Design Theories of Ship and Offshore Plant

Part I. Ship Design

Ch. 7 Outfitting Design

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Myung-Il Roh

Department of Naval Architecture and Ocean Engineering
Seoul National University

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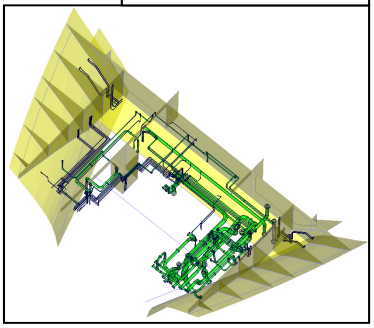
What is a "Outfitting"? (1/2)

☑ **Outfitting**
- All equipment and instrument to be required for showing all function of the ship
  - Hull outfitting: Propeller, rudder, anchor/mooring equipment, etc.
  - Machinery outfitting: Equipment, pipes, ducts, etc. in the engine room
  - Accommodation outfitting: Deck house (accommodation), voyage equipment, etc.
  - Electric outfitting: Power, lighting, cables, and so on
- Like internal organs or blood vessels of human

☑ **Outfitting design**
- Design task that determines the types, numbers, and specifications of outfitting

Pipe model of the VLCC



What is a "Outfitting"? (2/2)

☑ **All equipment (main machinery, together with auxiliaries, piping systems, deck gear, lifeboats, accommodation equipment, plumbing systems, and rigging) for the working and operation of ships and offshore plants**

Example of hull structure of midship region

All equipment except for hull structure

Example of outfitting in engine room

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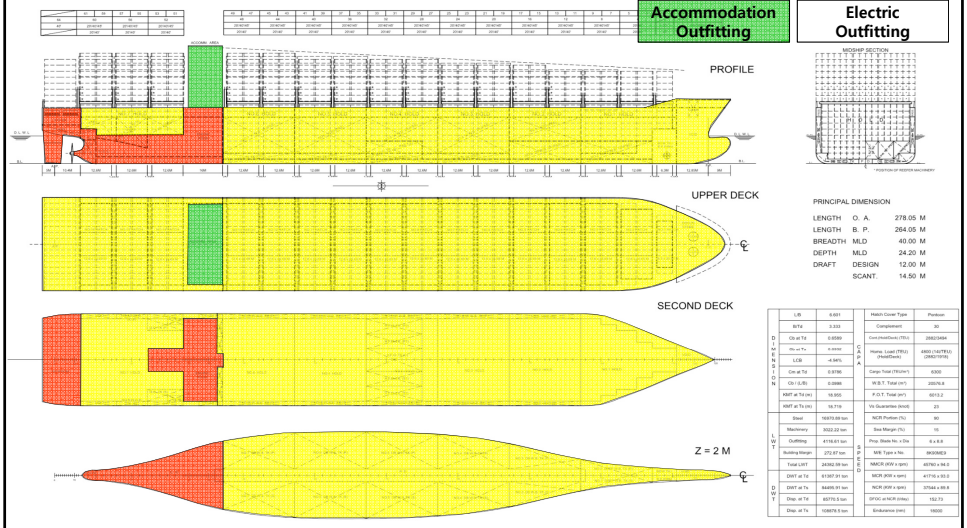
Categorization of Outfitting

G/A of a 6,300 TEU Container Ship

Hull Outfitting | **Machinery Outfitting**

Accommodation Outfitting | **Electric Outfitting**

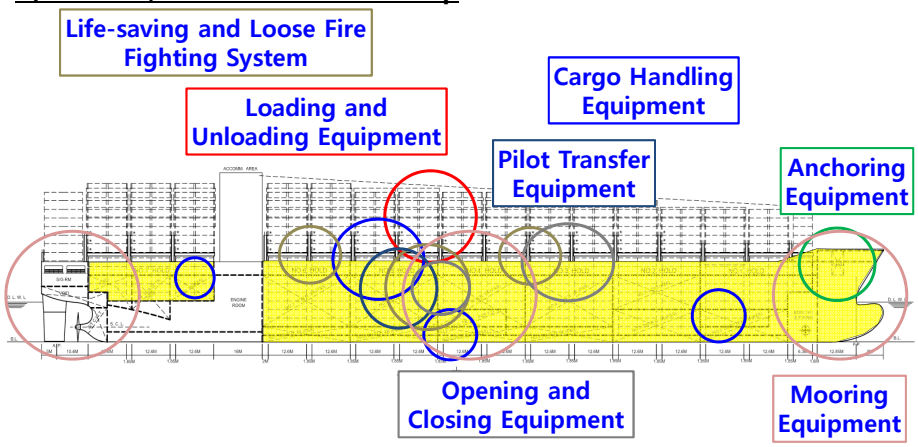


7.1 Hull Outfitting

(1) Hull Outfitting Equipment

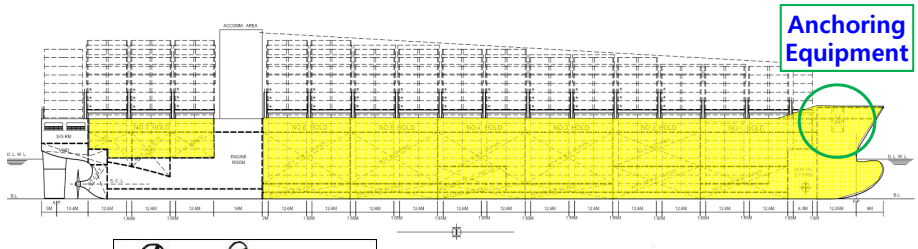
Overview of Hull Outfitting Equipment

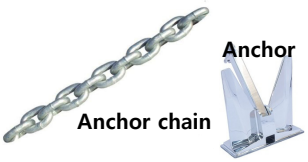
G/A of a 6,300 TEU Container Ship



Anchoring Equipment (1/6)

G/A of a 6,300 TEU Container Ship





Anchoring Equipment (2/6)

☑ **Purpose of Anchoring**

- Temporary mooring of a ship within a harbor or sheltered area when the vessel is awaiting berth, etc.

☑ **Equipment Numeral (EN)**

- Formula for anchoring equipment required to hold a ship in conditions such as to avoid dragging of anchor, based on the following assumption;
  - Wind speed: 25 m/sec
  - Current speed: 2.5 m/sec

☑ **Components**

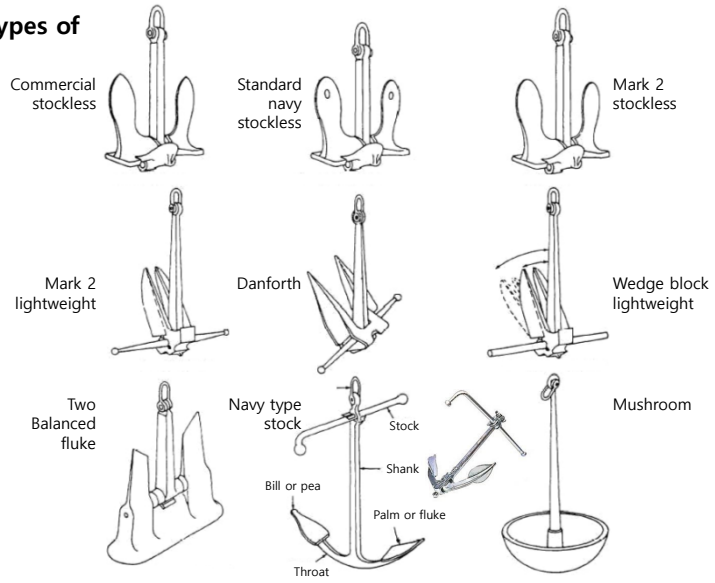
- Anchor, Anchor chain, Anchoring winch[1], Windlass[2], Chain compressor

1: Mechanical device that is used to pull in (wind up) or let out (wind out) or otherwise adjust the tension of a rope or wire rope
2: Apparatus for moving heavy weights. Typically, a windlass consists of a horizontal cylinder (barrel), which is rotated by the turn of a crank or belt.

Anchoring Equipment (3/6)

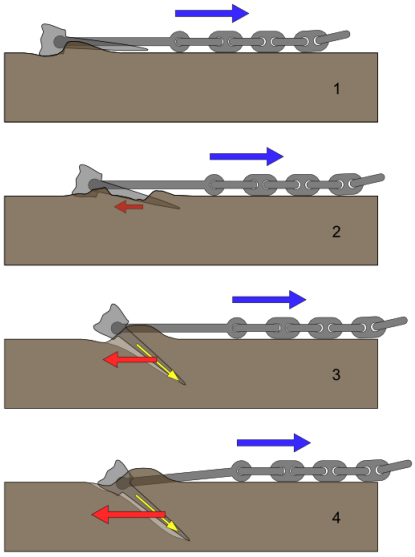
Anchoring Equipment (4/6)

Various types of anchors



Anchoring Equipment (5/6)

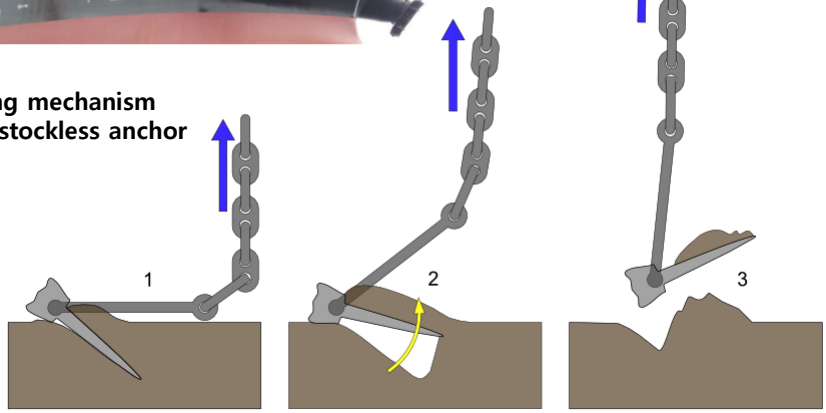
Various types of anchors



Holding mechanism of a stockless anchor

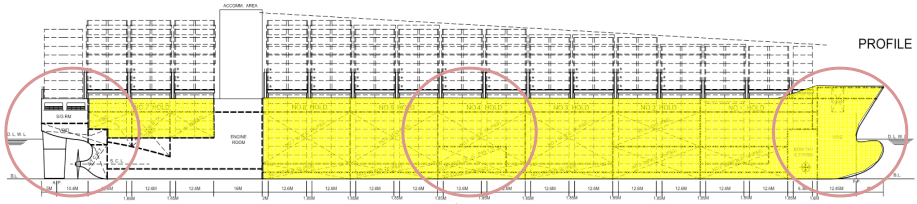
Anchoring Equipment (6/6)

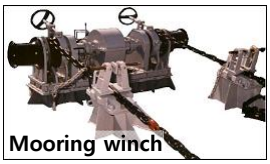
Lifting mechanism
of a stockless anchor

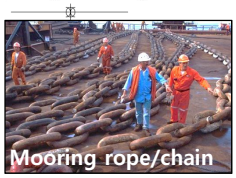


Mooring Equipment (1/4)

G/A of a 6,300 TEU Container Ship




Mooring winch

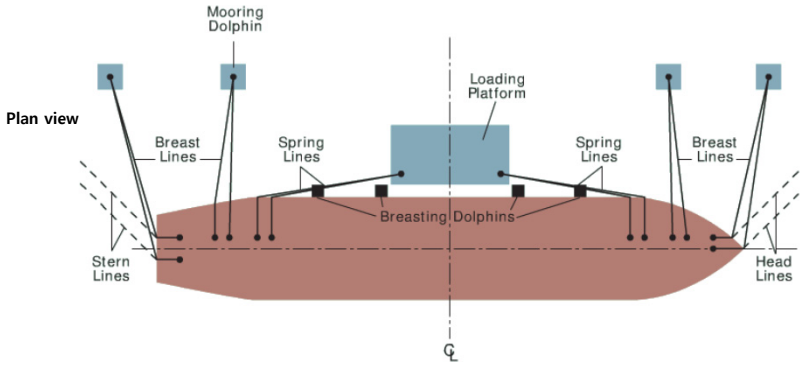

Mooring rope/chain

Mooring Equipment

Mooring Equipment (2/4)

☑ **Standard Environmental Conditions according to Mooring Equipment Guidelines (MEG3)**

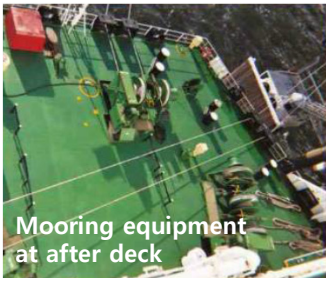
- **Wind: 60 knots from any direction simultaneously with;**
- **Current: 3 knots at 0° or 180°, or 2 knots at 10° or 170°, or 0.75 knots from the direction of maximum beam current loading**



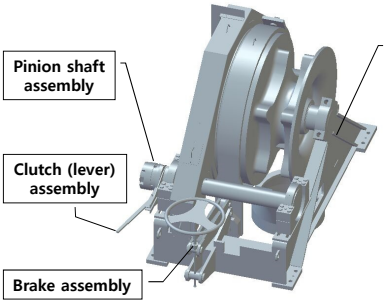
Typical mooring pattern

* OCIMF, Mooring Equipment Guidelines, 3rd Edition, 2008

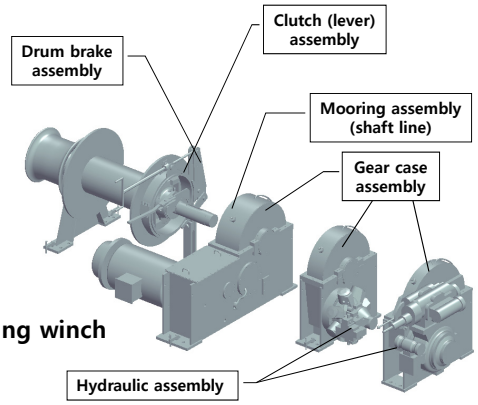
Mooring Equipment (3/4)



