NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF MECHANICAL ENGINEERING

2016

Design of an Oil Barge. Naval Architecture and Marine Engineering Design

COURSE:	**NAVAL PROJECTS I**
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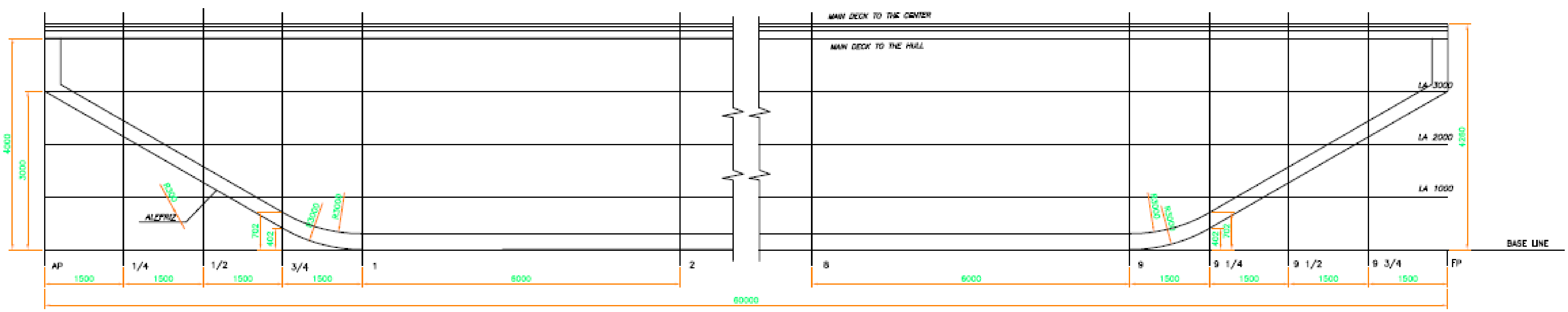
LIMA-PERU

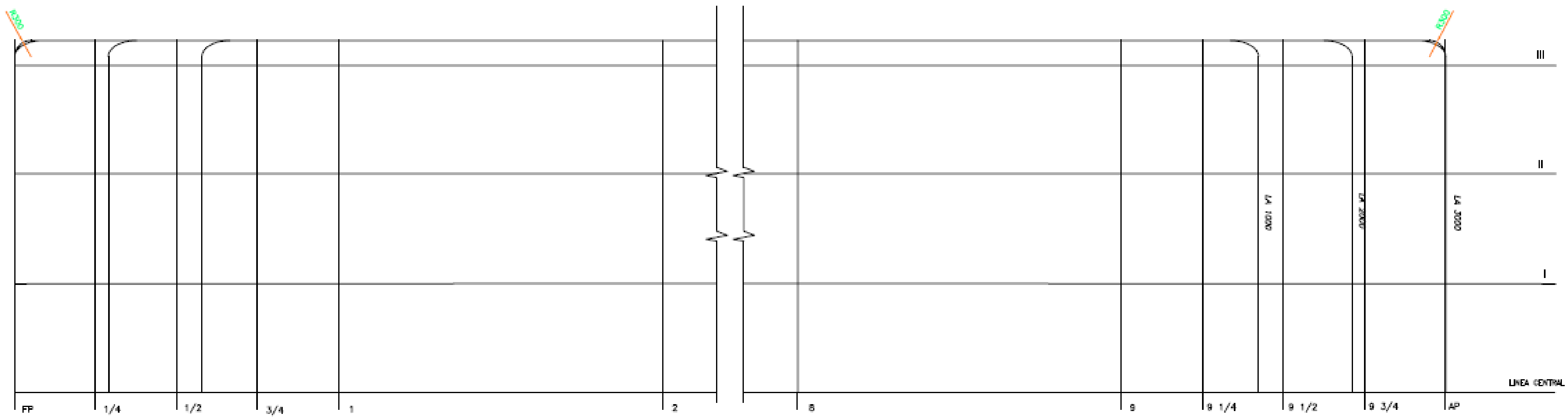
CONTENT

1. NAVAL ARCHITECTURE – SHAPE LINES

1.1. SHAPE LINES



LONGITUDINAL ELEVATION


III
II
I
LINEA CENTRAL
LA 1000
LA 2000
LA 3000
FP
1/4
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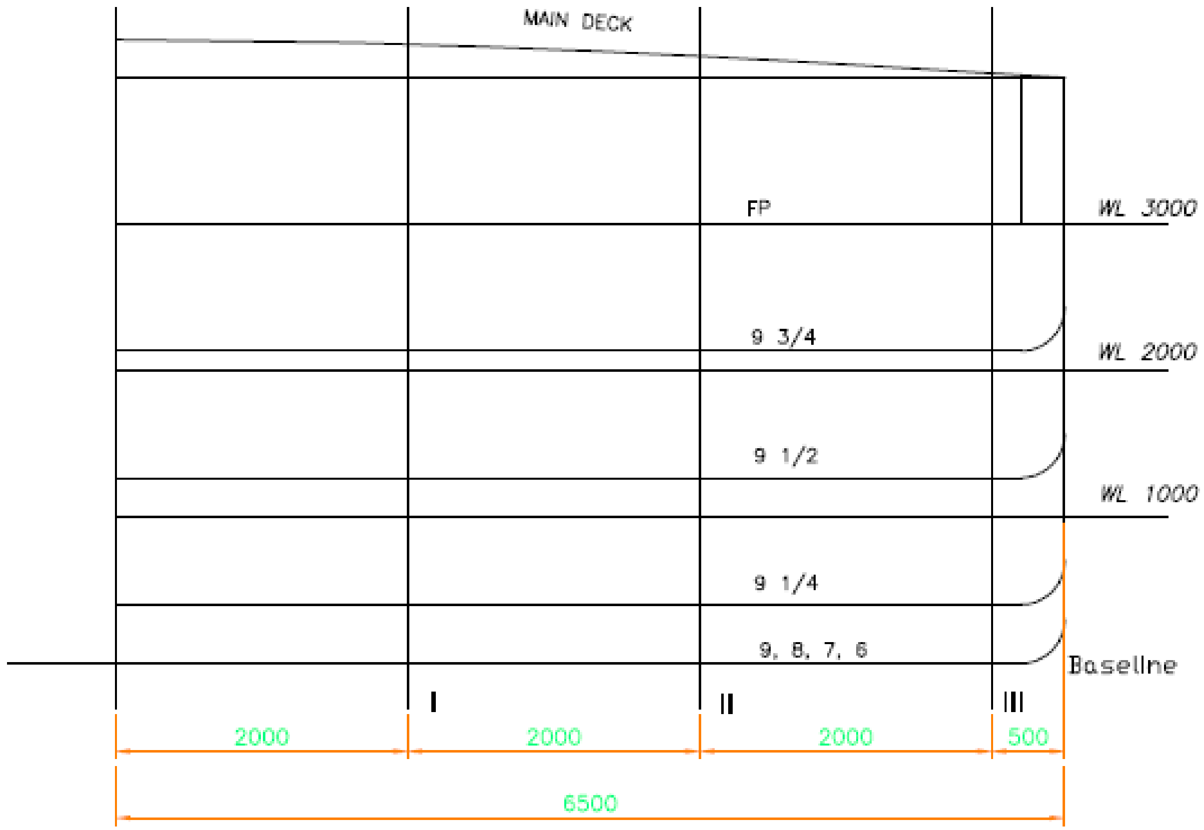
1
2
8
9
9 1/4
9 1/2
9 3/4
AP

TOP VIEW



CROSS SECTIONS

BOW AND STERN

2. NAVAL ARCHITECTURE – STRUCTURE CALCULATION

2.1. MAIN DIMENSIONS

MAIN DIMENSIONS	
LENGTH (L)	60 m
BREADTH (B)	13 m
DEPTH (D)	4 m

We use the longitudinal structuring system, due to better resistance.

