit
  - ■ Installation of F.O.T (FO Storage Tank)
  - ■ Installation of shaft generator, or not
  - ■ Installation of vibration damper, or not

Engine Room Height

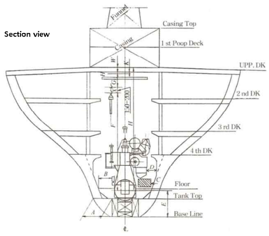
☑ Considerations for determining engine room height
- ■ M/E piston overhaul height
- ■ Height for intermediate decks (3 decks for large ship, 2 decks for middle ship
- ■ In the case of large ship, engine room height is no problem.



H >= F + G + W + K + X

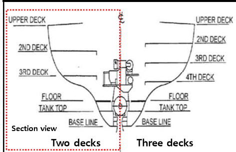
- ■ H: Distance between uppermost deck in E/R and center line of crank shaft
- ■ F: Distance between center line of crank shaft and crane hook
- ■ G: Distance for the installation of crane and I-beam
- ■ W: Depth of web of uppermost deck in E/R
- ■ K: Height for arrangement of pipe above crane (250 mm)
- ■ X: Clearance margin (150~200 mm)

Installation Position of Main Engine



- ☑ A: Space for the installation of side stopper and pipe
- ☑ B: Passage way of the side of turning gear
  - Passage way of minimum 600 mm is required. If not possible, the tuning gear can be installed in upper part.
- ☑ C: Passage way under air cooler
- ☑ D: Passage way around M/E
- ☑ E: Shaft center height

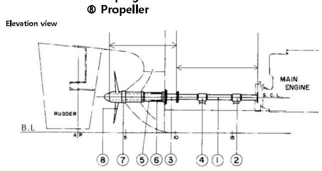
Criteria for Determining Deck Height in E/R



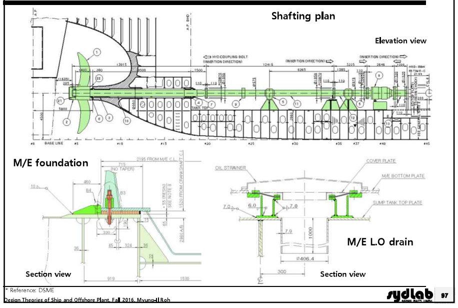
- ☑ Tank top height
  - ■ This is determined by considering propeller diameter, M/E type, lubrication oil sump tank, cofferdam, etc.
- ☑ Floor height
  - ■ For DWT 30,000~60,000 ton ship, the suitable height is 1,500~1,800 mm.
- ☑ Height of 3rd deck
  - ■ This is determined by considering structures and outfitting such as size of hull structure below 3rd deck, equipment on the floor, pipes, ducts, cables, etc.
- ☑ Distance between 2nd deck and upper deck
  - ■ For DWT 40,000~60,000 ton ship, the suitable distance is 4,000 mm minimum.
- ☑ Height of 2nd deck
  - ■ Consideration for whether the opening of piston of diesel generator is possible because the diesel generator is located 3rd deck.
  - ■ Many structures and outfitting such as pipes, ducts, cables, etc. are installed in the interval between 2nd and 3rd decks.

Shaft Arrangement (1/2)

① Intermediate shaft
② Intermediate shaft bearing
③ Propeller shaft
④ Aft most bearing
⑤ Stern tube
⑥ Stern tube bearing
⑦ Rope guard
⑧ Propeller



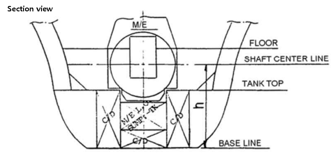
Shaft Arrangement (2/2)



* Reference: DSME

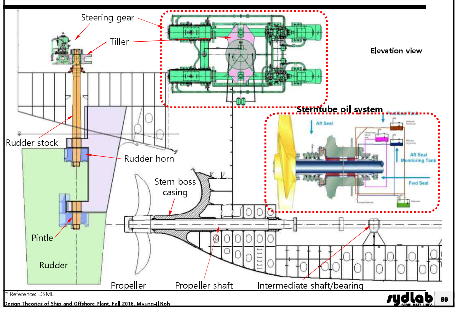
Shaft Center Height

☑ After the propeller diameter and M/E were determined, the shaft center height should be determined by considering propeller immersion, L.O sump tank, and cofferdam height (min. 600 mm) under L.O sump tank.



* C/D: Cofferdam

M/E Shafting and Rudder

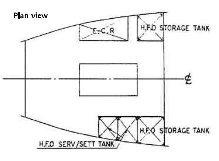


* Reference: DSME

Room Sizing in E/R (1/3)

☑ Many rooms are required for M/E control and work in engine room.