Mooring Equipment (4/4)



Windlass

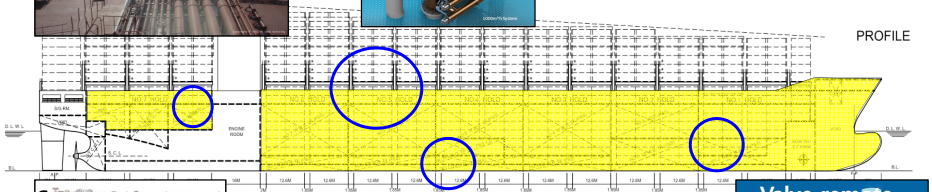


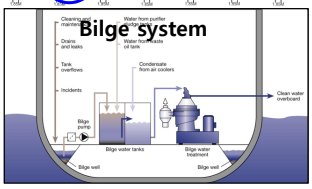
Mooring winch

Cargo Handling Equipment

G/A of a 6,300 TEU Container Ship

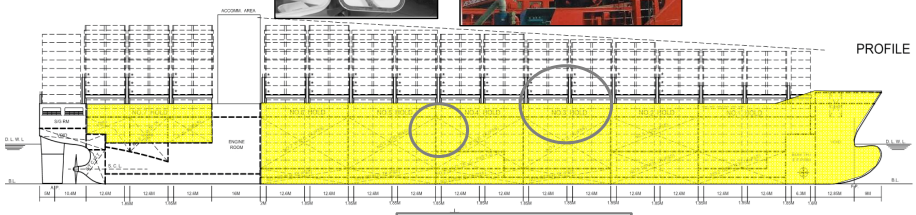
Cargo Handling Equipment





Cargo Handling Equipment
- Opening and Closing Equipment

G/A of a 6,300 TEU Container Ship

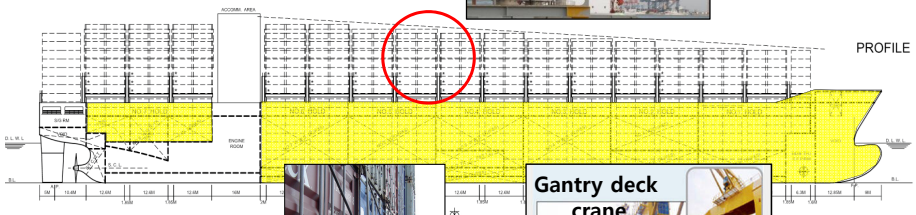


Opening and Closing Equipment

Cargo Handling Equipment
- Loading and Unloading Equipment

G/A of a 6,300 TEU Container Ship

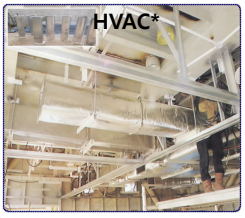
Loading and Unloading Equipment

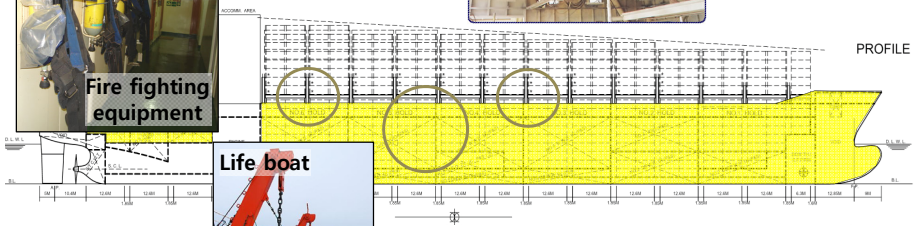


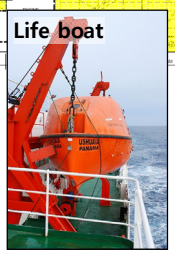
Life-saving and Loose Fire Fighting System

G/A of a 6,300 TEU Container Ship

Life-saving and Loose Fire Fighting System



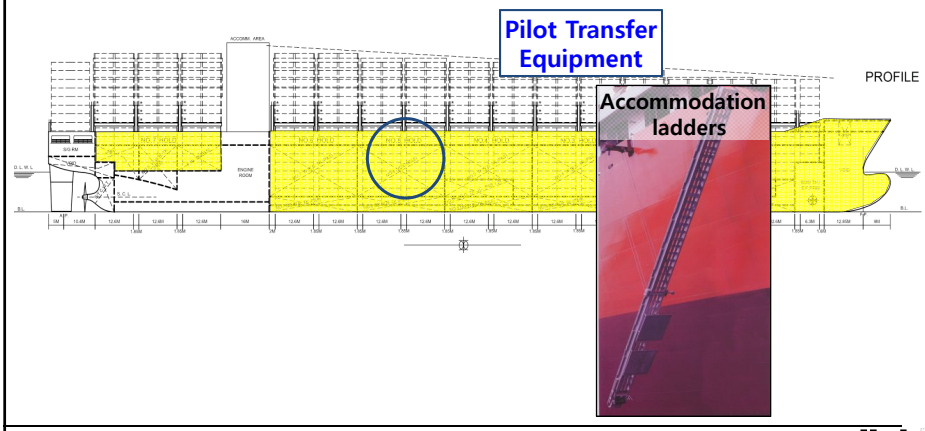




* Heating, Ventilation, and Air Conditioning

Pilot Transfer Equipment

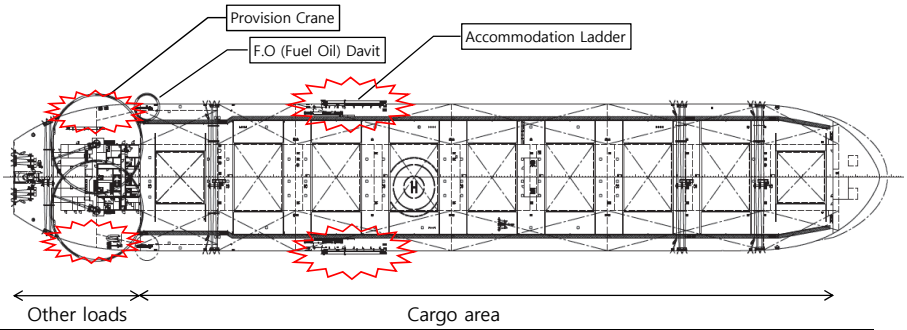
G/A of a 6,300 TEU Container Ship



Pilot Transfer Equipment
- Accommodation Ladder

- ☑ **Regulation: SOLAS Chapter II-1, Reg. 3-9 (Refer to: MSC.1/Circ. 1331)**
- ☑ **Requirement: As far as practicable, the means of embarkation and disembarkation should be sited clear of working area and should not be placed where cargo or other suspended loads may pass overhead.**

Example of accommodation ladder of bulk carrier



* Reference: STX Offshore and Shipbuilding

(2) Equipment Numeral

1. Definition of Equipment Numeral (1/5)

☑ **Design of the Anchoring Equipment**

- The anchoring equipment required herewith is intended for temporary mooring of a ship within a harbor or sheltered area when the ship is awaiting berth, tide, etc.
- The equipment is therefore not designed to hold a ship off fully exposed coasts in rough weather or to stop a ship which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large ships.
- The anchoring equipment presently required herewith is designed to hold a ship in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors will be significantly reduced.

* International Association of Classification Societies, Requirements Concerning Mooring, Anchoring and Towing, 2007

1. Definition of Equipment Numeral (2/5)

☑ **Design of the Anchoring Equipment (continued)**

- The Equipment Numeral (EN) formula for anchoring equipment required here under is based on an assumed current speed of 2.5 m/s, wind speed of 25 m/s and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.
- It is assumed that under normal circumstances a ship will use only one bow anchor and chain cable at a time.
- Manufacture of anchors and anchor chain cables is to be in accordance with UR W29 and UR W18.

* International Association of Classification Societies, Requirements Concerning Mooring, Anchoring and Towing, 2007

1. Definition of Equipment Numeral (3/5)

☑ **Equipment Numeral (EN) Formula**

■ **The equipment of anchors and chain cables is to be based on an "Equipment Numeral" calculated as follows:**

$$EN = \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$$

where,
Δ: Moulded displacements, in tones, to the Summer Load Waterline
B: Moulded breadth, in meters
h: Effective height, in meters, from the Summer Load Waterline to the top of the uppermost house; for the lowest tier "h" is to be measured at centerline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck.

$$h = f + \Sigma h_i$$

where,
f: Distance, in meters, from the Summer Load Waterline amidships to the upper deck
h_i: Height, in meters, on the centerline of each tier of houses having a breadth greater than B/4
A: Area, in square meters, in profile view, of the hull, superstructures, and houses above the Summer Load Waterline which are within the equipment length of the ship and also have a breadth greater than B/4
Equipment length: Length between perpendiculars (L_{BP}) but is not to be less than 96% nor greater than 97% of the extreme length on the Summer Waterline (measured from the forward end of the waterline)

* International Association of Classification Societies, Requirements Concerning Mooring, Anchoring and Towing, 2007

1. Definition of Equipment Numeral (4/5)

Anchoring equipment table

E.N.	Stockless bower anchors		Stud link chain cable for bower anchors			
				Min. dia.		
	No. *	Mass per anchor (kg)	Total length (m)	Mild steel Gr. 1 (mm)	Special quality Gr. 2 (mm)	Extra special quality Gr. 3 (mm)
1	2	3	4	5	6	7
205-240	3	660	302.5	26	22	20.5
240-280	3	780	330	28	24	22
280-320	3	900	357.5	30	26	24
320-360	3	1020	357.5	32	28	24
360-400	3	1140	385	34	30	26
400-450	3	1290	385	36	32	28
450-500	3	1440	412.5	38	34	30
500-550	3	1590	412.5	40	34	30
550-600	3	1740	440	42	36	32
600-660	3	1920	440	44	38	34
660-720	3	2100	440	46	40	36
720-780	3	2280	467.5	48	42	36
780-840	3	2460	467.5	50	44	38
840-910	3	2640	467.5	52	46	40
910-980	3	2850	495	54	48	42
980-1060	3	3060	495	56	50	44
1060-1140	3	3300	495	58	50	46
1140-1220	3	3540	522.5	60	52	46
1220-1300	3	3780	522.5	62	54	48
1300-1390	3	4050	522.5	64	56	50

E.N.	Stockless bower anchors		Stud link chain cable for bower anchors			
				Min. dia.		
	No. *	Mass per anchor (kg)	Total length (m)	Mild steel Gr. 1 (mm)	Special quality Gr. 2 (mm)	Extra special quality Gr. 3 (mm)
1	2	3	4	5	6	7
1390-1480	3	4320	550	66	58	50
1480-1570	3	4590	550	68	60	52
1570-1670	3	4890	550	70	62	54
1670-1790	3	5250	577.5	73	64	56
1790-1930	3	5610	577.5	76	66	58
1930-2080	3	6000	577.5	78	68	60
2080-2230	3	6450	605	81	70	62
2230-2380	3	6900	605	84	73	64
2380-2530	3	7350	605	87	76	66
2530-2700	3	7800	632.5	90	78	68
2700-2870	3	8300	632.5	92	81	70
2870-3040	3	8700	632.5	95	84	73
3040-3210	3	9300	660	97	84	76
3210-3400	3	9900	660	100	87	78
3400-3600	3	10500	660	102	90	78
3600-3800	3	11100	687.5	105	92	81
3800-4000	3	11700	687.5	107	95	84
4000-4200	3	12300	687.5	111	97	87

One is for a spare (not compulsory).

* International Association of Classification Societies, Requirements Concerning Mooring, Anchoring and Towing, 2007

1. Definition of Equipment Numeral (5/5)

Anchoring equipment table (continued)

E.N.	Stockless bower anchors		Stud link chain cable for bower anchors			
				Min. dia.		
	No. *	Mass per anchor (kg)	Total length (m)	Mild steel Gr. 1 (mm)	Special quality Gr. 2 (mm)	Extra special quality Gr. 3 (mm)
1	2	3	4	5	6	7
4200-4400	3	12900	715	114	100	87
4400-4600	3	13500	715	117	102	90
4600-4800	3	14100	715	120	105	92
4800-5000	3	14700	742.5	122	107	95
5000-5200	3	15400	742.5	124	111	97
5200-5500	3	16100	742.5	127	111	97
5500-5800	3	16900	742.5	130	114	100
5800-6100	3	17800	742.5	132	117	102
6100-6500	3	18800	742.5		120	107
6500-6900	3	20000	770		124	111
6900-7400	3	21500	770		127	114
7400-7900	3	23000	770		132	117
7900-8400	3	24500	770		137	122
8400-8900	3	26000	770		142	127
8900-9400	3	27500	770		147	132
9400-10000	3	29000	770		152	132
10000-10700	3	31000	770			137
10700-11500	3	33000	770			142
11500-12400	3	35500	770			147
12400-13400	3	38500	770			152
13400-14600	3	42000	770			157
14600-16000	3	46000	770			162

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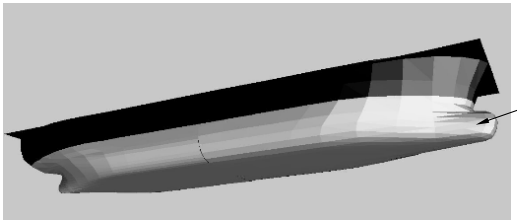
2. Meaning of Equipment Numeral (1/5)