2.2. MIDSHIP SECTION MODULUS (BASIC)

SMb = C1*C2*L^2*B*(Cb + 0.7)		2970.98135	cm^2 .m
Where:			
C1=16.33(L/100)2 – 15.47(L/100) + 7.7		4.64906688	
C2 = 0.01		0.01	
Cb=	0.95		
L=	65.6		

2.2.1. SPACING BETWEEN LONGITUDINALS

s=508+0.83L	562.448	mm
s appropriate	500	mm

2.2.2. HULL PLATING

DECK:

t1 = 0.066L + 2.5 mm	6.8296	mm	
s=	500	mm	
L=	65.6	m	
t appropriate	8	mm	(5/16'')

ON THE SIDE TO 0.4L FROM MIDSHIP:

t = 0.069L + 0.007s - 1.0mm		7.0264	L<73m
s	500	mm	
L	65.6	m	
t appropriate	8mm	(5/16")	

BOTTOM PLATE TO 0.4L FROM MIDSHIP:

t = 0.069L + 0.007s - 0.5 mm		7.5264
s	500	mm
L	65.6	m
t appropriate	8mm	(5/16")

PLATES AT THE ENDS TO 0.2L (BOW AND STERN):

t = 0.055L + 0.007s + 1.0 mm		8.108	L ≤ 76 m
s	500	mm	
L	65.6	m	
t appropriate	9.5mm	(3/8")	

SUBMERGED BOW ZONE PLATE:

t = 0.055L + 0.01s + 1.0 mm		8.608	L ≤ 110 m
s	400	mm	
L	65.6	m	
t appropriate	9.5 mm	(3/8)	

2.3. COLLISION BULKHEAD POSITION

Located between 5-8% L, that is between 3.280-5.248m. We locate the bulkhead at 4m from the bow.

2.3.1. BULKHEAD PLATES

Common bulkhead:

t=S*(h+6.1)/1830+3.05mm		5.88
s=	500	mm
h=	4.27	m
t appropriate	6.4mm	(1/4'')

Collision bulkhead: It's the same previous formula, but considering that stiffener spacing is 150 mm higher for this case.

t=S*(h+6.1)/1830+3.05mm		6.73
s=	650	mm
h=	4.27	m
t appropriate	8mm	(5/16'')

Tank bulkhead:

t=(S*h^0.5)/254+2.54mm		7.15
s=	500	mm
h=	5.49	m
t appropriate	8.00mm	(5/16'')

2.3.2. MAXIMUM SEPARATION BETWEEN BULKHEADS (Recommendation)

S = 0.153L + 3.81 m	L < 122 m		
L		65.6	m
s recommended		13.8468	m
s taken		12	m

2.4. MAIN ELEMENTS SECTION MODULUS

Deck longitudinals:

SM = 7.8*c*s*h*l^2		
c	1.75	
s	0.5	m
h	1.22	
l	2	
SM required	33.306	cm^3

WE USE A "L" PROFILE OF $3\,{}^{1}\!/_{2}{}'' * 2\,{}^{1}\!/_{2}{}'' * \frac{1}{4}{}''$

AREA = $\mathbf{927.41}\ \boldsymbol{mm^2}$

Side longitudinals:

SM = 7.8*c*s*h*l^2		
c	1.08	
s	0.5	m
h	4.22	m
l	2	
SM required	71.09	cm^3

WE USE A "L" PROFILE OF $\mathbf{4}'' * \mathbf{3}'' * \frac{\mathbf{5}}{\mathbf{16}}{}''$

AREA= $\mathbf{1348.28}\ \boldsymbol{mm^2}$

Bottom longitudinals:

SM = 7.8*c*s*h*l^2		
c	1.08	
s	0.5	
h	5.22	
l	2	
SM required	87.94	cm^3

WE USE A "L" PROFILE OF $5'' * 3'' * \frac{5}{16}''$

AREA = $\mathbf{1549.89\ mm^2}$

Double bottom Longitudinals

SM = 7.8*c*s*h*l^2		
c	1	
s	0.5	
h	5.22	
l	2	
SM required	81.432	cm^3

WE USE A "L" PROFILE OF $5'' * \mathbf{3}'' * \frac{\mathbf{5}}{\mathbf{16}}''$

AREA = $\mathbf{1549.89\ mm^2}$

2.5. AUXILIARY ELEMENTS

Reinforced beam:

SM = 7.9*c*s*h*l^2		
c	1.08	
s	2	
h	1.22	
l	6	
SM required	749.44	cm^3

WE USE A "L" PROFILE OF $\mathbf{12}'' * \mathbf{6.5}'' * \frac{\mathbf{7}}{\mathbf{16}}''$

AREA = 5098.27 $\mathbf{mm^2}$

Reinforced frame:

SM = 7.9*c*s*h*l^2	
c	1.08

s	2	
h	2.84	
l	3	
SM required	436.15	cm^3

WE USE A "L" PROFILE OF 29.5'' $* \frac{\mathbf{3}}{\mathbf{8}}''$

AREA = 3000000.00 $\boldsymbol{mm^2}$

Floor plate reinforced:

SM = 7.9*c*s*h*l^2		
c	1.08	
s	2	
h	4.22	
l	6	
SM required	2592.36288	cm^3

WE USE A "L" PROFILE OF $\mathbf{39} * \frac{\mathbf{3}}{\mathbf{8}}''$

AREA = 12000000.00 $\boldsymbol{mm^2}$

2.6. FOREPEAK AND AFTERPEAK

2.6.1. MAIN ELEMENTS (We use 2 lengths)

Beams:

SM = 7.9*c*s*h*l^2		
c	1.08	
s	0.5	
h	1.22	
l	4.00	
SM required	41.62	cm^3

WE USE A "L" PROFILE OF $\mathbf{3.5''} * \mathbf{2.5''} * \frac{\mathbf{1}}{\mathbf{4}}''$

AREA = 766.1275 $\boldsymbol{mm^2}$

Frame:

SM = 7.9*c*s*h*l^2		
c	1.08	
s	0.5	
h	2.84	
l	3	
SM required	109.03896	cm^3

WE USE A "L" PROFILE OF $\mathbf{5''} * \mathbf{3.5''} * \frac{\mathbf{5}}{\mathbf{16}}''$

AREA = 1650.70 $\boldsymbol{mm^2}$

Floor plate: (h: Distance in meters from the bottom of the launch in correspondence with the element).