☑ Engine Control Room (ECR)

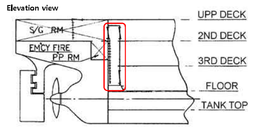


- E.C.R should be located near main equipment such as M/E, diesel generator, boiler, etc. to conveniently and easily examine them.
- E.C.R should be installed over E/R.
- E.C.R is located in front of M/E or port, and the breadth and length are 5~6 m and 12~14 m, respectively.
- H.F.O (Heavy Fuel Oil) service/settling tank and H.F.O storage tank should be separated from E.C.R.

* H.F.O. STOR. TK ➡ SETT. TK ➡ SERV. TK ➡ M/E

Room Sizing in E/R (2/3)

☑ Emergency escape trunk



- Emergency escape trunk over one from lower deck to weather deck should be prepared in E/R for fire and emergency.
- Emergency escape trunk should be as continuous as possible and has the minimum distance using emergency fire pump room and steering gear room.

Room Sizing in E/R (3/3)

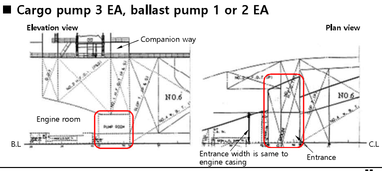
☑ Engine room workshop
- Space for storing machining tools and parts which are used to simply manufacture parts and spare of M/E, diesel generator, boiler, etc.

☑ Engine room store
- Space for storing spare parts, tools, etc. of auxiliary equipment

☑ Purifier room
- Space for installing equipment which are used to purify fuel oil and lubrication oil for ship operation
- In the purifier room, purifier, heater for purifier, feed pump for F.O purifier, and operating water tank should be installed.

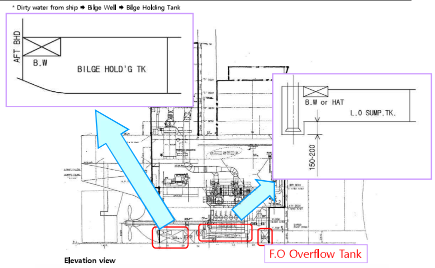
Pump Room

☑ For tanker, the pump room is located between E/R and cargo tank.
- The length of pump room is determined by considering the size of cargo pump and ballast pump, pipe layout, access and maintenance area, etc.
- In general, the maximum depth is less 1/3 of depth.
- Cargo pump 3 EA, ballast pump 1 or 2 EA

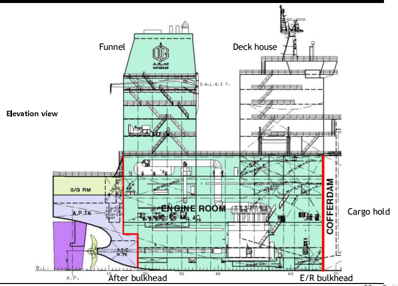


Hull Tank Arrangement in Engine Room (1/6)

* Dirty water from ship ➡ Bilge Well ➡ Bilge Holding Tank



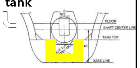
Hull Tank Arrangement in Engine Room (2/6)



Hull Tank Arrangement in Engine Room (3/6)

☑ Installation of cofferdam

- Between L.O.T (lubrication oil tank) and F.O.T (fuel oil tank)
- Between water tank and oil tank
- Between heating tank and grain storage tank
- In the case that F.O.T ends deck and the lower part of deck is space for other equipment or E/R
- Between E/R and emergency generator room
- The surroundings of main engine L.O sump tank
- Required part for isolation

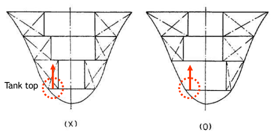


☑ Tank arrangement by considering damage stability

Hull Tank Arrangement in Engine Room (4/6)

☑ In case that rooms and tanks are vertically connected

- It is reasonable that the horizontal positions coincide with each other.
- If not, it is reasonable that upper tanks are arranged into the center of ship.
- It is not reasonable that lower tanks are arranged into the center of ship because pipes of equipment on tank top are installed inside of tanks.



Hull Tank Arrangement in Engine Room (5/6)

☑ Arrangement of double bottom tank in E/R

- In double bottom, tank system and auxiliary tanks which shoul d be arranged lower side of ship are arranged.
- Bilge Holding Tank
- M/E L.O Sump Tank
- F.O Overflow Tank
  - It is arranged in port side of fore body because the equipment and pipes related to fuel oil are arranged in port side
- Oily Bilge Tank (or Waste Oil Tank)
  - Tank for storing dirty oil. It is arranged in port side of double bott om of after body.
- Bilge Well
  - It is arranged in one for after body, one for port and starboard side of fore body, respectively.
- Drain tank, D.O storage tank, etc. are arranged in double bottom of E/R.