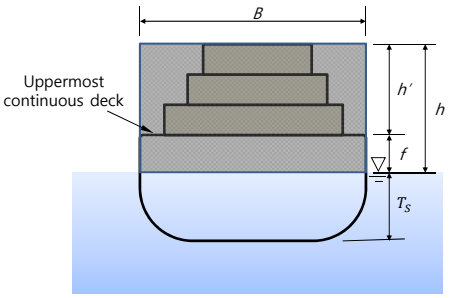
- ☑ **Meaning: Resistance of a full-loaded ship from wind and current**
- ☑ **Basis: Wind speed of 25 (m/s), Current speed of 2.5 (m/s)**
- ☑ $\mathbf{EN} = \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$
  - **Underwater area which the current force acts on. That is, wetted surface area**
  - **Δ: Moulded displacements to the Summer Load Waterline (ton)**
  - **The dimension changes into "Surface" by using displacement to the two thirds power.**



2. Meaning of Equipment Numeral (2/5)

☑ $EN = \Delta^{\frac{2}{3}} + 2.0 \cdot \boxed{Bh} + 0.1 \cdot A$

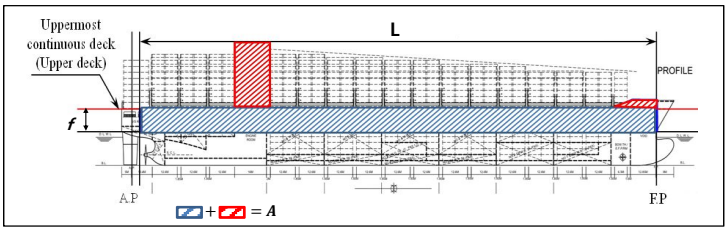
- Area which the wind force in longitudinal direction acts on. That is, sectional area above waterline
- $h = f + h'$ (m)
- f: Distance from the Summer Load Waterline amidships to the upper deck (m)
- h': The sum of the height (at centerline) of each tier of houses (superstructure, deckhouse or trunk) having a breadth greater than B/4 (m)



2. Meaning of Equipment Numeral (3/5)

☑ $EN = \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot \boxed{A}$

- Area which the wind force in transverse direction acts on. That is, lateral area above waterline
- $A = fL + \Sigma h'' l$ (m^2)
- f: Distance from the Summer Load Waterline amidships to the upper deck (m)
- Σh''l: The sum of the height (h'') times length (l) of each tier of houses (superstructure, deckhouse or trunk) having a breadth greater than B/4 and a height greater than 1.5 m (m)



In case of container ship, equipment numeral formula for anchoring includes projected lateral area of cargo, but that for mooring does not. (IACS UR A 2.2.3).

2. Meaning of Equipment Numeral (4/5)

☑ Relation among Equipment Numeral (EN), Holding Power of Anchors (P), and Force from Wind and Current (F)

- EN $\propto$ P
- P $\geq$ F

2. Meaning of Equipment Numeral (5/5)

☑ Why do we calculate equipment numeral at full loaded condition?

- Comparison of equipment numeral at full loaded condition (maximum draft) and ballast condition (minimum draft)

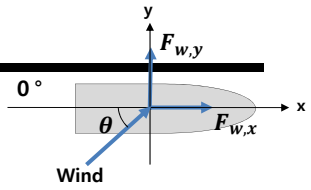
  (Target ships: VLCC Tanker, 18,000TEU Container Ship, Drillship)

Ship Type	Tanker (VLCC)		Containership (18,000TEU)		Drillship (230×42×19)	
Condition	Ballast	Full Loaded	Ballast	Full Loaded	Ballast	Full Loaded
$\Delta^{2/3}$						
2Bh						
0.1A						
Equipment Numeral						

The equipment numeral at full loaded condition is larger than that at ballast condition.

➡ This means that full loaded condition is considered as the most severe condition.

3. Wind and Current Force (1/5)



☑ Wind Force according to OCIMF*

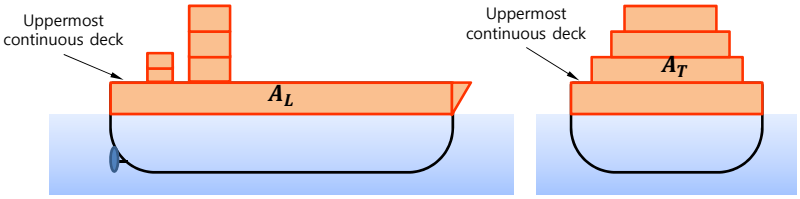
■ When the direction of wind is θ,

Longitudinal component of wind force: $F_{w,x} = \frac{1}{2} \cdot C_{w,x,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_T$

Projected sectional area above waterline

Transverse component of wind force: $F_{w,y} = \frac{1}{2} \cdot C_{w,y,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_L$

Projected lateral area above waterline



* Prediction of Wind and Current Loads on VLCCs, Oil Companies International Marine Forum (OCIMF), 2nd Edition, 1994 (First Published 1977)

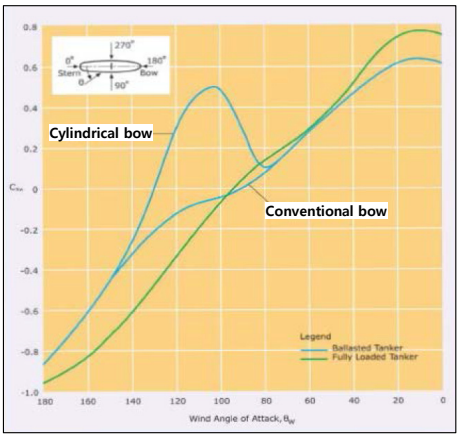
3. Wind and Current Force (2/5)

$$F_{w,x} = \frac{1}{2} \cdot C_{w,x,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_T$$

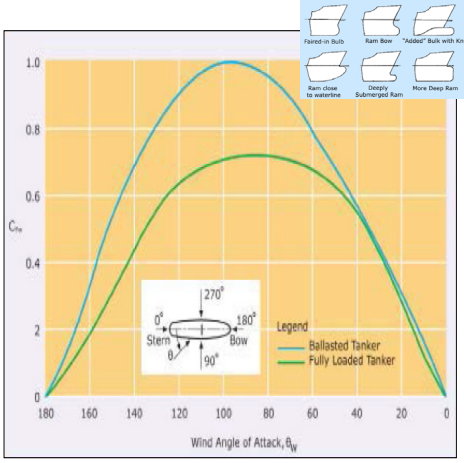
$$F_{w,y} = \frac{1}{2} \cdot C_{w,y,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_L$$

☑ Wind Force Coefficient ($C_{w,x,\theta}$, $C_{w,y,\theta}$) according to θ

■ Target ship: Tanker



Wind force coefficient ($C_{w,x,\theta}$) in longitudinal direction



Wind force coefficient ($C_{w,y,\theta}$) in transverse direction

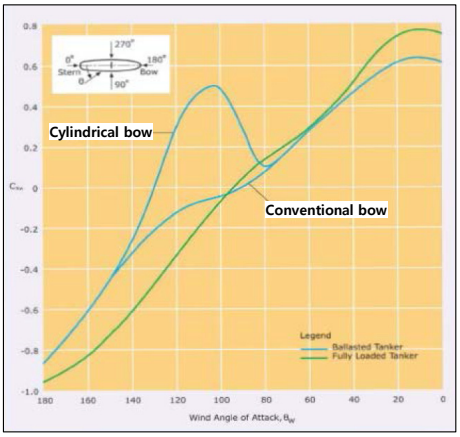
3. Wind and Current Force (3/5)

$$F_{w,x} = \frac{1}{2} \cdot C_{w,x,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_T$$

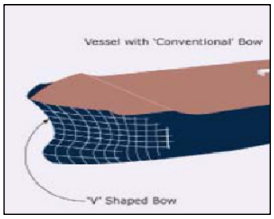
$$F_{w,y} = \frac{1}{2} \cdot C_{w,y,\theta} \cdot \rho_w \cdot {v_w}^2 \cdot A_L$$

☑ Wind Force Coefficient ($C_{w,x,\theta}$, $C_{w,y,\theta}$) according to θ

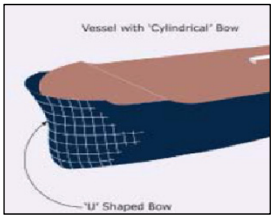
■ Target ship: Tanker



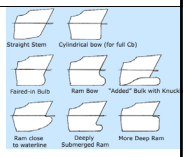
Wind force coefficient ($C_{w,x,\theta}$) in longitudinal direction



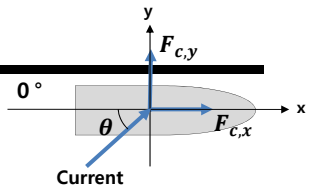
Conventional Bow = V Shaped Bow



Cylindrical Bow = U Shaped Bow



3. Wind and Current Force (4/5)



☑ Current Force according to OCIMF*

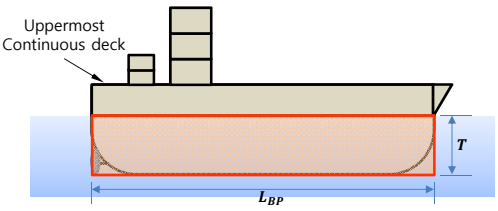
■ When the direction of current is θ,

Longitudinal component of current force: $F_{c,x} = \frac{1}{2} \cdot C_{c,x,\theta} \cdot \rho_c \cdot {v_c}^2 \cdot \underline{L_{BP}T}$

Why is not this $B \cdot T$ (projected sectional area)?

➡ Because frictional resistance is considered.

Transverse component of current force: $F_{c,y} = \frac{1}{2} \cdot C_{c,y,\theta} \cdot \rho_c \cdot {v_c}^2 \cdot L_{BP}T$



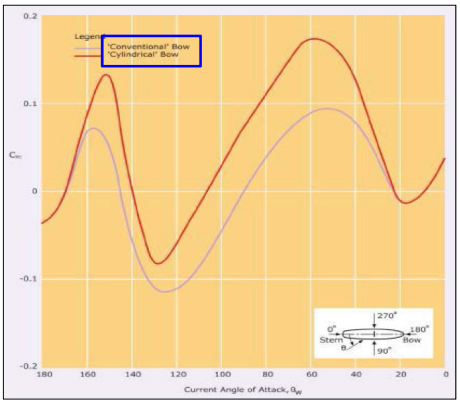
* Prediction of Wind and Current Loads on VLCCs, Oil Companies International Marine Forum (OCIMF), 2nd Edition, 1994 (First Published 1977)

3. Wind and Current Force (5/5)

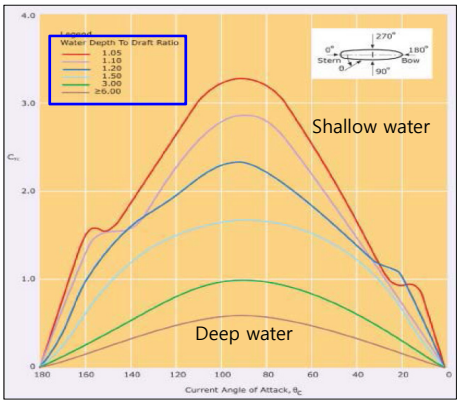
$$F_{c,x} = \frac{1}{2} \cdot C_{c,x,\theta} \cdot \rho_c \cdot {v_c}^2 \cdot L_{BP} T$$
$$F_{c,y} = \frac{1}{2} \cdot C_{c,y,\theta} \cdot \rho_c \cdot {v_c}^2 \cdot L_{BP} T$$

☑ Current Force Coefficient $C_{c,x,\theta}$, $C_{c,y,\theta}$ according to θ

■ Target ship: Tanker



Current force coefficient $(C_{c,x,\theta})$
in longitudinal direction at WD/T=1.1



Current Force Coefficient $(C_{c,y,\theta})$
in transverse direction

The smaller ratio (=WD/T, shallow water) of water depth (WD) and draft (T), the larger current force coefficient.

41

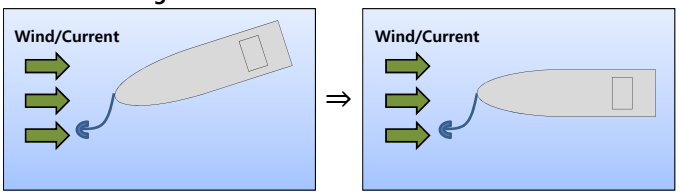
4. Analysis of Equipment Numeral Formula (1/3)

$$E = 1 \cdot \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$$

☑ Analysis of the Relation between Equipment Numeral Formula and Wind & Current Force

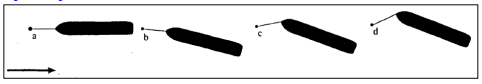
■ Which direction do wind and current act?

- Assumption: A ship rotates freely toward the direction of wind and current while anchoring.



- Thus, wind and current are from the bow.
- We apply transverse force of 5° by considering fish tailing instability* for high speed wind

A ship has yaw motion due to vortex shedding although hydrodynamic force from the bow.