SM = 7.9*c*s*h*l^2		
c	1.08	
s	0.5	
h	4.22	
l	2.00	
SM required	72.01	cm^3

WE USE A PLATE OF $\mathbf{8''} * \frac{\mathbf{5}}{\mathbf{16}}''$

AREA = 1549.89 $\boldsymbol{mm^2}$

2.6.2. SECONDARY ELEMENTS

Length:

SM = 7.9*c*s*h*l^2	
C	1.75
s	4
H	1.22
L	2

SM required	269.8644	cm^3

WE USE A "L" PROFILE OF $\mathbf{9''*4''*\frac{3}{8}''}$

AREA = 3263.60 $\boldsymbol{mm^2}$

Girder: (h: Distance in meters from de bottom of the launch in correspondence with the element)

SM = 7.9*c*s*h*l^2		
c	1.28	
s	4.00	
h	4	
l	2	
SM required	647.168	cm^3

WE USE A "T" PROFILE OF $\boldsymbol{Prop: 12''*\frac{1''}{4}\ ; Wing: 6''*\frac{7}{16}''}$

AREA= 3629.02 $\boldsymbol{mm^2}$

2.6.3. BULKHEAD STIFFENERS

Watertight:

As h=4.27 then h'=0.8*h+1.22=2.928

SM = 7.8*c*s*h*l^2		
c	0.56	
s	0.5	m
h	2.928	
l	4	
SM required	102.316032	cm^3

WE USE A "L" PROFILE OF $\mathbf{5''*3''*\frac{3}{8}''}$

AREA = 1844.75 mm^2

Colision:

SM requerido= 1.25*(102.316)= 127.89504

WE USE A "L" PROFILE OF $\mathbf{6'' * 3.5'' * \frac{5}{16}''}$

AREA = 1852.31 mm^2

Tank:

SM = 7.8*c*s*h*l^2		
c	1	
s	0.5	m
h	6.44	
l	4	
SM required	401.856	cm^3

WE USE A "L" PROFILE OF $\mathbf{12'' * 5'' * \frac{5}{16}''}$

AREA = 3364.40 mm^2

Corrugated:

a = 280mm, b = 196mm, c = 280mm, d = 200mm, t = 8mm

s = (a+b), h = D+1.2m, c = 1

SM = 7.9*c*s*h*l^2		
c	1	
s	0.476	m
h	5.2	
l	4	
SM required	312.86528	cm^3

Let's see the result of:

SM = t*d^2/6+a*d*t/2 = 277.33 cm^3

Therefore, to the given dimensions, the bulkhead's section modulus is appropriate.

2.6.4. DEPTHS

W = 1.07*b*h*s		
b	4	
s	2	m
h	4 m	
l	4 m	
W required	34.24	ton

From tables:

WE USE A "L" PROFILE OF $8'' * 8'' * \frac{1}{2}''$

2.6.5. CENTRAL REINFORCED GIRDER

$$S.M = 7.9 * 1.08 * 4.22 * 6 * 2^2 = 864.12\ cm^3$$

WE USE A "L" PROFILE OF $\mathbf{8}'' * \mathbf{8}'' * \frac{\mathbf{1}}{\mathbf{2}}''$

3. MARINE ENGINEERING – BARGE SYSTEMS

3.1. LOADING AND UNLOADING SYSTEM

3.1.1. BARGE DIMENSIONS

The barge will be dedicated to transport oil at sea.

LENGTH	60 m

BREADTH	13 m
DEPTH	4 m

3.1.2. MAXIMUM FLOW CALCULATION

Hold capacity: 1600 m^3

Unloading time: 8 hours

$$Q_{min} = \frac{V}{t} = \frac{1600}{8} = 200\ {m^3}/{h} = 3333.33\ {l}/{m}$$

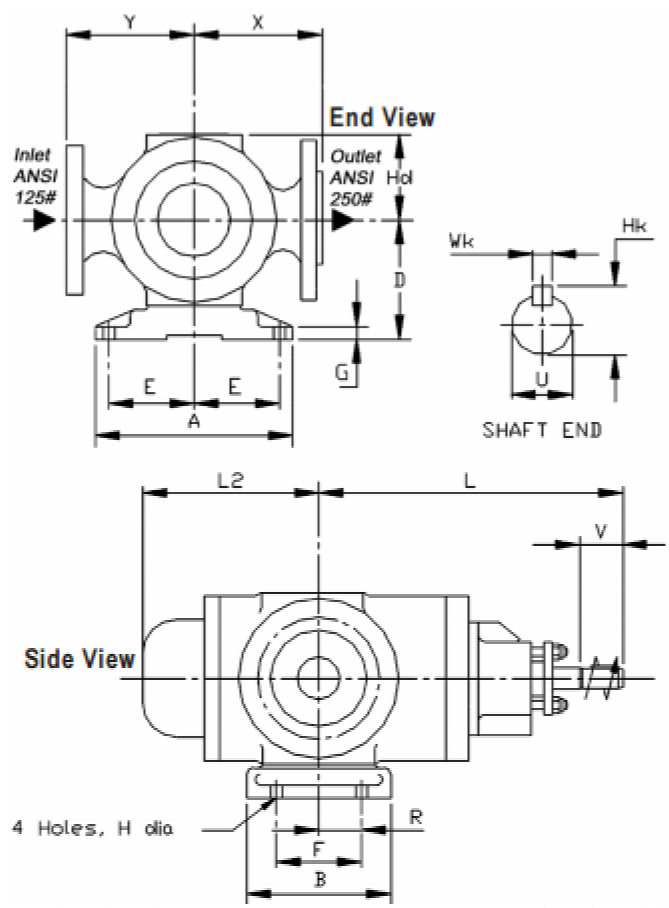
3.1.3. PUMP SELECTION, SUCTION PIPE AND DISCHARGE

3.1.3.1. PUMP

We'll choose ROGER PUMP pump.

Model #	Screw Displacement Gal/rev	Screw Displacement L/rev	Max Flow GPM	Max Flow L/min	Max Speed	ANSI 125# Inlet (inches)	ANSI 250# Outlet (inches)
D13789	0.13789	0.5219	460	1741	3333		
D17237	0.17237	0.6526	460	1741	2667		
D18916	0.18916	0.7160	567	2146	3000		
D21280	0.21280	0.8054	567	2146	2667	8	6
D23644	0.23644	0.8948	567	2146	2400		
D25177	0.25177	0.9529	687	2600	2727		
D31471	0.31471	1.1912	687	2600	2182		
D41563	0.41563	1.5732	887	3357	2133		
D51904	0.51904	1.9646	1112	4209	2143		
D77478	0.77478	2.9325	1453	5500	1875	12	10
D96848	0.96848	3.6657	1453	5500	1500		

Symbol	PUMP MODELS											
	D00185 D00369 D00492		D00608 D00757 D00811 D01014 D01059 D01077 D01211 D01513		D01967 D02155 D03147 D03934		D04618 D05773 D06053 D06488 D07264 D08110 D09685 D12106		D13789 D17237 D18916 D21280 D23644 D25177 D31471		D41563 D51904 D77478 D96848	
	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
A	130	5.12	185	7.28	210	8.27	320	12.60	420	16.54	540	21.26
B	75	2.95	135	5.31	190	7.48	300	11.81	425	16.73	660	25.98
D	100	3.94	112	4.41	160	6.30	225	8.86	280	11.02	400	15.75
E	57.5	2.26	80	3.15	90	3.54	135	5.31	180	7.09	225	8.86
F	50	1.97	80	3.15	140	5.51	210	8.27	300	11.81	520	20.47
G	10	0.39	12	0.47	16	0.63	20	0.79	25	0.98	36	1.42
H	7	0.28	11	0.43	14	0.55	22	0.87	26	1.02	36	1.42
Hd	71	2.80	80	3.15	112	4.41	160	6.30	200	7.87	280	11.02
Hk	16	0.63	21.5	0.85	31	1.22	41	1.61	59	2.32	85	3.35
L	210	8.27	285	11.22	355	13.98	490	19.29	650	25.59	900	35.43
L2	130	5.12	165	6.50	240	9.45	325	12.80	460	18.11	670	26.38
R	25	0.98	40	1.57	70	2.76	105	4.13	150	5.91	260	10.24
U	14	0.55	19	0.75	28	1.10	38	1.50	55	2.17	80	3.15
V	30	1.18	40	1.57	60	2.36	80	3.15	110	4.33	170	6.69
Wk	5	0.20	6	0.24	8	0.31	10	0.39	16	0.63	22	0.87
X	100	3.94	120	4.72	150	5.91	190	7.48	250	9.84	340	13.39
Y	100	3.94	120	4.72	150	5.91	190	7.48	250	9.84	340	13.39
Inlet	-	1.25	-	2.00	-	3.00	-	5.00	-	8.00	-	12.00
Outlet	-	1.00	-	1.50	-	2.50	-	4.00	-	6.00	-	10.00



3.1.3.2. SUCTION AND DISCHARGE

The pipe manufactured by TUBISA SAC will be chosen; with a nominal diameter of 12 “and SHC 40 for suction.