Hull Tank Arrangement in Engine Room (6/6)

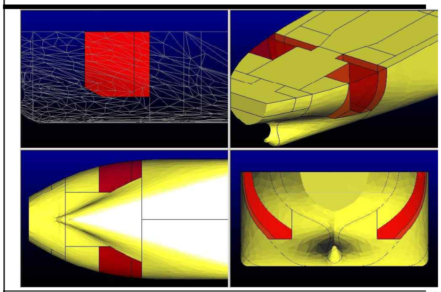
☑ Arrangement of F.O.T (Fuel Oil Tank)

- All F.O tank are arranged as hull tank. If not possible, it are arranged as potable tank having drip tray.
- The one surface of F.O tank should contact with double bottom top. If not possible, e.g., contact with deck, cofferdam should be installed in upper or lower part of deck.
- It is reasonable that F.O tank is constructed as one boundary and arranged to contact with forward bulkhead of E/R (E/R bulkhead).
- Any kind of ship with an aggregate oil fuel capacity of 600 m^3 and above requires double hull protection of fuel oil tanks. (MARPOL Annex I, Reg. 12A)
  - For which the building contract is placed on or after [1 August 2007]; or
  - In the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after [1 February 2008]; or
  - The delivery of which is on or after [1 August 2010];

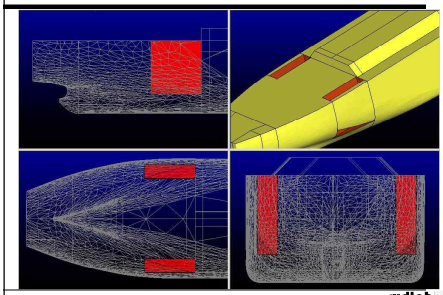
☑ Arrangement of L.O.T (Lubrication Oil Tank)

- L.O tank should not contact with side shell.

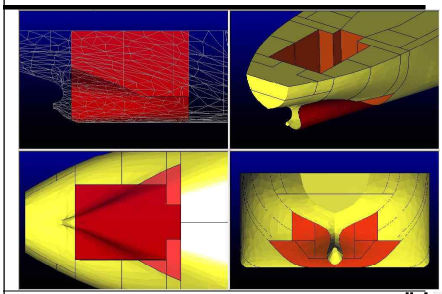
F.O.T of a 320K VLCC



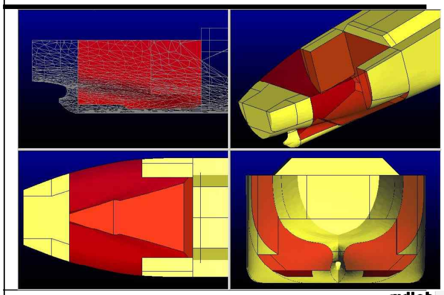
F.O.T of a 145K LNGC



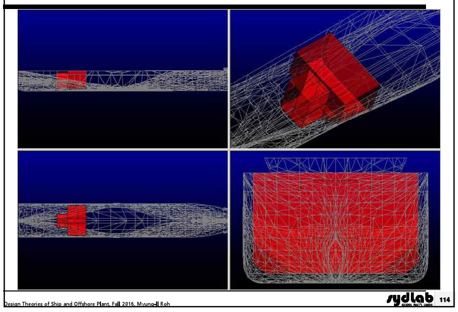
Engine Room of a 320K VLCC



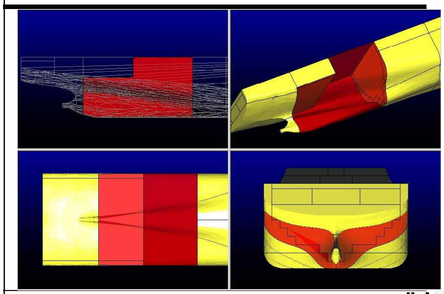
Engine Room of a 145K LNGC



Engine Room of a 4,500 TEU Container Ship

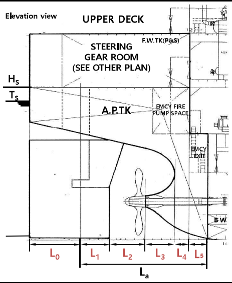


Engine Room of a 9,000 TEU Container Ship



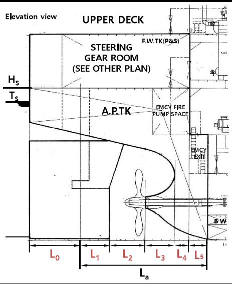
Arrangement Design of After Part

Length of After Part (1/2)