* Aghamohammadi, F., An Experimental Study of the Large Amplitude Fish-tailing Instabilities of a Taker at a Single Point Mooring, Applied Ocean Research, Vol. 12, No. 1, pp. 26, 1990

4. Analysis of Equipment Numeral Formula (2/3)

$E = 1 \cdot \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$

☑ **Wind and Current Force according to OCIMF***

- **Target ship: Tanker**

<Condition for the coefficient>
1. The value at full loaded condition
2. Ratio of water depth and draft (WD/T) = 1.1 (most severe condition)
3. The value for a tank having a conventional bow (from OCIMF)

$$F = Current\ force + Wind\ force = F_c + F_w$$

$$= F_{c,x,180} + F_{w,x,180} + F_{w,y,175}$$

$$= \frac{1}{2} C_{c,x,180} \rho_c v_c^2 L_{BP} T + \frac{1}{2} C_{w,x,180} \rho_w v_w^2 A_T + \frac{1}{2} C_{w,y,175} \rho_w v_w^2 A_L$$

$$= \frac{1}{2}(0.04)(1025)(2.5)^2 L_{BP} T + \frac{1}{2}(0.96)(1.28)(25)^2 A_T + \frac{1}{2}(0.045)(1.28)(25)^2 A_L$$

$$= 128.125 \cdot L_{BP} T + 384 \cdot A_T + 18 \cdot A_L \ (N)$$

* Prediction of Wind and Current Loads on VLCCs, Oil Companies International Marine Forum (OCIMF), 2nd Edition, 1994 (First Published 1977)

4. Analysis of Equipment Numeral Formula (3/3)

$E = 1 \cdot \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$

☑ **Derivation of Equipment Numeral Formula from Wind and Current Force**

$$F = 128.125 \cdot L_{BP} T + 384 \cdot A_T + 18 \cdot A_L \ (N)$$

$$= 128.125 \cdot k \cdot \Delta^{\frac{2}{3}} + 384 \cdot A_T + 18 \cdot A_L \quad (\because L_{BP} T = k \cdot \Delta^{\frac{2}{3}},\ k \approx 1.42)$$

$$= 182 \cdot \Delta^{\frac{2}{3}} + 384 \cdot A_T + 18 \cdot A_L$$

$$= 182 \cdot (1 \cdot \Delta^{\frac{2}{3}} + 2.1 \cdot A_T + 0.1 \cdot A_L)$$

	AFRAMAX	SUEZMAX	VLCC	Mean
Δ (MT)				
$\Delta^{2/3}$				
$L_{BP}T$				
k				

<k values for three different tankers>

- The ratio of coefficients is very similar to that of equipment numeral formula.
- Equipment Numeral can be regarded as the value of wind and current force divided by 182. That is, EN = F / 182.

5. Verification of Equipment Numeral Formula (1/5)

☑ Comparison between Holding Power of Anchors & Chain Cables and Wind & Current Force

- Calculation of holding power of anchors and chain cables corresponding the equipment numeral
- Check whether holding power exceeds wind and current force or not

☑ Holding Power (P) of Anchors and Chain Cables according to KR Rule

- Determination of anchors and chain cables according to equipment numeral
- Calculation of holding power of anchors and chain cables*

P = Holding power of anchors + Holding power of chain cables
$= K_a W_a + K_c L_c W_c$

where, K_a: Holding power coefficient for anchor, K_c: Holding power coefficient for anchor chain, W_a: Submerged weight of anchor, L_c: Length of anchor chain contact with seabed, W_c: Submerged weight of anchor chain per 1 meter
※ Submerged weight $= 0.869 \times$ Weight in the air

* KR, Standard of Floating Offshore Structure, p. 8, 2010

5. Verification of Equipment Numeral Formula (2/5)

$P = K_a W_a + K_c L_c W_c$

☑ Example

- Target ship: AFRAMAX Tanker

<Calculation condition>

1. Ratio of water depth and draft (WD/T) = 1.1
   (same condition at the calculation of wind and current force)
2. Use of anchors of three types (widely used in shipyards)
3. Use of conservative values for $K_a = 2$, $K_c = 0.6$

	Mud	Hard mud	Sand-mud	Sand	Stone-sand
K_a	2	2	2	3~4	3~4
K_c	0.6	0.6	-	0.75	0.75

4. Calculation of holding power of two anchors (general case)

- Calculation of equipment numeral

$$EN = 1 \cdot \Delta^{\frac{2}{3}} + 2.0 \cdot Bh + 0.1 \cdot A$$
$$= 1 \cdot (130,500)^{\frac{2}{3}} + 2.0 \cdot (1,004) + 0.1 \cdot (1,907) = 4,771$$

5. Verification of Equipment Numeral Formula (3/5)

$P = K_a W_a + K_c L_c W_c$

☑ Example

- Target ship: AFRAMAX Tanker
- Equipment numeral: 4,771

E.N over	E.N below	Stockless bower anchors No	Stockless bower anchors Mass per anchor (kg)	Stud link chain cable for bower anchors Total length (m)	Min. diameter Gr. 1 (mm)	Min. diameter Gr. 2 (mm)	Min. diameter Gr. 3 (mm)
4200	4400	2	12900	715	114	100	87
4400	4600	2	13500	715	117	102	90
4600	4800	2	14100	715	120	105	92
4800	5000	2	14700	742.5	122	107	95

Anchoring equipment table

Diameter d (mm)	Mass per 1 meter (kg)
90	177.4
92	185.4
95	197.6

Anchor chain weight table

- Determination of anchoring equipment and calculation of their holding power according to equipment numeral

$$W_a = 0.869 \times 14,100 = 12,253\ (\mathrm{kg})$$
$$L_c = (L/2 - WD) \times 2 = (L/2 - 1.1 \cdot T) \times 2 = (715/2 - 1.1 \cdot 15) \times 2 = 682\ (m)$$
$$W_c = 0.869 \times 185.4 = 161\ (\mathrm{kg})$$
$$\therefore\ P = 2 \times (K_a W_a + K_c L_c W_c) = 2 \times (2 \cdot 12,253 + 0.6 \cdot 682 \cdot 161) \times 9.8/1,000$$
$$= 1,126\ (\mathrm{kN})$$

5. Verification of Equipment Numeral Formula (4/5)

☑ Wind and Current Force according to OCIMF*

$$F = 128.125 \cdot L_{BP} T + 384 \cdot A_T + 18 \cdot A_L\ (N)$$

☑ Example

- Target ship: AFRAMAX Tanker

$$L_{BP}T = 3,600\ (m^2), A_T = 1,004\ (m^2), A_L = 1,907\ (m^2)$$
$$\therefore\ F = (128.125 \times 3,600 + 384 \times 1,004 + 18 \times 1,907)/1,000 = 836\ (\mathrm{kN})$$

Ship Type	AFRAMAX
Equipment Numeral	
P (kN)	
F (kN)	
P / F	

- Repeat this calculation for various types of ships.

* Prediction of Wind and Current Loads on VLCCs, Oil Companies International Marine Forum (OCIMF), 2nd Edition, 1994 (First Published 1977)

5. Verification of Equipment Numeral Formula (5/5)

☑ Comparison between Holding Power (P) of Anchors & Chain Cables and Wind & Current Force (F)

	Tanker			LNGC		CONT.		
	AFRAMAX	SUEZMAX	VLCC	150K	210K	9,200TEU	13,050TEU	14,000TEU
Equipment Numeral								
P (kN)								
F (kN)								
P / F								

Larger than other types of ship

※ The numbers in "( )" mean to consider cargo area when calculating projected lateral area.

The projected lateral area of cargo should be also considered when calculating equipment numeral for anchoring as well as that for mooring, because wind force acts on cargo.

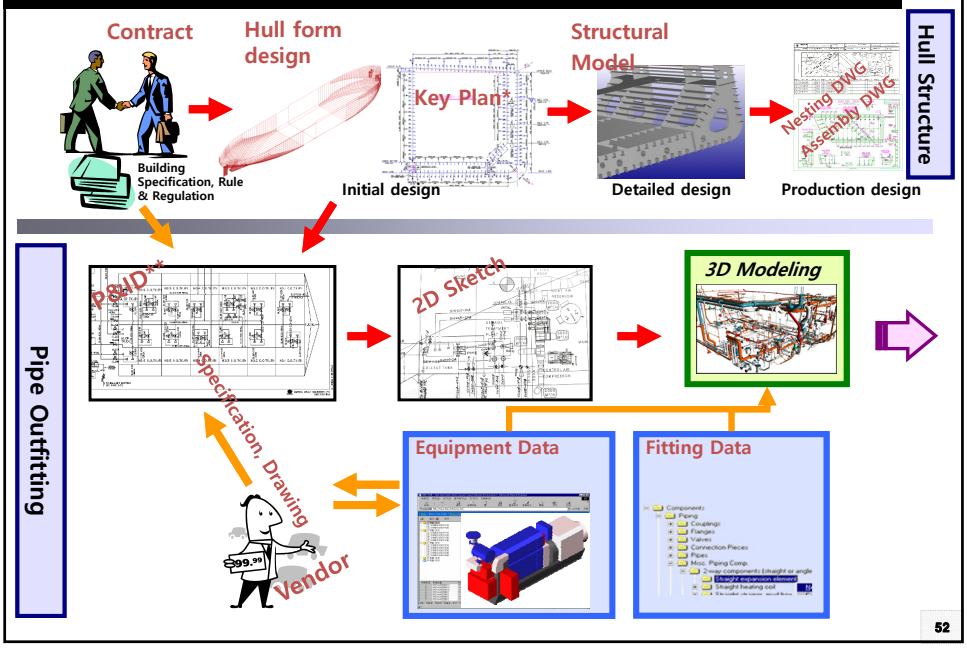
7.2 Machinery Outfitting

(1) P&ID (Piping and Instrumentation Diagram)
(2) Major Equipment in Engine Room (E/R)
(3) Examples of P&ID

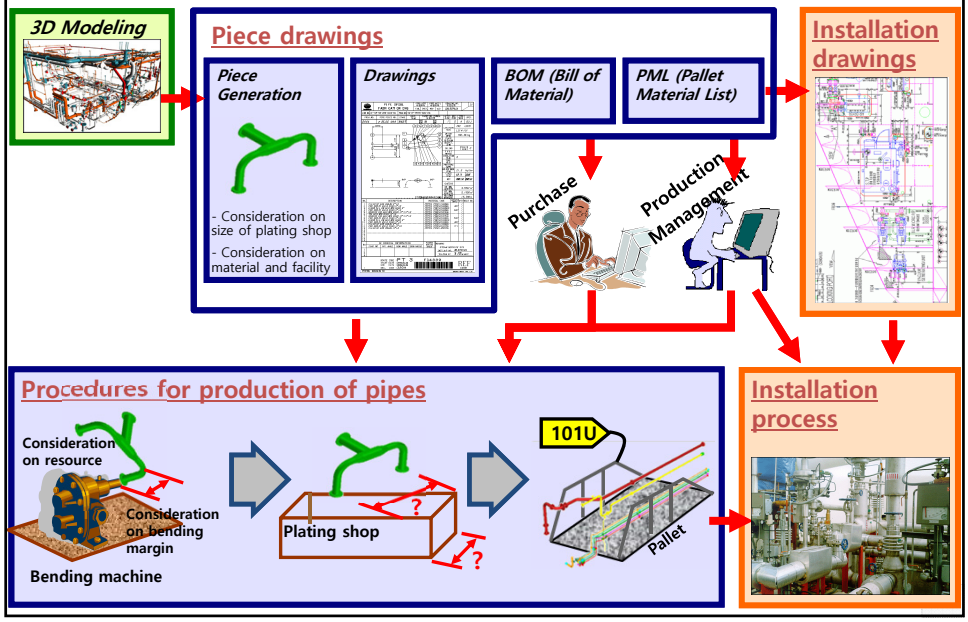
(1) P&ID (Piping and Instrumentation Diagram)

Work Flow of Pipe Outfitting - From Contract to 3D Modeling

* Key Plan: Lines, G/A (General Arrangement), M/A (Machinery Arrangement), Midship Section, Construction Profile, Shell Expansion
** P&ID: Piping and Instrumentation Diagram

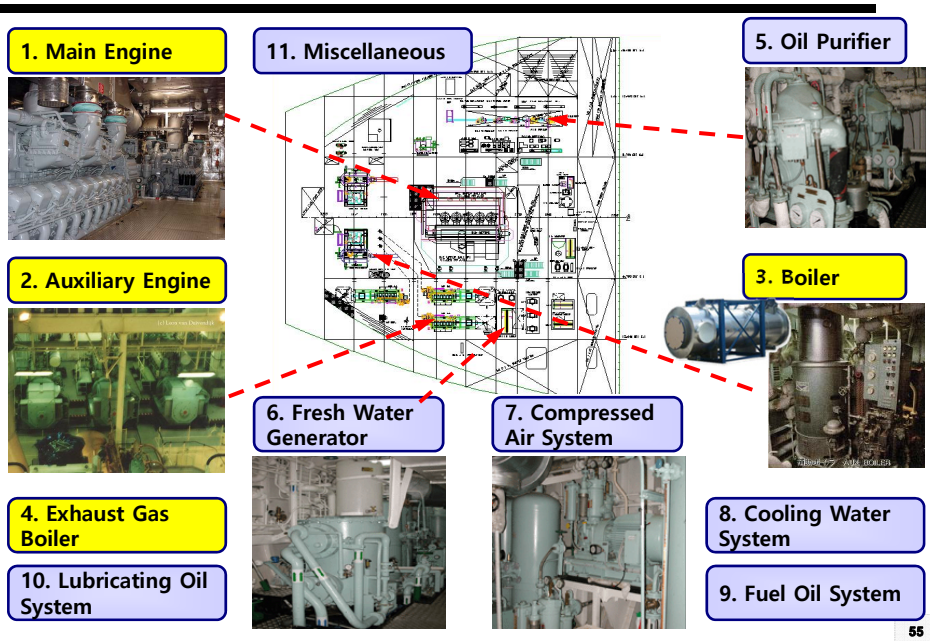


Work Flow of Pipe Outfitting
- From 3D Modeling to Installation



(2) Major Equipment in Engine Room (E/R)

Major Equipment in Engine Room (1/2)



Major Equipment in Engine Room (2/2)

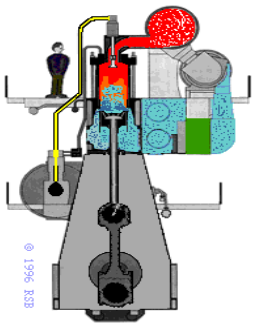
☑ **Main Engine (2-stroke Diesel Engine)**
- Generating propulsion power by burning H.F.O (Heavy Fuel Oil)

☑ **Diesel Generator Engine (4-stroke Diesel Engine)**
- Generating electric power by burning H.F.O