The pipe manufactured by TUBISA SAC will be chosen; with a nominal diameter of 10 “and SHC 40 for discharge.

Diámetro Nominal	Diámetro Exterior		Schedule N°	Espesor de Pared		Peso Teórico	Presión de Prueba	
	pulgada	mm		pulgada	mm	Kg/m	libras/pulgada²	Kg/cm²
10"	10.750	273.0	40	0.365	9.270	60.290	1430	100.00
			80	0.594	15.090	95.970	2320	162.00
12"	12.750	323.8	40	0.406	10.310	79.700	1340	94.00
			80	0.688	17.480	132.040	2270	159.00
			STD S/C	0.375	9.520	73.880	1240	87.00
			STD ERW	0.375	9.520	73.880	1240	87.00

3.1.4. PIPES FROM TANK TO MANIFOLD

Since 2 tanks will be discharged at the same time, the internal area of the suction pipe to the pump should be equal to the sum of the internal areas of the two pipes coming from each tank.

$$Area_{manifold-pump} = 2 * Area_{manifold-tank}$$

$$\frac{\pi D_{mb}{}^2}{4} = \frac{2\pi D_{mt}{}^2}{4}$$

$$(323.8 - 2x10.31)^2 = 2D_{mt}^2$$

$$D_{mt} = 214.38\ mm = 8.44\ ''$$

$$D_{mt} = 10\ ''$$

Then we choose a 10” diameter manifold – tank pipe.

Diámetro Nominal	Diámetro Exterior		Schedule N°	Espesor de Pared		Peso Teórico	Presión de Prueba	
	pulgada	mm		pulgada	mm	Kg/m	libras/pulgada²	Kg/cm²
10"	10.750	273.0	40	0.365	9.270	60.290	1430	100.00
			80	0.594	15.090	95.970	2320	162.00

3.1.5. MAIN MANIFOLD

Due to the manifold must meet the suction and discharge requirements, the area of its section should not be less than the sum of suction and discharge.

$$Area_{manifold} = Area_{manifold-tank} + Area_{manifold-pump}$$

$$D_m{}^2 = 2D_{mt}{}^2 + D_{mb}{}^2$$

$$\boldsymbol{D_m{}^2 = 2(214.38)^2 + (323.8 - 2x10.31)^2}$$

$$\boldsymbol{D_m = 428.76 = 16.88''}$$

$$\boldsymbol{D_m = 18''}$$

The main manifold pipe will have 18'' diameter.

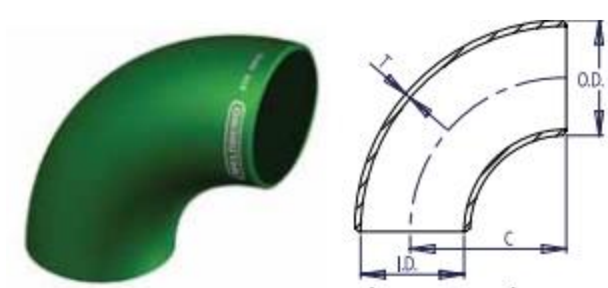
Diámetro Nominal	Diámetro Exterior		Schedule Nº	Espesor de Pared		Peso Teórico	Presión de Prueba	
	pulgada	mm		pulgada	mm	Kg/m	libras/pulgada²	Kg/cm²
18"	18.000	457.2	40	0.562	14.270	155.870	1310	92.00
			80	0.938	23.830	254.550	2190	154.00
			STD S/C	0.375	9.520	105.100	880	62.00
			STD ERW	0.375	9.520	105.100	880	62.00

3.1.6. ACCESSORIES

3.1.6.1. ELBOWS

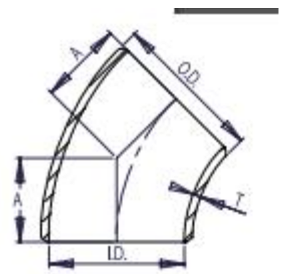
- **90° Long radius elbow**

Tamaño del tubo NPS	Diámetro exterior O.D.	Diámetro interior I.D.	Espesor de la pared T	Centro a extremo C	Nro. de cédula del tubo	Peso aprox. en kilogramos
6	168.3	154.08	7.11	229	40	28.26
8	219.1	202.74	8.18	305	40	42.55
10	273.0	254.46	9.27	381	40	60.29
12	323.8	303.18	10.31	457	40	79.71



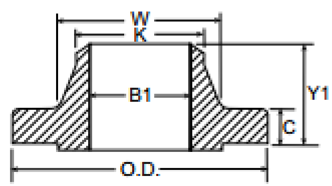
- **45° Long radius elbow**

Tamaño del tubo NPS	Diámetro exterior O.D.	Diámetro interior I.D.	Espesor de la pared T	Centro a extremo A	Nro. de cédula del tubo	Peso aprox. en kilogramos
8	219.1	202.74	8.18	127	40	10.57
10	273.0	254.46	9.27	159	40	18.55
12	323.8	303.18	10.31	190	40	29.48

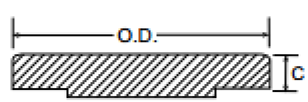


3.1.6.2. <u>FLANGES</u>

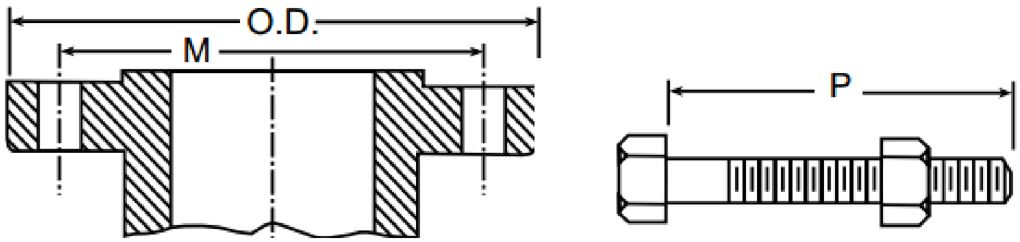
Welding neck flanges are used for the connections and blind type for the manifold.