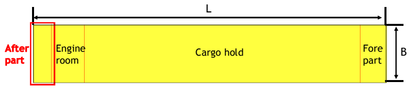
- ☑ L_0: Obtained from hull form design
- ☑ L_1: Rudder balance ratio. Obtained from rudder design
- ☑ L_2: Distance for propeller removal for repair
- ☑ L_3: Minimum distance between propeller and hull. Required for the reduction of reaction, vibration, etc. by propeller

Length of After Part (2/2)



- ☑ L_4: Determine by considering welding about 2 frame spacing (G/A aspect)
- ☑ L_5: Remain about 2 frame spacing for emergency exit from E/R (This can be not considered according to APT capacity)
- ☑ L_a: Distance from AP to E/R. Length of Aft BHD (L_1 ~ L_5)
- ☑ H_s: Height for steering gear floor
  Hs = Scantling Draft (Ts) + (0.6~1.2) m

Tanks and Spaces in After Part



- A.P. TK (After Peak Tank): Tank for storing ballast water for trim control
- Steering Gear Room: Space for motor and equipment for rudder control
- F.W. TK (Fresh Water Tank): Tank for storing fresh water for the crew
- Distilled F.W. TK: Tank for storing distilled water for activating the boiler
- C.W.T (Cooling Water Tank) or S.T.C.W.T (Stern Tube C.W.T)
  : Tank for storing water to cool down heat generated from stern tube when engine cooling or propeller rotation
- CO_2 Room: Room for storing CO_2 to be used at a fire

A.P.T. (After Peak Tank)

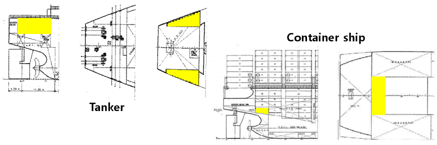
☑ Generals
- Included to ballast tank required by MARPOL
- However, the purpose is trim and strength control as compared with general tanks.
- Thus, optimum design for its capacity is required.

☑ Design Point
- Trim control, Strength control, Stability control, Ballast exchange control, Cost and maintenance

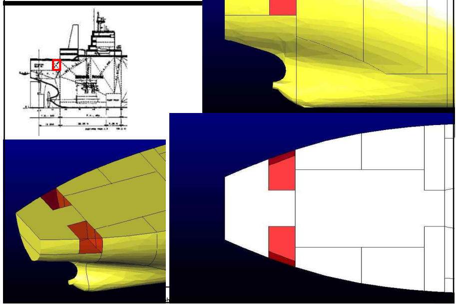
☑ Design Guidance
- Top level of tank: Ts (scantling draft) + 0.8~1.0 m

Fresh Water Tank (F.W.T)

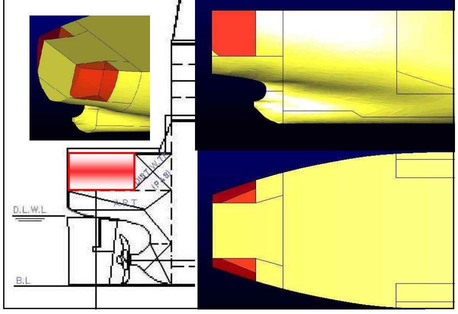
- ☑ Tanker & bulk carrier: Port or starboard side in steering gear room
- ☑ Container ship: Forward of E/R or lower part of afterward passage way
- ☑ Categorize and mark into distilled W.T and potable W.T
- ☑ Greek Rule: Void is arranged between potable W.T and ballast tank



F.W.T of a 320K VLCC

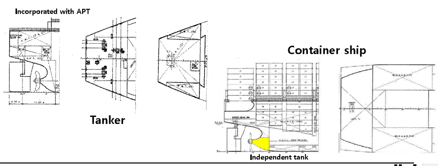


F.W.T of a 145K LNGC

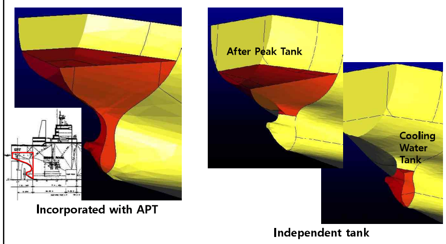


Cooling Water Tank (C.W.T)

- ☑ Independent tank or incorporated with APT
- ☑ Independent Tank: 0.3~0.5 m above of propeller shaft. Alignment with the height of E/R 4th Floor

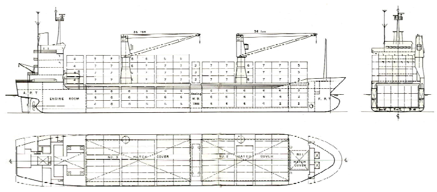


C.W.T of a 320K VLCC



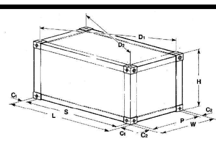
4.4 Arrangement Design of Container Ship