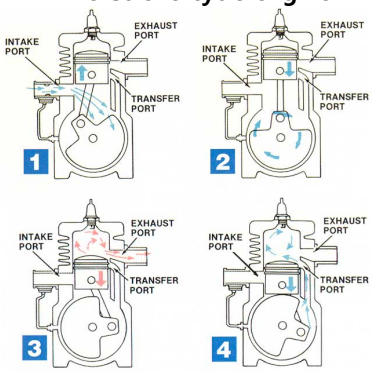
☑ **Boiler**
- Generating steam gas which is needed for heating, cooking, and equipment by burning H.F.O

☑ **Exhaust Gas Boiler (Economizer)**
- Generating steam by using exhaust gas from main engine

(1) Main Engine



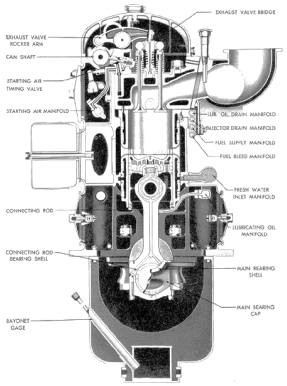
Two-stroke cycle engine



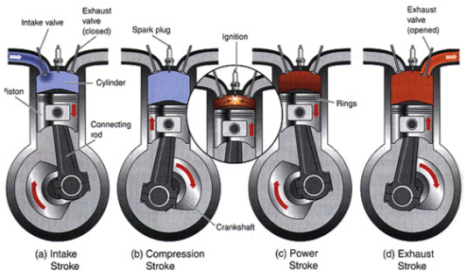
- ☑ Usage of low quality heavy oil of 700 cSt/150˚C ➡ Fuel Oil System (Circulation Pump, Viscosity, Purifier, Heater, ...)
- ☑ Prevention of wear of piston ➡ L.O (Lubricating Oil) System
- ☑ Cooling of engine ➡ Cooling System
- ☑ Processing of exhaust gas ➡ Exhaust Gas System

* 1 cSt (centistoke) = 0.01 St = 0.000001 m^2/s = 1 mm^2/s

(2) Auxiliary Engine (Diesel Generator Engine)

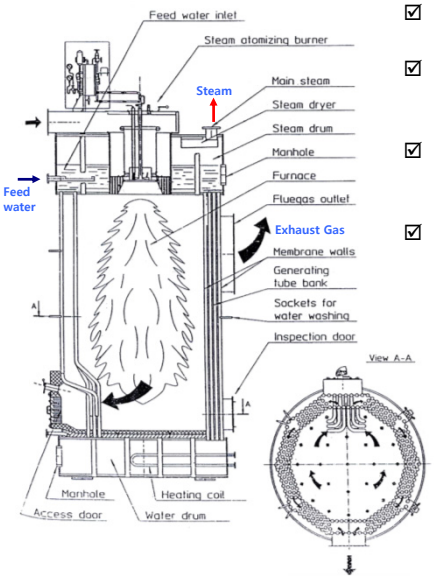


Four-stroke cycle engine

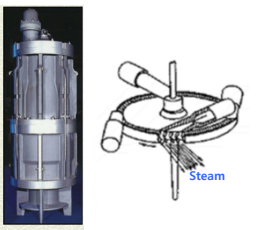


- ☑ Engines for operating generators which are source of all power in ship (auxiliary engine + generator set).
- ☑ In general, 3~4 engines are installed in one ship and heavy fuel oil or diesel oil is used for operation.
- ☑ Similar systems should be equipped due to similar operation with M/E.

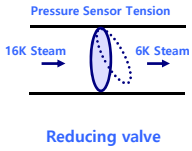
(3) Boiler



- ☑ Equipment for generating steam gas which is needed for heating, cooking, and equipment
- ☑ For oil tanker, if cargo oil pump and water ballast pump are steam driven type, the capacity for them should be considered.
- ☑ For general cargo ship, low pressure gas of pressure of 7 kg/cm^2 and temperature of 169°C are generated in the boiler.
- ☑ For tanker, steam gas of 16K 212°C, 6K 168°C, 4K 152°C are generated through depression from 16 kg/cm^2 in the boiler.

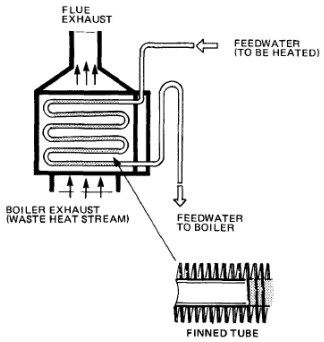


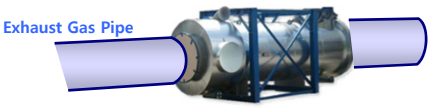
Operation of Cargo Oil Pump



Reducing valve

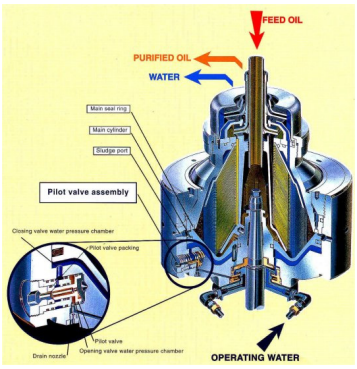
(4) Exhaust Gas Boiler (Economizer)





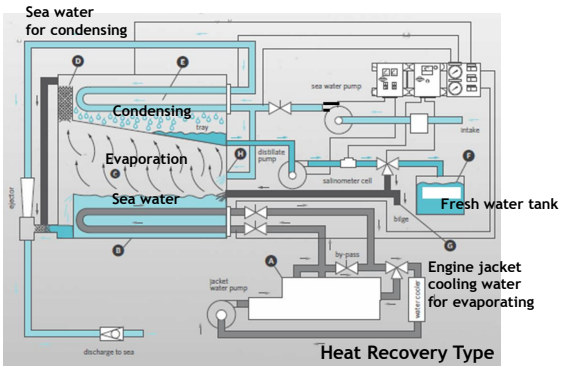
- ☑ Equipment for generating steam gas by using exhaust gas of about 250°C from M/E for saving fuel
- ☑ Steam gas is generated by circulating boiler water in boiler and heating with exhaust gas through economizer.
- ☑ It can operate during voyage since steam gas can be generated when M/E operates.

(5) Oil Purifier



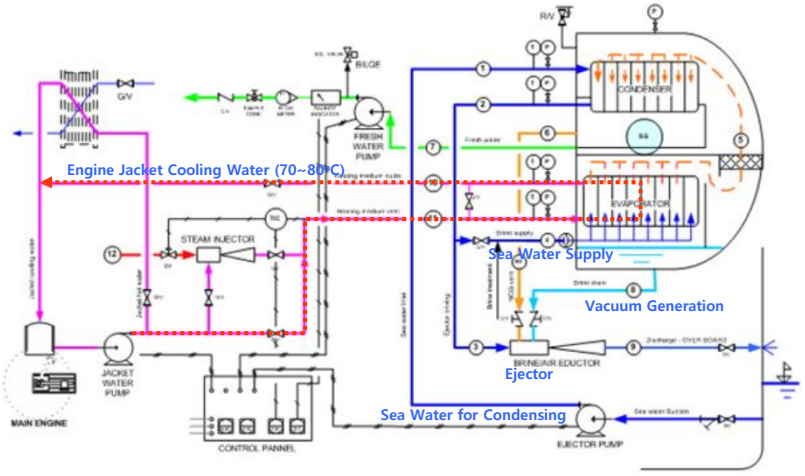
- ☑ Impurities exist in heavy fuel oil and lubricating oil used in M/E, aux. engine, and boiler. They affect the combustion condition and accelerate the wear of engine.
- ☑ Oil purifier is used to remove water, ash content, etc. in heavy fuel oil and lubricating oil.
- ☑ Oil, water, and impurities are separated by centrifugal force of high speed (6,000~8,000 rpm) according to difference in density.

(6) Fresh Water Generator (1/3)



- ☑ Equipment for generating fresh water which is needed as household water and boiler feed water by evaporating and condensing sea water
- ☑ There are 'heat recovery type' which boils and evaporates sea water by using cooling water of 70~80°C from engine and 'reverse osmosis type' which uses osmosis between sea water and fresh water.

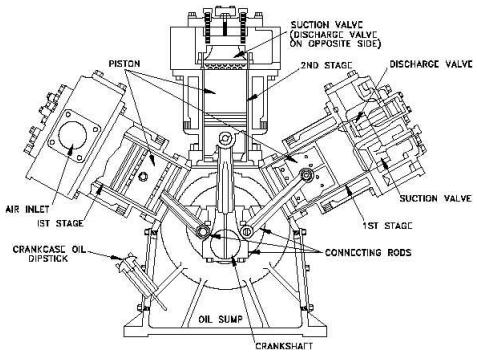
(6) Fresh Water Generator (2/3)



(6) Fresh Water Generator (3/3)

- ☑ A method of evaporating sea water by using residual heat (70~80°C) of jacket cooling heater after cooling M/E jacket
- ☑ Sea water can be evaporated at low temperature (40~50°C) by raising the degree of vacuum through suction out of air with air ejector in the evaporator.
- ☑ The steam is changed to fresh water by condenser. Sea water can be used for feed water in the fresh water generator and cooling water for condensing steam. In addition, sea water contributes to make vacuum state by sucking out air with air ejector in the evaporator (The principle that the ambient air is sucked and vacuum state is instantly made after a train goes through fast).

(7) Compressed Air System (1/2)

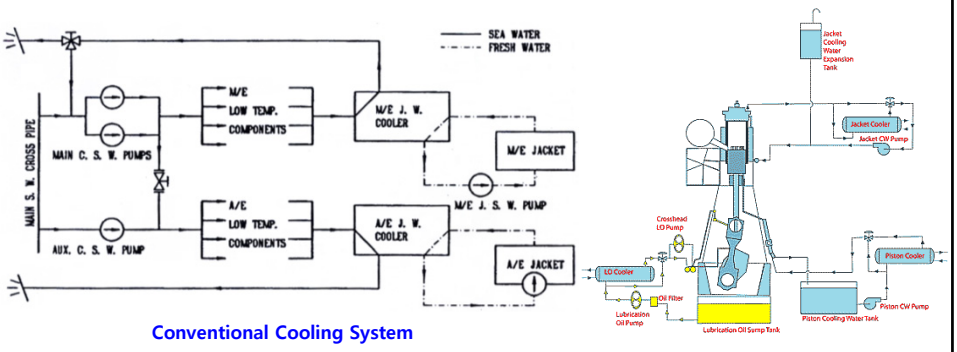


- ☑ Compressed air is used for startup of M/E and auxiliary engine, for operation of equipment for control, monitoring, measurement, and alarm, and for cleaning machinery.
- ☑ Since high compressed air of 30 kg/cm^2 is used for startup of M/E and auxiliary engine, compressed air should be made with two or more compressed air systems of piston type and stored in starting air reservoir for the use of startup.

(7) Compressed Air System (2/2)
- Types of Compressed Air System

- ☑ Control Air System
  - It is used for operating automatic control equipment of main engine maneuvering, control valve, pneumatic gauge, etc.
  - Control air is made and used by decompressing it through reducing valve, and by using control air compressor and reservoir.
  - Control air gets through precision parts in the system and thus it should be filtered by control air dryer to remove dust, moisture, oil, and so on from it.
- ☑ Service Air System
  - It is used for cleaning air horn of radar mast and funnel top, fire alarm, and major equipment.
  - Service air is made by decompressing high pressure air of main air reservoir or by using additional compressor, and stored in service air reservoir.
- ☑ Quick Closing Air System
  - It is a system which makes shut-off remotely major valves from engine room outside.
  - In case of fire, it prevents the fire from spreading when oil leaks from F.O or L.O tank.
  - It also prevents oil leakage when tank outlet pipe line is damaged.

(8) Cooling Water System
- Conventional Cooling System



Conventional Cooling System

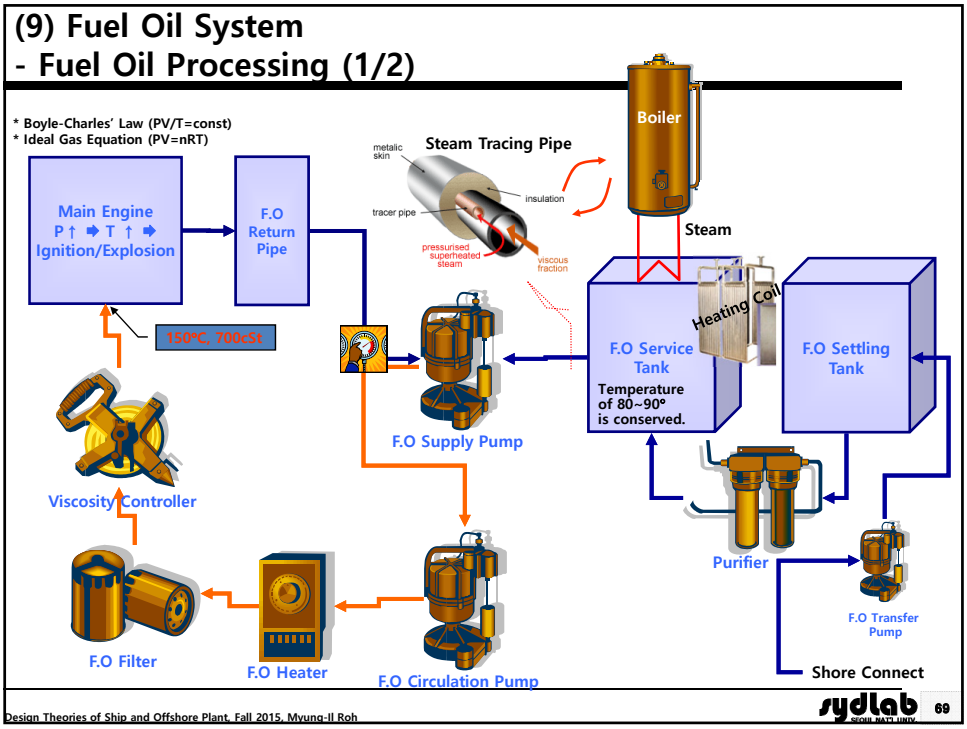
- ☑ Cooling Water System: System for cooling internal combustion engines such as M/E and aux. engine in engine room, and for condensing and cooling exhaust steam
- ☑ Conventional Cooling System
  - ■ System which cools down cylinder jacket of M/E and aux. engine cools down with fresh water, and others with sea water.
  - ■ Sea water cooling system consists of two groups: one is equipment related to main engine which cooling sea water is supplied to by main cooling sea water pumps, the other is equipment related to aux. engine which cooling sea water is supplied to by aux. cooling sea water pumps
  - ■ By constructing independent cooling system per equipment function, it can save operating cost and has advantage in system operation. However, most pipes are used for sea water operation and it has disadvantage in pipe corrosion.