Tamaño del tubo	Diámetro exterior de la brida	Espesor de la brida (Min.)	Espesor de la junta de solapa (Min.)	Diámetro del centro*	Diámetro del cuello para soldar	Longitud a lo largo del centro: Roscada, deslizable y enchufe para soldar	Longitud a lo largo del centro: Loca	Longitud a lo largo del centro: Cuello para soldar	Largo de la rosca (Min.)	Diámetro interior: Deslizable y enchufe para soldar (Min.)	Diámetro interior: Loca (Min.)	Diámetro interior: Cuello para soldar y encastre/enchufe para soldar	Radio de la junta de solapa	Profundidad del enchufe
NPS	O.D.	C	C	W	K	Y2	Y3	Y1	T	B2	B3	B1 ▲	J	D
ASME B16,5														
8	345	27.0	28.6	246	219.1	43	44	100	44	221.5	222.2	202.7	13	
10	405	28.6	30.2	305	273.0	48	49	100	49	276.2	277.4	254.6	13	
12	485	30.2	31.8	365	323.8	54	56	113	56	327.0	328.2	304.8	13	



Tamaño del tubo	Diámetro exterior de la brida	Espesor de la brida (Mín.)	Espesor de la junta de solapa (Mín.)	Diámetro del centro*	Diámetro del cuello para soldar	Longitud a lo largo del centro: Roscada, deslizable y enchufe para soldar	Loca	Cuello para soldar	Largo de la rosca (Mín.)	Diámetro interior: Deslizable y enchufe para soldar (Mín.)	Loca (Mín.)	Cuello para soldar y encahufe para soldar	Radio de la junta de solapa	Profundidad del enchufe
NPS	O.D.	C	C	W	K	Y2	Y3	Y1	T	B2	B3	B1 ▲	J	D
14	535	33.4	35.0	400	355.6	56	79	125	57	359.2	360.2	*	13	
16	595	35.0	36.6	457	406.4	62	87	125	64	410.5	411.2	*	13	
18	633	38.1	39.7	505	457.0	67	97	138	68	461.8	461.8	*	13	



Patrón de empernado y largo de los pernos								
		Taladrado				Largo de los pernos		
Tamaño del tubo	Diámetro exterior	Diámetro del círculo del perno	Diámetro de los agujeros de los pernos	Número de agujeros de los tornillos	Diámetro de los pernos	Pernos prisioneros para bridas de cara realzada 2 mm	Pernos prisioneros Junta tipo anillo	Pernos comunes para bridas de cara realzada 2 mm
NPS	O.D.	M				P	P	P
ASME B16.5								
8	345	298.5	⅞	8	¾	110	120	90
10	405	362.0	1	12	⅞	115	125	100
12	485	431.8	1	12	⅞	120	135	100
14	535	476.3	1 ⅛	12	1	135	145	115
16	595	539.8	1 ⅛	16	1	135	145	115
18	633	577.9	1 ¼	16	1 ⅛	145	160	125

3.1.6.3. VALVES

We use 10” and 12”gate valves in all connections.

3.1.6.4. SEAWATER INLET

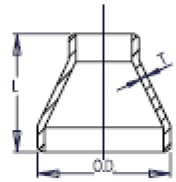
The design must meet the following conditions.

$$A_{free\ s.} \geq 1.5\ A_{pipe}$$

$$A_{free\ s.} = \frac{1.5x\pi x254.46^2}{4} = 81940.73mm^2$$

$$D_{free\ s.} = 323\ mm$$

The minimum diameter of the suction bell shall not be less than 323 mm.



Tamaño del tubo	DIÁMETRO GRANDE			DIÁMETRO PEQUEÑO			Largo	Nro. de cédula del tubo	Peso aprox. en kilogramos
	Diámetro exterior	Diámetro interior	Espesor de la pared	Diámetro exterior	Diámetro interior	Espesor de la pared			
NPS	O.D.	I.D.	T	O.D.	I.D.	T	L		
PARA CONOCER LAS ESPECIFICACIONES DE LAS DIMENSIONES DE NPS ½ A 10 CONSULTE CÉDULA STD									
16 x 14	406.4	381.00	12.70	355.6	333.34	11.13	356	40	43.77
16 x 12	406.4	381.00	12.70	323.8	303.18	10.31	356	40	43.77
16 x 10	406.4	381.00	12.70	273.0	254.46	9.27	356	40	43.77
16 x 8	406.4	381.00	12.70	219.1	202.74	8.18	356	40	43.77

For the design of the box where the bell goes, the area should be 1.5 times the area of the bell mouth.

$$A_{box} = \frac{1.5x\pi x381^2}{4} mm^2$$

$$A_{box} = 171013.62\, mm^2$$

$$L_{box} = 414 \text{ mm}$$

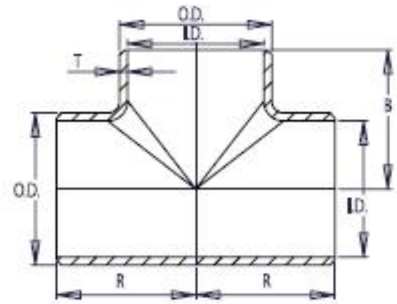
The side of the base of the box where the bell will go must not be less than 414 mm, by which we will assign 500 mm and for the top we will give 600 mm.

The height of the bell at the base of the box shall not be less than: $\mathrm{h}.\pi.381 = \frac{\pi x381^2}{4}\ mm^2$

$$\mathrm{h} = 95.25\ mm$$

The height of the base of the box to the mouth of the bell will not be less than 95.25 mm for which we will choose: h = 100 mm.

3.1.6.5. T STRAIGHT PIPE



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OI

Tamaño del tubo	Diámetro exterior	Diámetro interior	Espesor de la pared	Centro a centro	Centro a extremo	Nro. de cédula del tubo	Peso aprox. en kilogramos
NPS	O.D.	I.D.	T	R	B		
6	168.3	154.08	7.11	143	143	40	9.43
8	219.1	202.74	8.18	178	178	40	15.01
10	273.0	254.46	9.27	216	216	40	25.63
12	323.8	303.18	10.31	254	254	40	41.23

3.1.7. BULKHEAD FEEDTHROUGH

3.1.7.1. COMMOM BULKHEAD FEEDTHROUGH

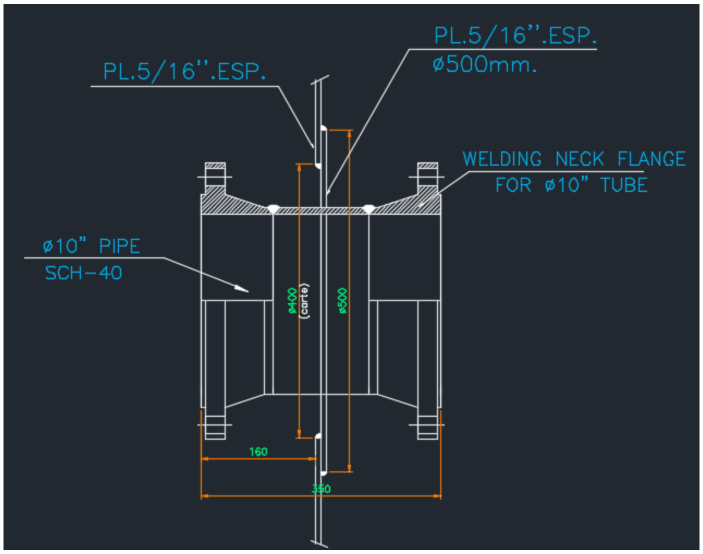
For the design we must consider that the cutted area must be compensated, therefore we must calculate the diameter of the reinforcement that compensates that area.

$$A_{cutted} = \frac{\pi}{4}(400^2)$$

$$\frac{\pi}{4}(400^2) = \frac{\pi}{4}(D^2 - 273^2)$$

$$D_{min} = 484.28\ mm$$

The minimum diameter should be 484.28 mm, we will consider a diameter of 500 mm for the structure.