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

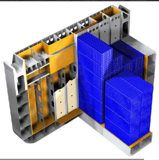
Size and Weight of Different Container Types



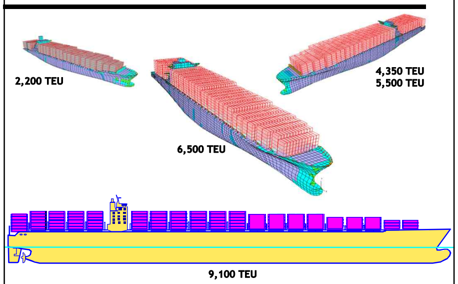
Type	Height (H)		Width (W)		Length (L)		Max Weight (kg)
	mm	ft-in	mm	ft-in	mm	ft-in	
1A	2,438	8'	2,438	8'	12,192	40'	30,480
1AA (FEU)	2,591	**8'-6"**	2,438	**8'**	12,192	**40'**	30,480
1B	2,438	8'	2,438	8'	9,152	29'-11 1/4"	25,400
1C	2,438	8'	2,438	8'	6,058	19'-10 1/2"	20,320
1CC (TEU)	2,591	**8'-6"**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

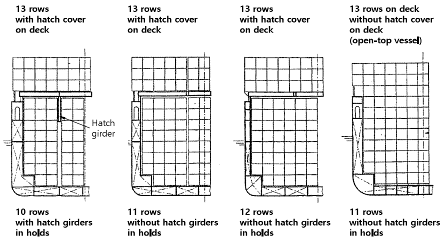


Various Sizes of Container Ship

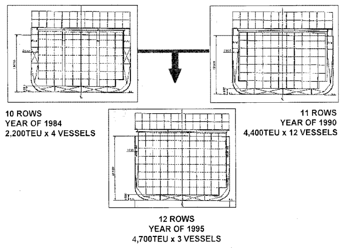


* Reference: DSME

Various Container Arrangement in Midship Section



Increased Rows of a PAX (Panamax) Beam Container Ship



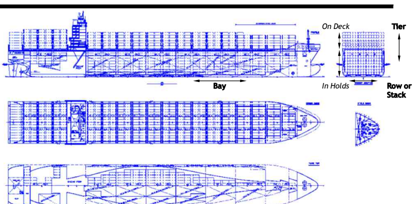
Examples of Large Size Container Ship

13,800 TEU Container Ship by HHI

18,270 TEU Container Ship by DSME

* Reference: HHI and DSME

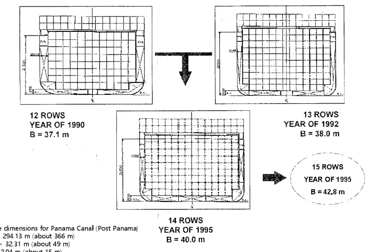
G/A of a 6,500 TEU Container Ship



Principal Dimensions		**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	27.0 knots	MCR	93,120 PS x 104.0 rpm
at NCR with 15% sea margin		NCR	83,810 PS x 100.4 rpm
		Cruising range	23,500 N/M

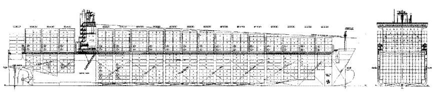
* Reference: DSME

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



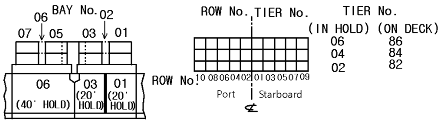
* Allowable dimensions for Panama Canal (Post Panama)
- Length = 294.13 m (about 366 m)
- Breadth = 32.31 m (about 49 m)
- Draft = 12.04 m (about 15 m)
- Container Capacity = 4,400 TEU (14,000 TEU)

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

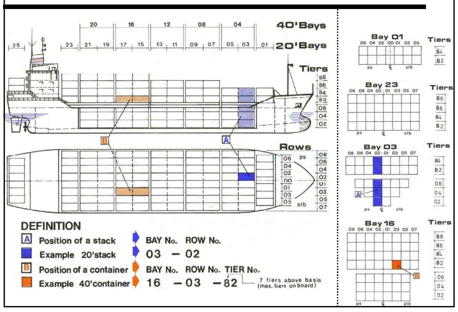


Code of the Container Position (1/2)

- ☑ 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 (bay), transverse (row), and vertical location (tier) 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.