(9) Fuel Oil System

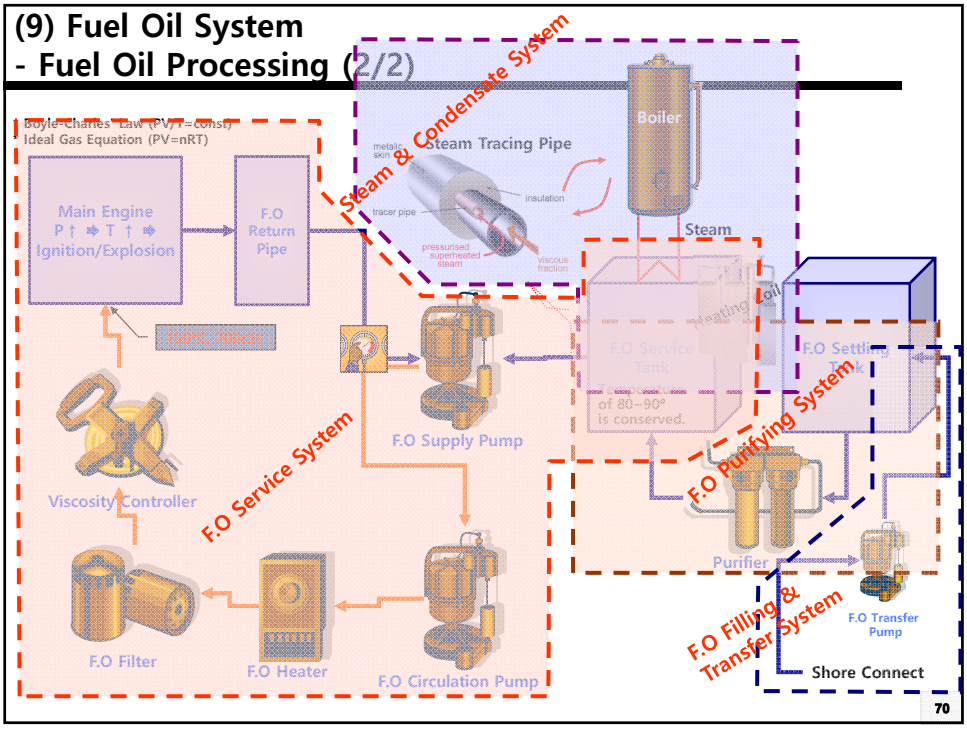
- ☑ A series of systems for supplying the machinery which generates power and requires fuel oil such as M/E and auxiliary engine in engine room with fuel oil (H.F.O, D.O)

- ☑ Categorization of Fuel Oil System
  - ■ Fuel oil filling and transfer system
  - ■ Fuel oil service system
    - ● M/E fuel oil service system
    - ● Auxiliary engine fuel oil service system
    - ● Boiler fuel oil service system
  - ■ Fuel oil purifying system
  - ■ Fuel oil drain system

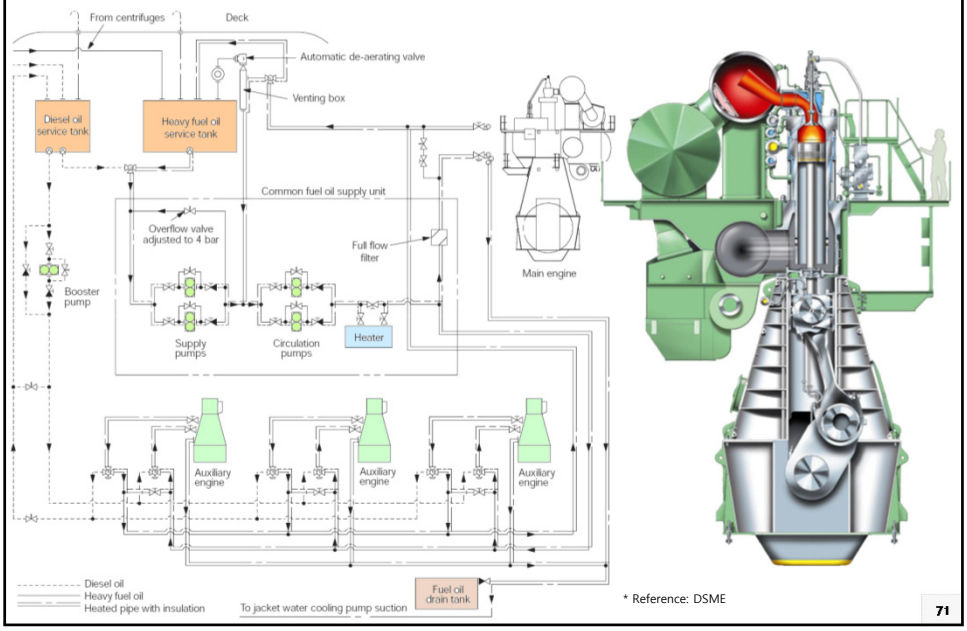
(9) Fuel Oil System
- Fuel Oil Processing (1/2)



(9) Fuel Oil System
- Fuel Oil Processing (2/2)



(9) Fuel Oil System
- Schematic Diagram of Fuel Oil System



* Reference: DSME

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(10) Lubricating Oil System (1/2)

- ☑ A series of systems and pipes for supplying the machinery which requires lubrication and cooling in engine room with lubricating oil
- ☑ It has the purpose of lubrication which reduces wear and friction resistance by forming oil film between acting parts of machine and thus by transforming solid friction to fluid friction.
- ☑ It also has cooling, cleaning, and sealing action.

(10) Lubricating Oil System (2/2)

☑ Categorization of Lubricating Oil System
- Main engine lubricating oil system
- Camshaft lubricating oil system
- Cylinder lubricating oil system
- Piston load stuffing box lubricating oil drain system
- Auxiliary engine lubricating oil system
- Lubricating oil transfer system
- Lubricating oil purifying system
- Stern tube lubricating oil system
- Scavenging air box drain system

(11) Miscellaneous Equipment (1/3)

Sterilizer

Rehardening Filter

Hot Water Calorifier

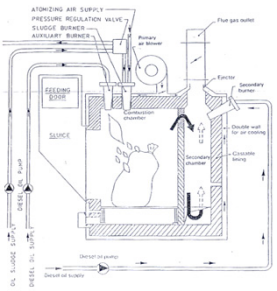
☑ Sterilizer: Fresh water generated from fresh water generator includes microorganisms such as viruses or bacteria because heating temperature is as low as 70~80°C. It is inadequate for use as drinking water. For this, sterilizer such as UV disinfection type, anion electrolytic type, chlorine injection type, etc. is used.

☑ Rehardening Filter: Fresh water generated from fresh water generator is distilled water, and thus inadequate for use as drinking water. It is supercooled, condensed, and absorbs CO2 from the air, and becomes acid. The rehardening filter gets through the fresh water in the compound for generating ions (OH-) and hydroxide, makes it alkaline water by increasing PH value, and converts it potable water like natural water by melting Ca and Mg (rehardening).

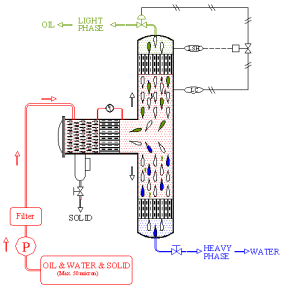
☑ Hot Water Calorifier: Equipment for supplying hot water (about 70~80°C) which in needed in the ship and offshore plant by boiling fresh water. For this, steam gas or electricity is used.

(11) Miscellaneous Equipment (2/3)

Sewage Treatment Plant



Incinerator



Oil Separator

- ☑ Sewage Treatment Plant: Equipment for decompose and discharging sewage and wastewater through biological or chemical operation in order to prevent marine pollution
- ☑ Incinerator: Equipment for destroying municipal waste, waste of F.O or L.O, oil separated from bilge in engine room, etc. by fire (Preheat temperature: 650°C, Temperature of exhaust gas: 850~1,200°C)
- ☑ Oil Separator: Drain from equipment operation is collected at the bottom in engine room. This is called bilge. This bilge is exported to the sea by bilge pump. At this time, oil separator is used to separate oil and water.

(11) Miscellaneous Equipment (3/3)

$2\,NaCl + 2H_2O \rightarrow H_2 + Cl_2 + 2NaOH$

Anode: $2Cl \text{ --- } Cl_2 + 2e$

Cathode: $2Na + 2H_2O + 2e - 2NaOH + H_2$

$\downarrow$

$2NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$

$\downarrow$

$NaClO + H_2O \rightarrow HClO + NaOH$

- ☑ M.G.P.S (Marine Growth Preventing System)
  - ■ As sea water enters equipment and pipe of cooling system, the product by sea water such as growth of micro-organisms, shells, slime, seaweed, etc. comes fixation in the equipment and pipe, makes damages, interferes with the smooth flow, and finally blocks the pipe.
  - ■ To solve this problem, M.G.P.S which prevents electrochemically the adherence of marine products is used.
  - ■ Typically, 15,000~2000 ppm of chlorine to the sea water present in the ION state. The M.G.P.S makes NaClO and HClO, which have a strong bactericidal action of several orders of magnitude to several hundred times than general chlorine, by performing electrolysis of chlorine in the ION state, and commits it to the pipe.`

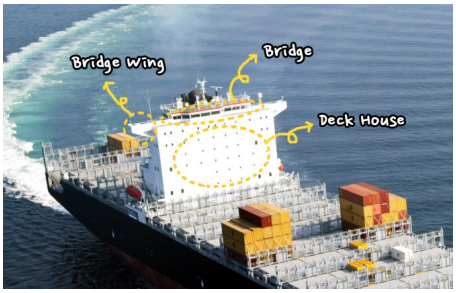
7.3 Accommodation Outfitting

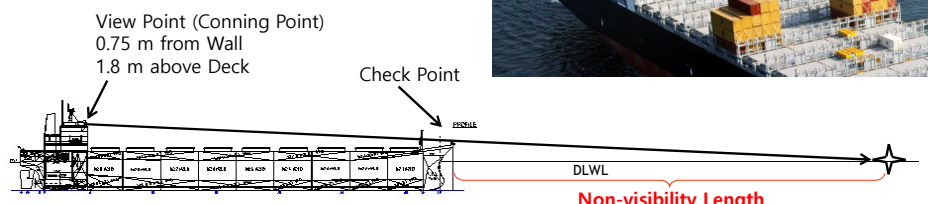
Deck House (Accommodation)

☑ **In deck house design, the assurance of space for deck house is most important according to owner's requirement.**

☑ **IMO Visibility**

- **2×Loa or 500 m, whichever is less**





Elevation view

Any Draft, Trim

Visibility Limit = 2×Loa or 500 m, whichever is less

Result of calculation for B/C = 373 m < 500 m

* Reference: Samsung Heavy Industries

General Arrangement of Deck House (1/3)

☑ Considerations for determining the length, breadth, and height of deck house

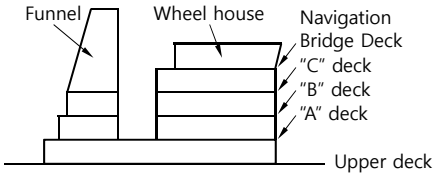
Item	Considerations
Length	- Consideration on structural safety and vibration by aligning with main bulkhead (BHD) - Determination of after and fore BHD after determining E/R length - Space between engine casing and deck house: Assurance of E/R maintenance space - Deck house length: Consideration on optimum cabin arrangement - Engine casing: Consideration on arrangement of boiler, etc.
Breadth	- Alignment with hull longi. (Inner & Outer Hull) - E/R compartment and HFO tank alignment - Consideration on lifeboat arrangement - Consideration on minimum equipment numeral - Assurance of passage way on upper deck
Height	- Assurance of deck clear height: Each tier - Assurance of visibility: Total tiers - Air draft check: Total tiers - Vibration level check: No resonance

General Arrangement of Deck House (2/3)

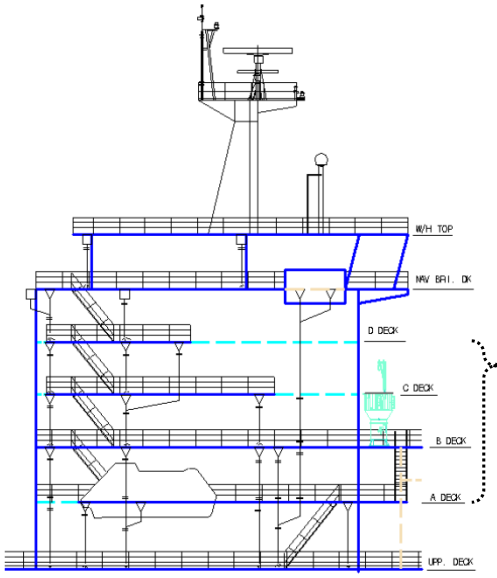
☑ Use of Deck House

Tier	Purpose or Use
Upper Deck	Provision store, Air-con. room, Changing room, Control room, Hospital, Laundry, Gymnasium, Store, etc.
"A" Deck	Galley, Pantry, Recreation room
Other Decks	Crew cabin, Officer cabin
Navigation Bridge Deck	Wheel house, Chart room, Radio room

Elevation view



General Arrangement of Deck House (3/3)



Navigation Bridge Deck
- Communication equipment for voyage are allocated.