3.1.7.2. CORRUGATED BULKHEAD FEEDTHROUGH

We must compensate the cutted area for which we will find the area that is cut from the corrugated bulkhead, the calculation will be done with the surface formulations of the cones.

$$A_{cutted} = \pi.250.357 - \pi.150.230 + \pi.150^2$$

$$A_{cutted} = 242687.82\ mm^2$$

$$242687.82 = \pi.g.r - \pi.150.230$$

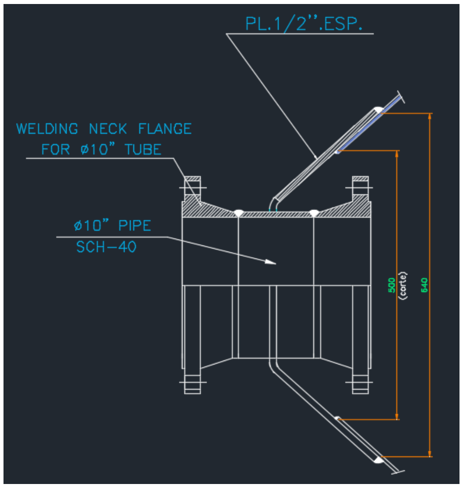
But by the graph we know that g = 1.1r then:

$$242687.82 = 1.1\pi.r^2 - \pi.150.230$$

$$r = 318.7mm$$

$$D_{min} = 637.46\ mm$$

For the diameter of the structure we will take a value of 640 mm.



3.1.7.3. DECKCONDUIT

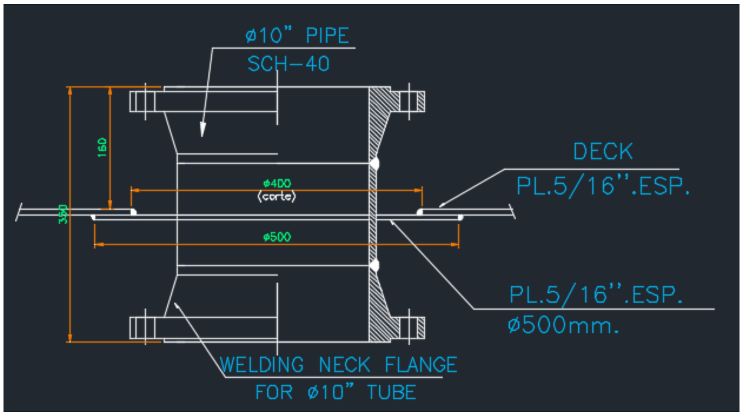
For the design we must consider that the cutted area must be compensated, therefore we must calculate the diameter of the reinforcement that compensates that area.

$$A_{cutted} = \frac{\pi}{4}(400^2)$$

$$\frac{\pi}{4}(400^2) = \frac{\pi}{4}(D^2 - 273^2)$$

$$D_{min} = 484.28\ mm$$

The minimum diameter should be 484.28 mm, we will consider a diameter of 500 mm for the structure.



3.1.8. CALCULATION OF LOSSES

For the calculation of the load losses of the pipes the most critical length will be chosen, although the lengths are similar we will take the discharge from the holds 1 to starboard and 4 to port.

$$\mathbf{J} = f\,\frac{l}{d}\,\frac{v^2}{2g}$$

Where:

J: Loss of load per unit length

f: Friction factor

l: Total pipe length

d: Inside diameter of pipe, m

v: Average Fluid Velocity, m/s

g: Acceleration of gravity, 9.81 m/s^2

Also:

e: Rugosity

d: Inside diameter

K/d: Relative Roughness.

Q: Flow

v: velocity

ρ: density

µ: viscosity

Re: Reynolds number.

3.1.8.1. PRIMARY LOSSES

PUMP TO UPPER TANK		
Description	Value	Unity
e	0.00927	m
d	0.25446	m
e/d	0.03643	
Q	0.05595	m3/s
v	1.1002	m/s
ρ	936	kg/m3
μ	0.356	Pa-s
Re	735.93	Laminar
f	0.0869	
L pump to elbow	0.2	m
L elbow to elbow	0.3	m
L elbow to elbow	1.74	m
L elbow to valve	0.16	m
L valve to cross	0.083	m
L cross to elbow	1.05	m
L elbow to elbow	1.8	m
L elbow to t	2.5	m
L t to valve	0.2	m
L total	8.033	m
d	0.25446	m
v	1.1002	m/S
g	9.81	m/s2
J per meter	0.02106903	m/m
J	0.16924751	m

PUMP TO MANIFOLD		
Description	Value	Unity
e	0.01031	m
d	0.30318	m
e/d	0.034	
Q	0.05595	m3/s
v	0.775	m/s
ρ	936	kg/m3
μ	0.356	Pa-s
Re	617.771831	Laminar

f	0.10359812	
L pump to manifold	1.37	m
d	0.30318	m
v	0.775	m/s
g	9.81	m/s2
J per meter	0.01046058	m/m
J	0.01433099	m

MANIFOLD TO STARBOARD TANK 1		
Description	Value	Unity
e	0.00927	m
d	0.25446	m
e/d	0.03643	
Q	0.027976	m3/s
v	0.55012	m/s
ρ	936	kg/m3
μ	0.356	Pa-s
Re	368.046598	Laminar
f	0.17389102	
L manifold	3.5	m
d	0.25446	m
v	0.55012	m/s
g	9.81	m/s2
J per meter	0.0105408	m/m
J	0.03689279	m

MANIFOLD TO PORT TANK 4		
e	0.00927	m
d	0.25446	m
e/d	0.03643	
Q	0.027976	m3/s
v	0.55012	m/s
ρ	936	kg/m3
μ	0.356	Pa-s
Re	368.046598	Laminar
f	0.17389102	
L manifold to elbow	6.38	m
L elbow to elbow	0.39	m

L elbow to elbow	9.58	m
L elbow to elbow	0.39	m
L elbow to elbow	9.85	m
L elbow to elbow	8.05	m
L elbow to reducer	0.2	m
L total	34.84	m
d	0.25446	m
v	0.55012	m/s
g	9.81	m/s2
J per meter	0.0105408	m/m
J	0.36724142	m

3.1.8.2. SECONDARY LOSSES

The secondary losses occur in the accessories, in our case in elbows, valves and manifold.

$$J_S = \frac{K v^2}{2g}$$

Where:

K: Experimental coefficient that characterizes the singularity.

V: Average velocity in the pipeline, accurately specified before or after the singularity, m/s.

ELBOWS

The losses in the elbows will be calculated according to the CRANE fluid mechanics book.

For 10" elbows between pump and deck:

Description	Value	Unity
K	0.256	
V	1.1002	m/s
G	9.81	m/s2

D	0.25446	m
# 90° elbows	5	
Js	0.0789	m

Losses at the elbow of bulkhead to manifold:

Description	Value	Unity
K	0.256	
V	0.55012	m/s
G	9.81	m/s2
D	0.25446	m
# 90° elbows	2	
Js	0.00789	m

VALVES

For valves between pump and deck inlet:

Description	Value	Unity
K	5.75	
v	1.1002	m/s
g	9.81	m/s^2
# valves	2	
Js	0.7094	

For valves between pump and manifold:

Description	value	unity
K	5.75	
v	1.101	m/s
g	9.81	m/s^2
# valves	1	

Js	0.3226	

For valves between manifold and tanks inlet (Port N°4 tank and Starboard N°1 tank):

Description	value	unity
K	5.8	
v	0.85	m/s
g	9.81	m/s^2
# valves	1	
Js	0.4272	

3.1.9. TOTAL LOSSES

The following table summarizes the total losses found. We also consider an additional loss of 25 m for the additional connection outside the barge and in the end is considered a 20% more due to the losses due to aging of the pipes.