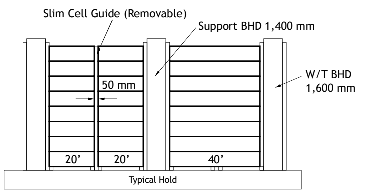


Code of the Container Position (2/2)



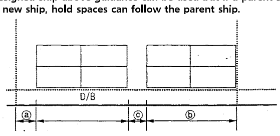
Container Arrangement in Hold

- ☑ 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.

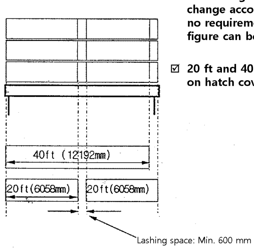


Criteria for Container Arrangement in Hold

- ☑ 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.

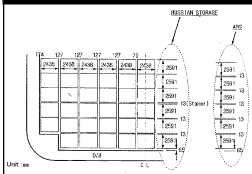


Criteria for Container Arrangement on Deck



- ☑ 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.

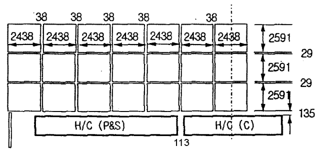
Criteria for Container Loading in Hold



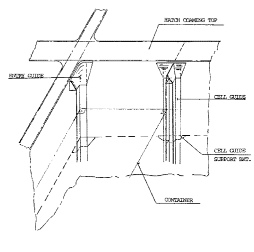
- ☑ The container arrangement in holds can be a basis of G/A, VCG of cargo in trim & stability calculation, and the check point of cargo in holds. Thus, it should be confirmed in early stage.
- ☑ For Russian storage (20 ft containers are loaded without slim cell guides in holds and 40 ft containers are 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.

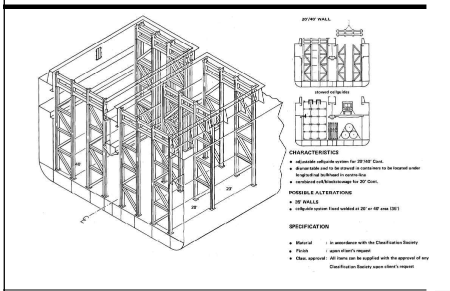


Cell Guide System of Container Carrier (1/2)



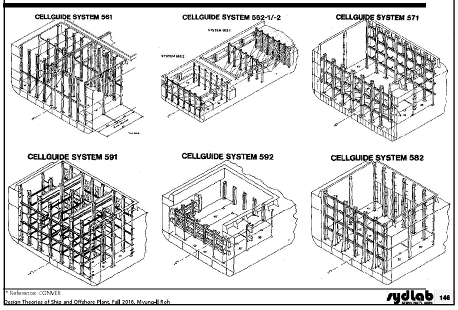
* Reference: CONVER

Cell Guide System of Container Carrier (2/2)



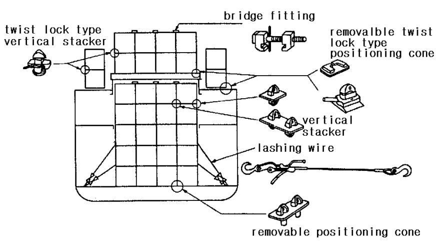
* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 145

Various Cell Guide Systems



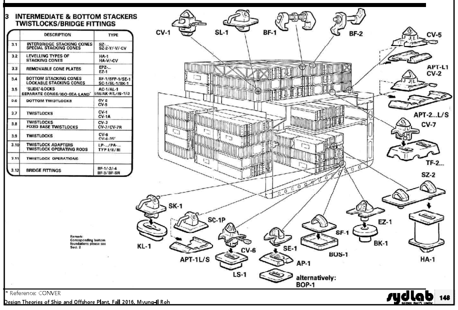
* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 146

Various Container Fittings (1/2)



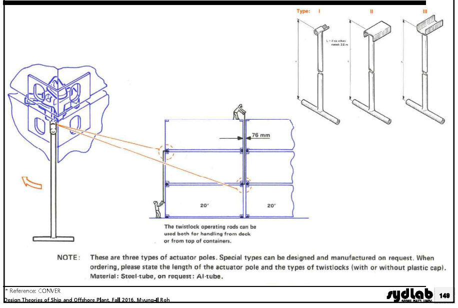
* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 147

Various Container Fittings (2/2)



* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 148

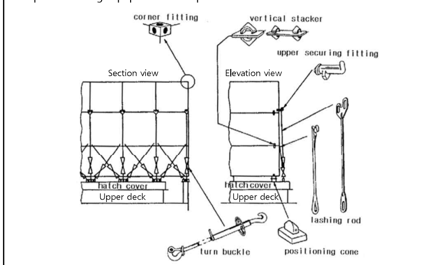
Twistlock Operating Rods



* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 149

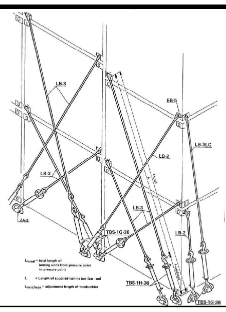
Container Lashing Equipment on Deck (1/2)

Example of lashing equipment for exposed containers



* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 150

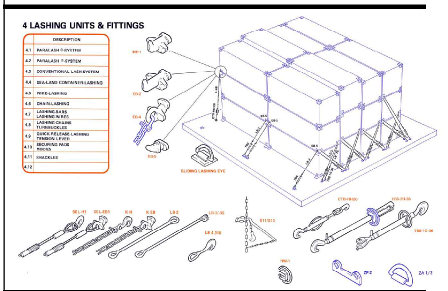
Container Lashing Equipment on Deck (2/2)



LB: Lashing Bar
TBS: Turn Buckle

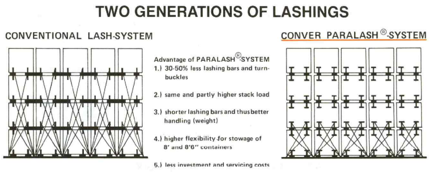
* Reference: CONVER 151

Lashing Units & Fittings



* Reference: CONVER
Design Theories of Ship and Offshore Plant, Fall 2016, Myung-Il Roh 152

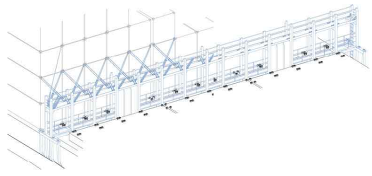
Lashing System



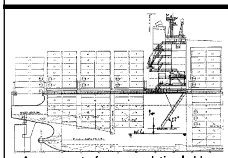
* Reference: CONVER

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.

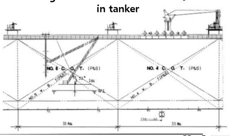


Accommodation Ladder

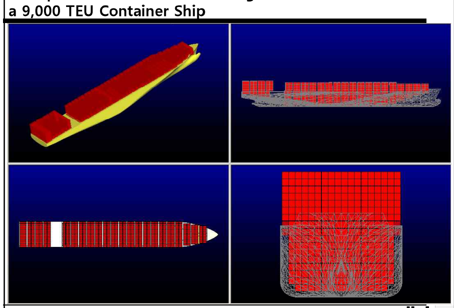


Arrangement of accommodation ladder in container ship

Arrangement of accommodation ladder in tanker

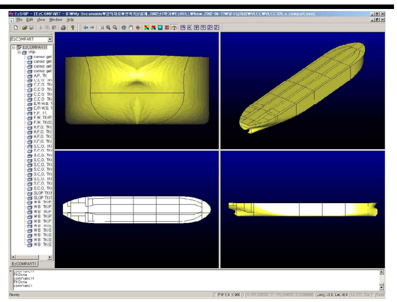


Example of the Container Loading of a 9,000 TEU Container Ship

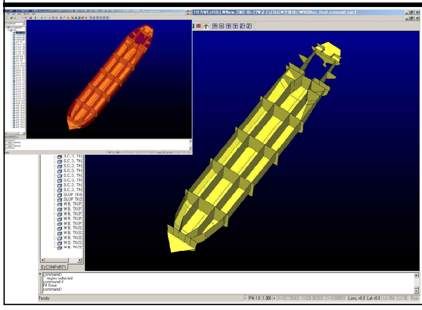


4.5 Examples of General Arrangement Design

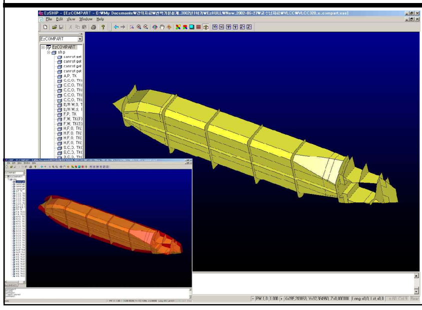
General Arrangement Design of a 320K VLCC (1/3)



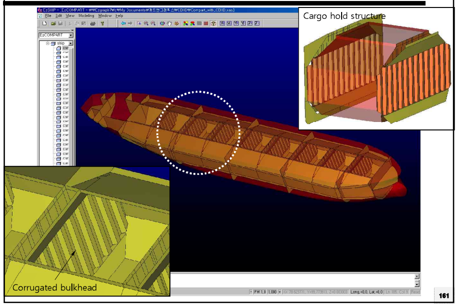
General Arrangement Design of a 320K VLCC (2/3)