Other (A~D) Decks
- Galley, dining room, etc. are allocated in A DECK.
- Convenience equipment such as recreation room, gymnasium, etc. are allocated.
- Cabins are mainly allocated. Cabins for seniors are allocated in higher deck.

Upper Deck
- HVAC equipment such as air-conditioning room, ventilation fan, etc. are allocated. Ducts for HVAC of accommodation are distributed from here.
- Cold chambers (freezer, refrigerator) are allocated.
- Passages are allocated for entering engine room.

Example of Wheel House

* Reference: DSME

Navigation Bridge Visibility (1/3)

☑ Regulation: SOLAS Chapter V, Reg. 22 (2006 amendment from 1994/1995 amendment)

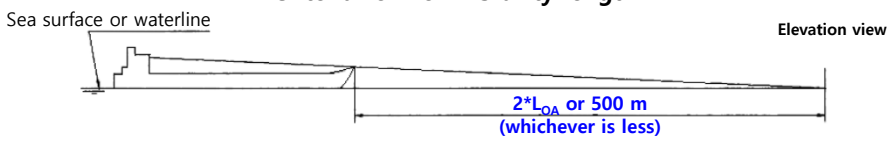
☑ Requirements

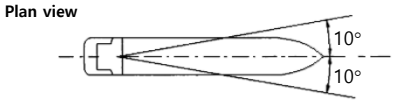
Item	Requirements	Check List
Target ships	Ships of 45m or more in length built on or after 1 July 1998	Ship length, Keel laying date
Non-visibility length	The view of the sea surface from the conning position shall not be obscured by more than two ship lengths, or 500 m, whichever is the less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo.	Bulwark top at stem
Blind sector	No blind sector shall exceed 10°. The total arc of blind sectors shall not exceed 20°. The clear sectors between blind sectors shall be at least 5°. However, in the view described above (10° on either side), each individual blind sector shall not exceed 5°.	Crane, vent mast, etc.
Horizontal field of vision	From the conning position, over an arc of not less than 225°, that is from right ahead to not less than 22.5°, abaft the beam on either side of the ship	Position of wheelhouse
	From each bridge wing, over an arc at least 225°, that is from at least 45° on the opposite bow through right ahead and then from right ahead to right astern through 180° on the same side of the ship	Bridge wing
	From main steering position, over an arc from right ahead to at least 60° on each side of the ship	

* Coning positon: 1,800 mm from the bottom of wheel house, 750 mm afterward from front wall of wheel house

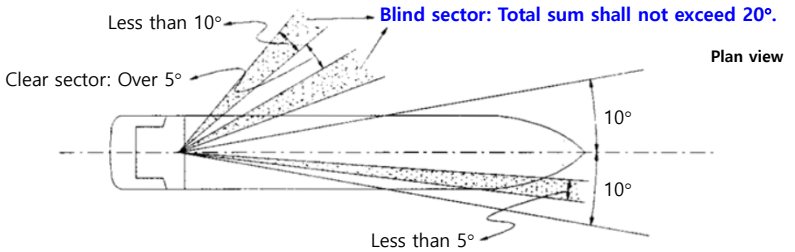
Navigation Bridge Visibility (2/3)

Criteria for non-visibility length

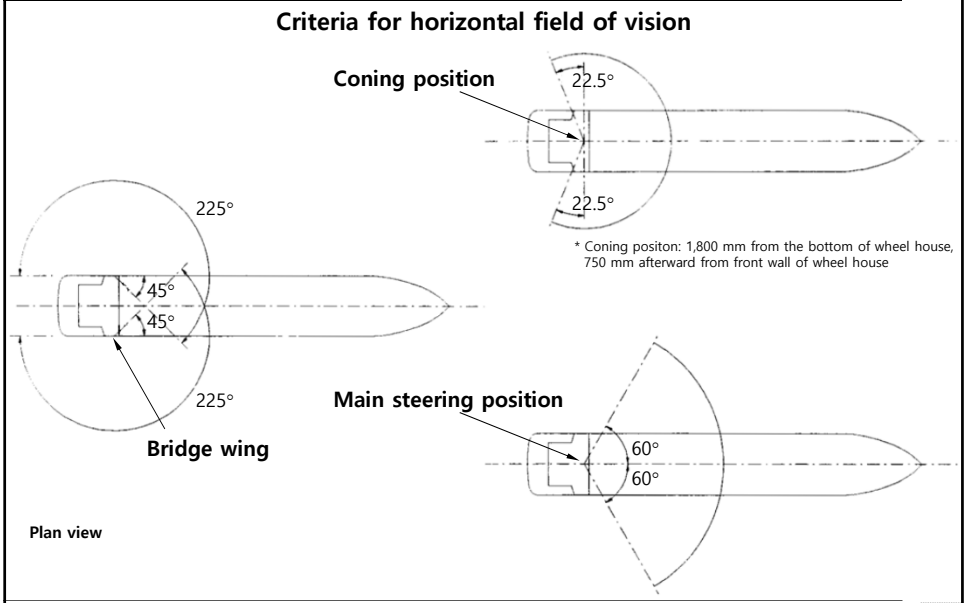




Criteria for blind sector



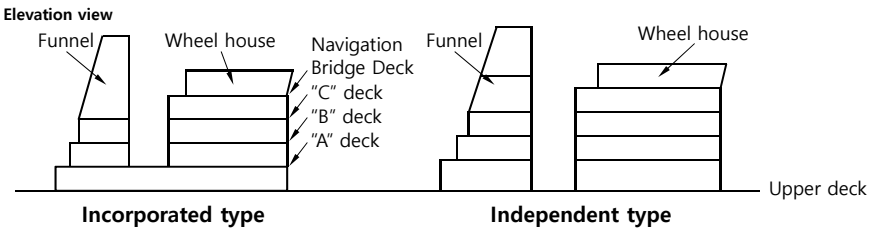
Navigation Bridge Visibility (3/3)



Types of Accommodation

☑ **Types of Accommodation**
- ■ **Superstructure type (small ship), Deck house type (large ship)**

☑ **Deck House Type**
- ■ **Incorporated type**
  - ● **High space applicability, Structural safety**
- ■ **Independent type**
  - ● **Advantageous in noise and vibration, Increase of steel material**

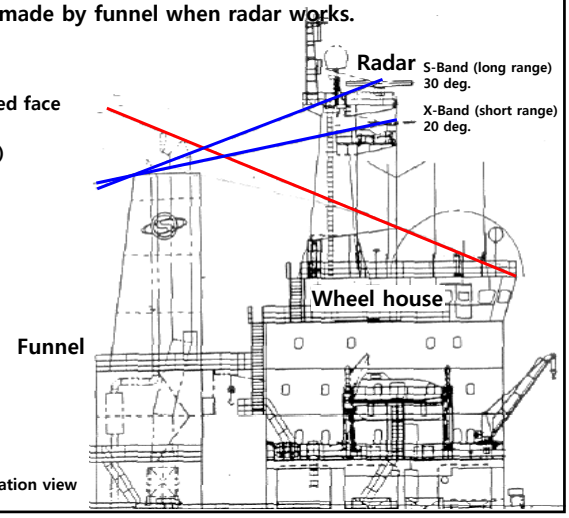


* Reference: STX Offshore and Shipbuilding

Funnel and Radar Mast

☑ **Angle between Funnel and Wheel House: about 20 degree**
- Air flow from wheel house top should not disturb gas flow from funnel.

☑ **Angle between Funnel and Radar: about 15 degree**
- Blind sector should not be made by funnel when radar works.
- Different from maker
- Countermeasure
  - Funnel having round shaped face
  - Height-variable radar (consideration on air draft)



Elevation view

* Reference: STX Offshore and Shipbuilding

7.4 Electric Outfitting

Electric Outfitting

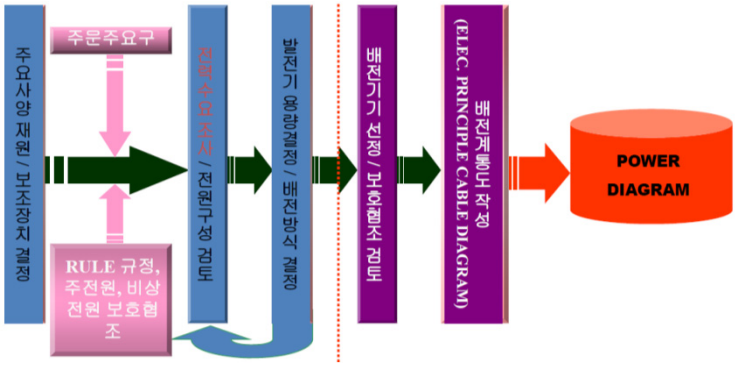
- ☑ Electric outfitting of the ship and offshore plant can be equal to the blood supply and flow inside the body.
- ☑ If a necessary structure is made, the required machinery is installed in the structure, and people lives in there, various electrical equipment should be installed together.
- ☑ Considerations on installation of electrical equipment
  - Equipment which a stable power supply is possible for
  - Fully automated equipment which can control and monitor 24 hours
  - Equipment which can be communicated with bridge in any situation
  - Equipment which can be operated under extreme condition
  - Equipment considering suitable number of people and work environment
- ☑ Task of electric outfitting consists of selection of suitable equipment and their layout.

Components of Electric Outfitting

- ☑ Power System
  - Supplying power from main generator and emergency generator to each equipment
- ☑ Control System
  - Including various systems and sensors for operating main and auxiliary engines
- ☑ Navigation and Communication System
  - Including wired and wireless equipment for navigation and communication
- ☑ Lighting System
  - Including systems for general lighting, navigation/signal lighting, and decorative lighting
- ☑ Fire Detection and Alarm System
  - Including systems for fire detection and alarm on board

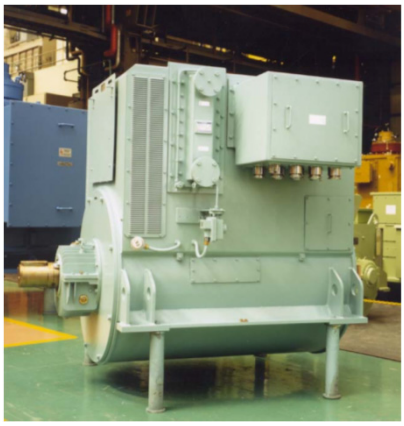
Power System

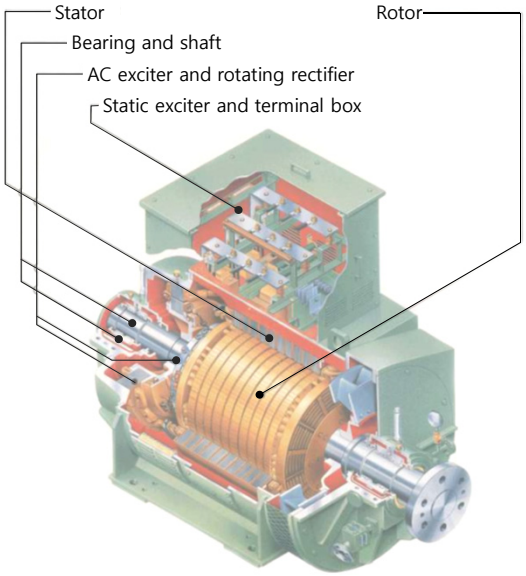
☑ A series of systems for distributing power in the ship and offshore plant after determining the capacity of main generator and emergency generator through load analysis from all electrical equipment and hotel load



* Reference: DSME

Power System
- Power Generator (Alternator)





* Reference: DSME

Power System
- Power Distribution System (Switchboard) (1/2)

- ☑ A group of panels which controls power generator and distributes power from the generator to each consumer
- ☑ In the ship and offshore plant, the panels for power generation and distribution are centralized. However, on land, power plant controls power generator having high capacity and transmits power after boosting. Then, substation receives the power and distributes it after decompression.
- ☑ In the ship and offshore plant, a generator panel and a feeder panel are allocated at both sides of a synchronizing panel by introducing the mirror switchboard system.