Description	Value	Unity
$(J+Js)_{total}$	2.1337	m
$H_{conection}$	25	m
H_{static}	4.57	m
H_{total}	31.7037	m
(h_{total})*1.2	38.05	m

Where:

$H_{suction}$ **= 0.94**

$H_{discharge}$**=3.63**

H_{static}**=** $H_{suction}+H_{discharge}$ **= 4.57 m**

3.1.10. DYNAMIC HEIGHT

$$H_D = H_{static} + h_{suction\ and\ discharge} + 10\frac{(P_2 - P_1)}{G.E} + \frac{V^2}{2g}$$

Where:

H_{static}	: Static height (m)
$h_{suction\ and\ discharge}$	: Suction loss height (m)
P_1 y P_2	: Absolute pressures (Kg/cm^2)
G.E	: Specific gravity (Kg/cm^2)
V	: Discharge speed
g	: gravity (9.81 m/s^2)

Replacing values:

$$\boldsymbol{H_D = 4.57 + 38.05 + 10\frac{(P_2 - P_1)}{G.E} + \frac{V^2}{2g}}$$

$$\boldsymbol{H_D = 39.44 + 10x\frac{(1atm - 1atm)}{G.E} + \frac{1.101^2}{2x9.81}}$$

$$\boldsymbol{H_D = 39.501\ m}$$

3.1.11. ENGINE SELECTION

We calculate the power of the engine, we consider the efficiency of the pump equal to 0.6.

$$P = \frac{Q x H_D}{76xEf}$$

Where:

Q: Flow (l/s)

H_D: Dynamic height

E_f: Pump Efficiency (0.6)

Replacing:

$$\boldsymbol{P = \frac{\frac{3357}{60}x39.501}{76x0.6}}$$

$$P = 49\ HP$$

We use a Cummins model 6BTA5.9-DM (MARINE AUXILIARY) 100HP Engine.

General Specifications

Configuration	In-line, 6 cylinder, 4-stroke diesel	
Aspiration	Turbocharged/Aftercooled	
Displacement	5.9 L	359 in³
Bore & Stroke	102 x 120 mm	4.02 x 4.75 in
Fuel System	Inline Injection Pump	

Prime Power Ratings

Output Power		Hz	ISO Fuel Cons		Emissions*
kW	BHP		L/hr	Gal/hr	
75	100	60	12.1	3.2	EPA2
93	125	60	14.1	3.7	EPA2

Product Dimensions

Length	mm (in)	1051	(41)
Width	mm (in)	681	(27)
Height	mm (in)	1201	(47)
Weight	kg (lb)	426	(940)

Dimensions may vary based on selected engine configuration

Because the engine is 60 Hz (3600 rpm) and the rpm of the pump is 2133 rpm, the engine and pump will be connected by a belt. The ratio of the diameters will be:

$$\frac{D_{motor}}{D_{polea}} = 0.5925$$

If we consider a pulley for the 20 mm motor the diameter of the pulley for the pump will be 33.76 mm.

3.2. VENTILATION SYSTEM

For the design it will be taken into account that the difference in ambient temperature with the engine room does not exceed 9 ° C for which we will consider a combined circuit due to the arrangement of the plane of the boat.

According to Caterpillar Marine Engine Maintenance, Testing and Installation Manual.

A rule is to use 1.25 squared inches for each hp of the engine.

$$A_{ventilator} = 100x1.25\,pulg^2 = 0.080645\,m^2$$

$$\boldsymbol{L_{Square\ pipe} = 0.30\ m}$$

Also do not exceed the speed 610 m /min.

$$\boldsymbol{Q_{in} = 0.080645m^2x610\ {}^{m}/_{min} = 49.19\ \frac{m^3}{min} = 0.82\ \frac{m^3}{s} = 2959\frac{m^3}{hr}}$$

It is recommended that the output flow is 1.2 times the inlet flow rate.

$$\boldsymbol{Q_{out} = 1.2x0.82\ \frac{m^3}{s} = 0.984\ \frac{m^3}{s} = 3542.4\ \ \frac{m^3}{hr}}$$

$$\boldsymbol{A_{extractor} = 0.09678\,m^2}$$

$$\boldsymbol{L_{Square\ pipe} = 0.32\ m}$$

This would be the maximum value for not having excess noise, but as we have the motor data then:

BHP=100 HP = 33%

IHP= 303.1 HP= 100%

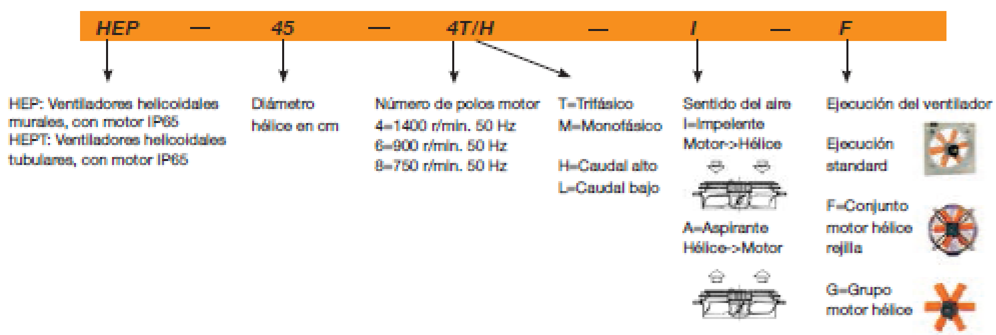
Heat transferred to the atmosphere = 7 %(IHP)= 22 HP= 933 BTU/min.

3.2.1. VENTILATOR AND EXTRACTOR SELECTION

We will choose a ventilator and extractor of the SODECA brand as they are for marine use.

3.2.1.1 VENTILATOR SELECTION

HEP
HEPT



Características técnicas

Modelo		Velocidad (r/min)	Intensidad máxima admisible (A) 220-240V	380-415V	Potencia absorb. desc. libre (W)	Caudal máximo (m³/h)	Nivel presión sonora dB(A)	Peso aprox. (Kg) HEP	HEPT
HEP-35-4T/H	HEPT-35-4T/H	1340	0,74	0,43	155	3500	58	7,1	7,6
HEP-35-4M/H	HEPT-35-4M/H	1340	0,98	-	160	3500	58	7,1	7,6
HEP-35-4T/L	-	1410	0,69	0,40	110	2650	56	6,5	-

3.2.1.2 EXTRACTOR SELECTION

CHT
CVT

CHT

CVT

Código de pedido

CHT — 200 — 4T — BS

CHT: Extractores centrífugos de tejado 400ºC/2h, con salida de aire horizontal

CVT: Extractores centrífugos de tejado 400ºC/2h, con salida de aire vertical

Tamaño turbina

Número de polos motor
2=2900 r/min. 50 Hz
4=1400 r/min. 50 Hz
6=900 r/min. 50 Hz
8=750 r/min. 50 Hz
12=500 r/min. 50 Hz