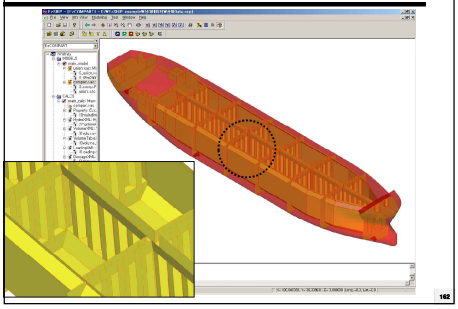
General Arrangement Design of a 320K VLCC (3/3)



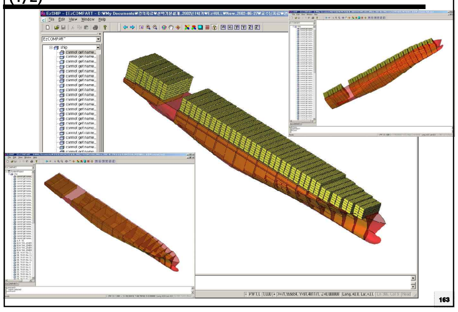
General Arrangement Design of a 182K Bulk Carrier



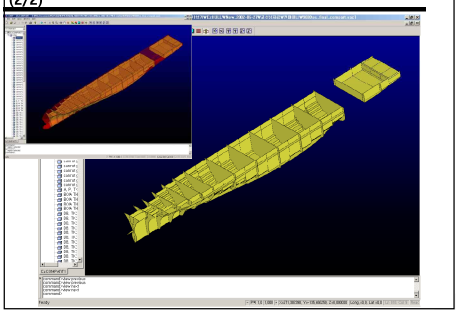
General Arrangement Design of a 40K Product/Chemical Carrier



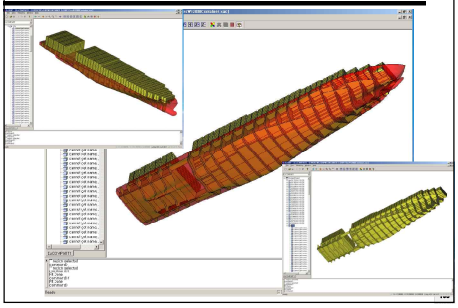
General Arrangement Design of a 9,000 TEU Container Ship (1/2)



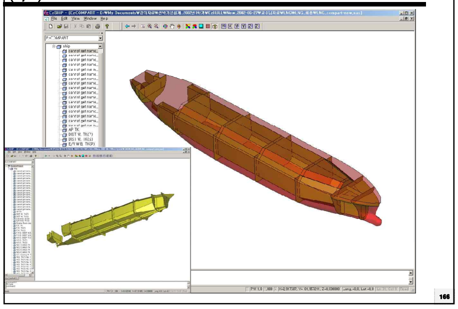
General Arrangement Design of a 9,000 TEU Container Ship (2/2)



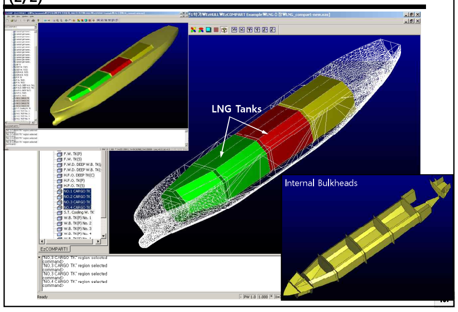
General Arrangement Design of a 12,000 TEU Container Ship



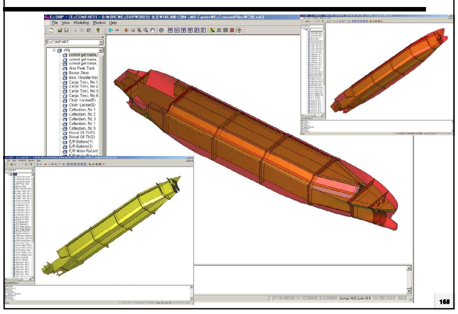
General Arrangement Design of a 145,000 CBM LNG Carrier (1/2)



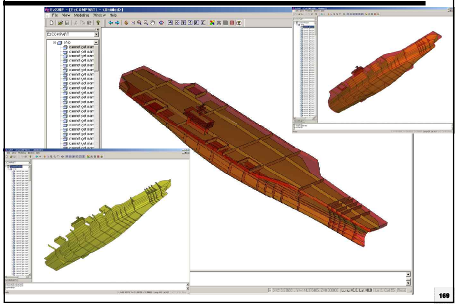
General Arrangement Design of a 145,000 CBM LNG Carrier (2/2)



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)