Example of switchboard

* Reference: DSME

Power System
- Power Distribution System (Switchboard) (2/2)

- ☑ Components and Functions
  - ■ Generator panel
    - ● Panel which controls generator and receives output power from the generator through ACB (Air Circuit Breaker).
  - ■ Synchronizing panel
    - ● Panel which is needed to synchronize two or more generators which are installed and operate in parallel
  - ■ Feeder panel
    - ● Panel which distributes input power from generator to each consumer by bus bar

* Reference: DSME

Power System
- Power Sources Used in Ship and Offshore Plant (1/2)

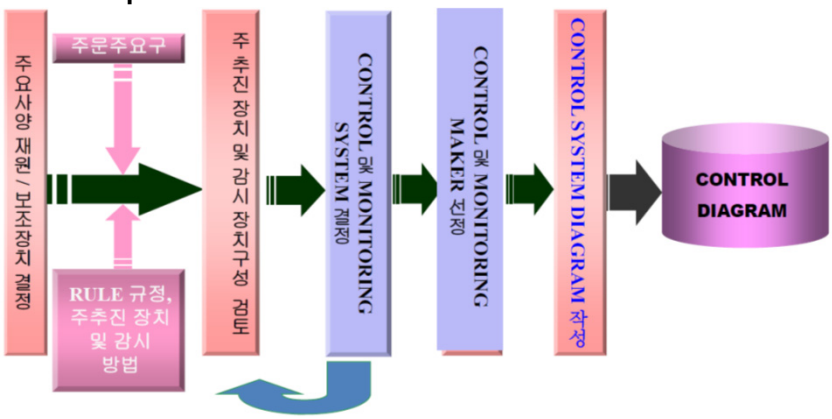
- ☑ AC (Alternating Current)
  - High voltage: Over 1,000 V
    - 3,300 V, 60 Hz, 3 Phase
    - 6,600 V, 60 Hz, 3 Pahse
    - 7,200 V, 60 Hz, 3 Pahse
  - Low voltage: Less than 1,000 V
    - 690 V or 480 V or 450 V, 60 Hz, 3 Phase
    - 220 V, 60 Hz, 3 Phase or 1 Phase
    - 110 V, 60 Hz, 3 Phase or 1 Phase
- ☑ DC (Direct Current): 24 V DC, 110 V DC or more
- ☑ UPS (Uninterrupted Power Supply): 24 V DC ➡ 220 V AC outside

Power System
- Power Sources Used in Ship and Offshore Plant (2/2)

- ☑ Necessity of High Voltage System
  - Enlargement of ship and offshore plant
  - Increase of capacity of main engine, auxiliary engine, and auxiliary equipment
  - Increase of load related to cargo such as reefer container
  - No suitable materials such as main breaker, bus bar, and so on according to capacity of generator capacity
  - Increase of installation cost

Control System

☑ A series of systems for configuring alarm and control functions by monitoring the states of main engine, generator, and auxiliary equipment, for securing the safety and improving maintainability by automating control and monitoring, and for operating ship and offshore plant with minimal crews



* Reference: DSME

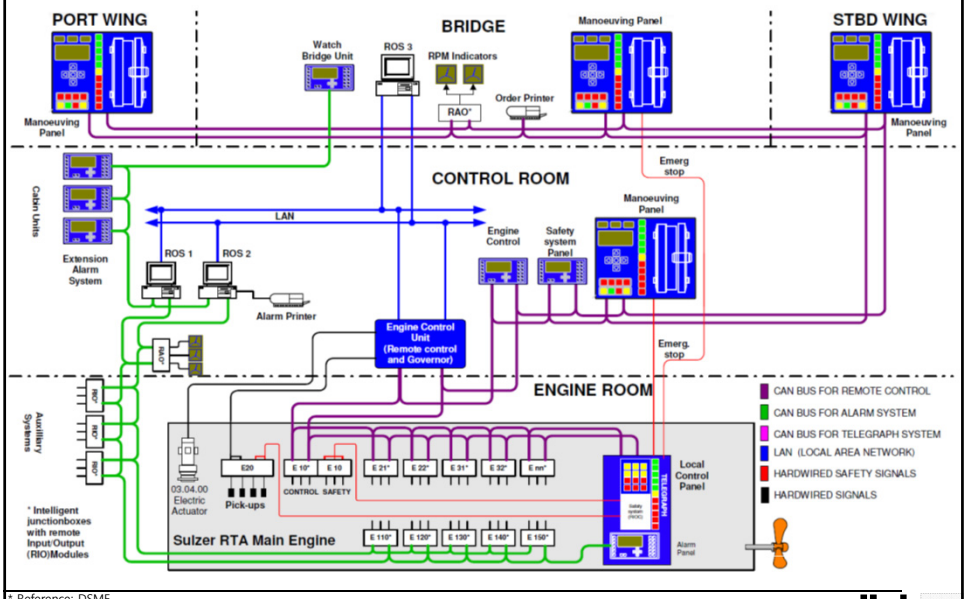
Control System
- Main Engine Remote Control System (1/2)

☑ A series of systems to remotely control main engine of engine room in bridge (wheel house) and ECR (Engine Control Room)

☑ This system has essential functions for start and stop of main engine, forward and backward motion, speed control, and check of normal and abnormal states. It is essential to safe voyage or operation of the ship and offshore plant.

* Reference: DSME

Control System
- Main Engine Remote Control System (2/2)



* Reference: DSME

Control System
- Alarm and Monitoring System

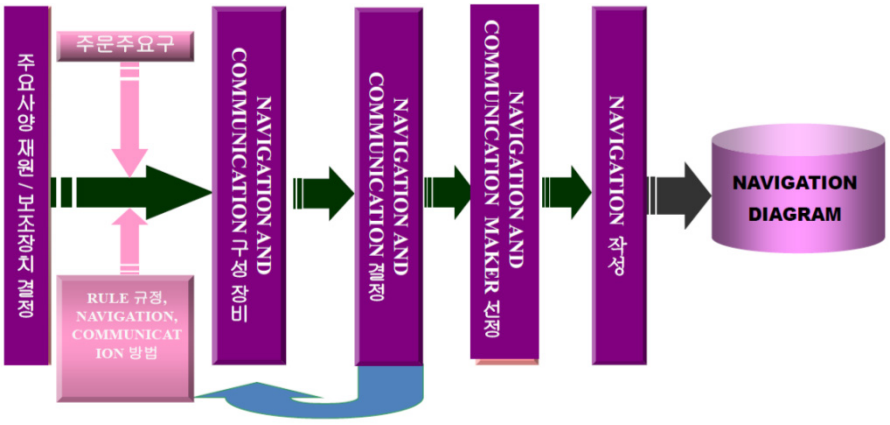
☑ **A series of systems which gives alarm to crew and to allows crew to take safety measures when their setting values are exceeded through continuous monitoring of major equipment such as main engine, auxiliary engine, etc. on board.**

☑ **Main functions**
- **Monitoring function for checking the current state of equipment**
- **Alarm function for giving notification when setting value is exceeded**
- **Control function for operating equipment when needed**
- **Extension function which allows night watcher to receive and check all information**
- **Control function for remotely operating main generator**

☑ **Main Engine Bridge Maneuvering System**
- **Apart from alarm and monitoring system, it is installed on engine control console and bridge, and is used to control main engine only.**
- **Main control function can be monitored in engine room during the day and in bridge during the night.**

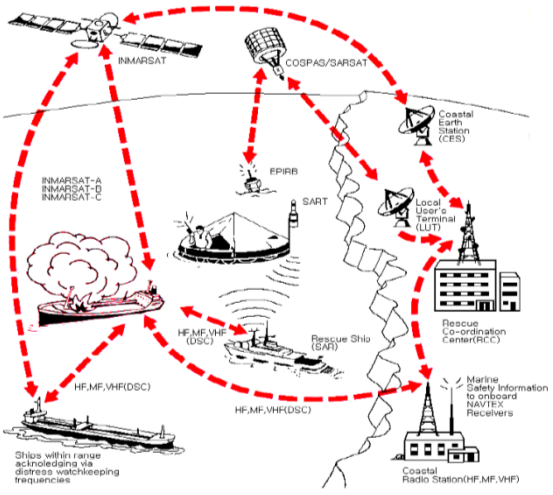
Navigation and Communication System (1/5)

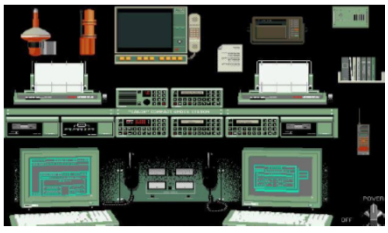
☑ A series of systems for navigation, radio, and onboard communication



* Reference: DSME

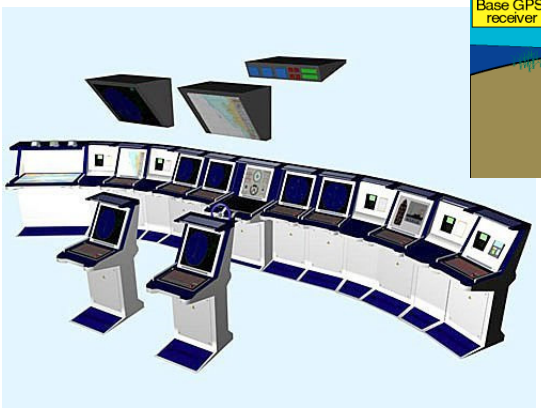
Navigation and Communication System (2/5)

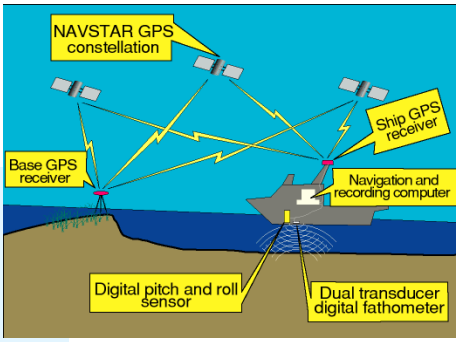




* Reference: DSME

Navigation and Communication System (3/5)

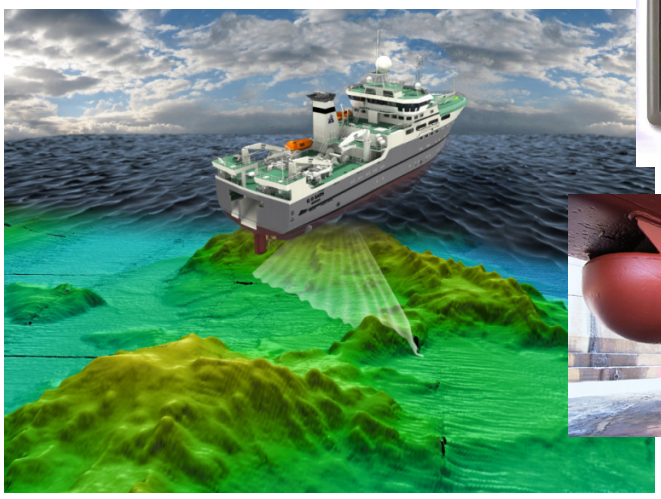


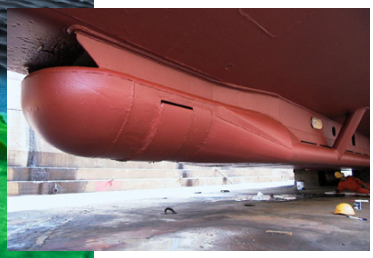


Total navigation system

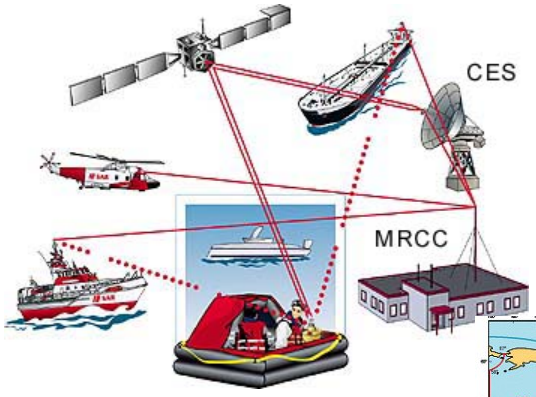
Navigation and Communication System (4/5)

Echo sounder

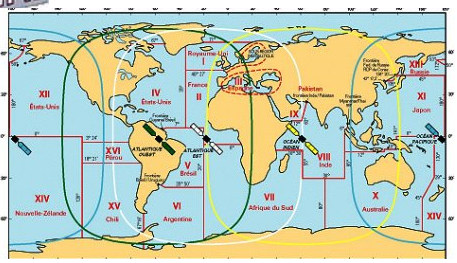




Navigation and Communication System (5/5)



Global maritime distress and safety system



Lighting System (1/2)

☑ A series of systems for lighting the ship and offshore plant

☑ Category of lighting system

- General lighting
  - The type, size, position of lighting should be determined by considering quality and quantity of light which is suitable for the environment and work according to the purpose of given location.
  - It should secure suitable illumination, brightness distribution, and spectral distribution by considering clear visibility of objects, minimal fatigue of crew, and special structure of the ship and offshore plant.
- Navigation/signal lighting
  - It is needed to prevent collision from ship and offshore plant and to secure safety in advance.
  - It is used during the night. Even the daytime it should be used in the limited visibility such as rain, fog, and smoke.
- Decorative lighting
  - Additional lighting for decorating the ship and offshore plant

Lighting System (2/2)

General lighting

Navigation/signal lighting

* Reference: DSME

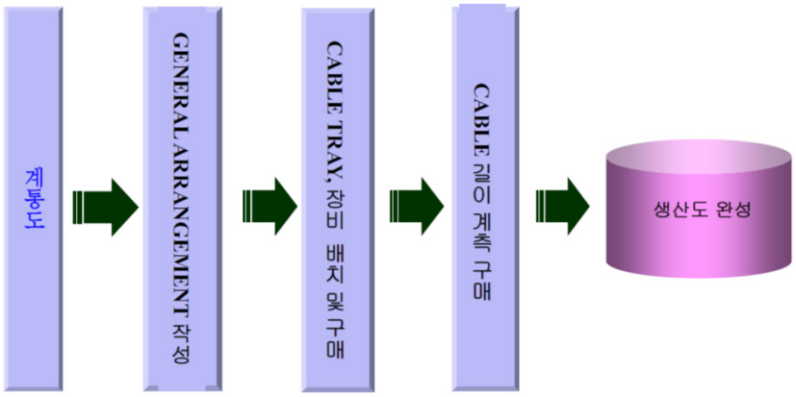
Fire Detection and Alarm System

☑ A series of systems for fire detection and alarm on board

☑ It detects fire and gas leakage on board, and transfer the information to bridge in order to suppress them in early stage.

Arrangement Design

- ☑ This task is to make drawings for installation of all equipment after determining their specifications.
- ☑ These drawings include equipment layout, cable way or tray, equipment seat, information on cable installation, material information, etc.



* Reference: DSME

Arrangement Design
- Example of Cable Way in Side Passageway

* Reference: DSME