T=Trifásico

BS: Base soporte elevada
BSS: Base soporte elevada con silenciador

Características técnicas

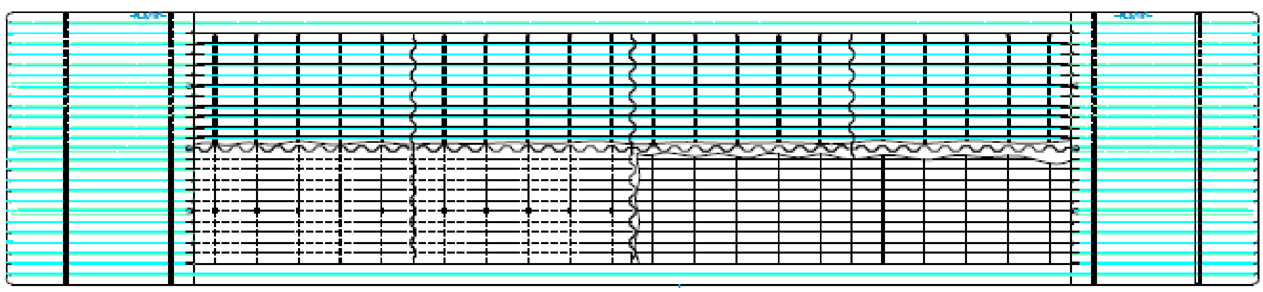
Modelo			Velocidad (r/min)	Intensidad máxima admisible (A) 230V	400V	Potencia instalada (kW)	Caudal máximo (m³/h)	Nivel sonoro dB(A) Aspiración	Descarga	Peso aprox. (Kg)
CHT	CVT	200-4T	1350	1,66	0,96	0,25	1450	37	43	25
CHT	CVT	200-4M	1380	0,65		0,25	1450	37	43	25
CHT	CVT	225-4T	1350	1,66	0,96	0,25	2100	41	47	25
CHT	CVT	225-4M	1380	0,95		0,25	2100	41	47	25
CHT	CVT	225-6T	900	1,51	0,87	0,25	1400	30	36	26
CHT	CVT	225-6M	890	0,50		0,25	1400	30	36	26
CHT	CVT	250-4T	1350	1,66	0,96	0,25	3100	45	50	34
CHT	CVT	250-4M	1380	1,35		0,25	3100	45	50	34
CHT	CVT	250-6T	900	1,51	0,87	0,25	2000	33	40	35
CHT	CVT	250-6M	890	0,65		0,25	2000	33	40	35
CHT	CVT	315-4T	1380	2,92	1,69	0,55	4950	48	54	39
CHT	CVT	315-4/8T	1450/720		1,70 / 0,80	0,55 / 0,19	4950 / 2475	48 / 33	54 / 39	40

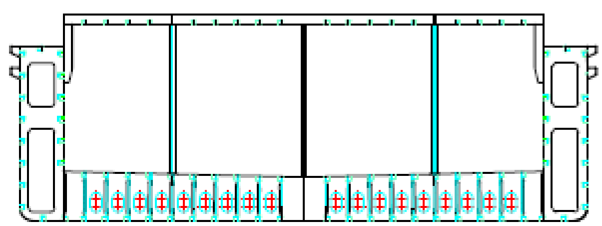
4. NAVAL ARCHITECTURE – TRIM AND STABILITY BOOKLET

4.1. BARGE DESCRIPTION

GENERAL CHARACTERISTICS

L=60 m B=13 m D= 4 m



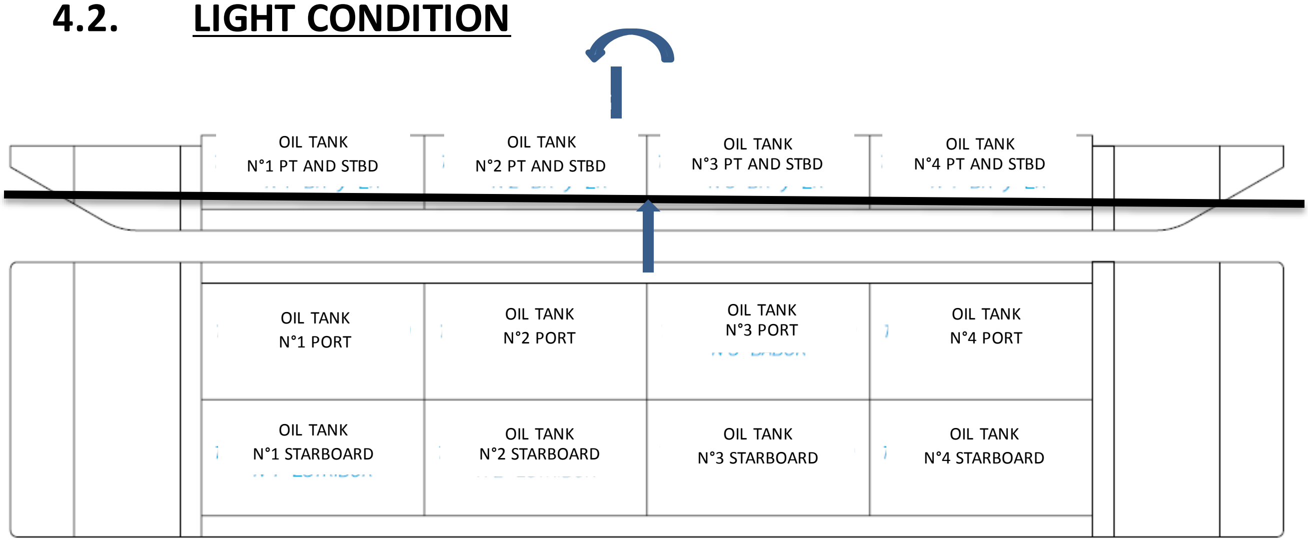


BARGE'S TOTAL WEIGHT: SUMMARY

DESCRIPTION	Weight	Momentum(KG)	Momemtum(LCG)
	(kg)	(Ton-m)	(Ton-m)
HULL PLATING	189037.97	368.37	5671.14
TRANSVERSE ELEMENTS	111747.11	337.35	3298.64
LONGITUDINAL ELEMENTS	66152.34	136.99	1984.57
DECKHOUSE	2605.75	14.16	12.73
MACHINE ROOM	876.00	1.82	6.63

PIPE SYSTEM	20131.54	38.40	318.38
TOTAL	390550.71	897.09	11292.10
KG (From baseline) =	2.30	m	
LCG (From stern) =	28.91	m	
LCG (From midship) =	1.09 to stern	m	

4.2. LIGHT CONDITION



Element	Weight (Kg)	KG	M V (Ton.m)	LCG	M L (Ton.m)
Dead Weight	390550.71	2.3	897.09	28.91	11292.1
Tank 1 PT, STBD	0	0	0	0	0
Tank 2 PT, STBD	0	0	0	0	0
Tank 3 PT, STBD	0	0	0	0	0
Tank 4 PT, STBD	0	0	0	0	0
Fuel Tank	0	0	0	0	0
Crew	0	0	0	0	0
Water tank, crew and engine	0	0	0	0	0
Total	390550.71		897.09		11292.1

OIL TANK
N°1 PT AND STBD

HYDROSTATIC CURVES		
Displacement	390.55	Ton

L= 60 m

Mean draft	0.58	m
MTC	25.5	Ton-m/cm
LCB	0	m
LCF	0	m
BMt	24.7	m
KB	0.3	m
KMt	25	m
GM	22.7	m
BML	389.7	m
KML	390	m
TPC	6.87	Ton/cm

KG = **2.3** **m** (from base line)

LCG = **1.09** **m** (To stern from midship)

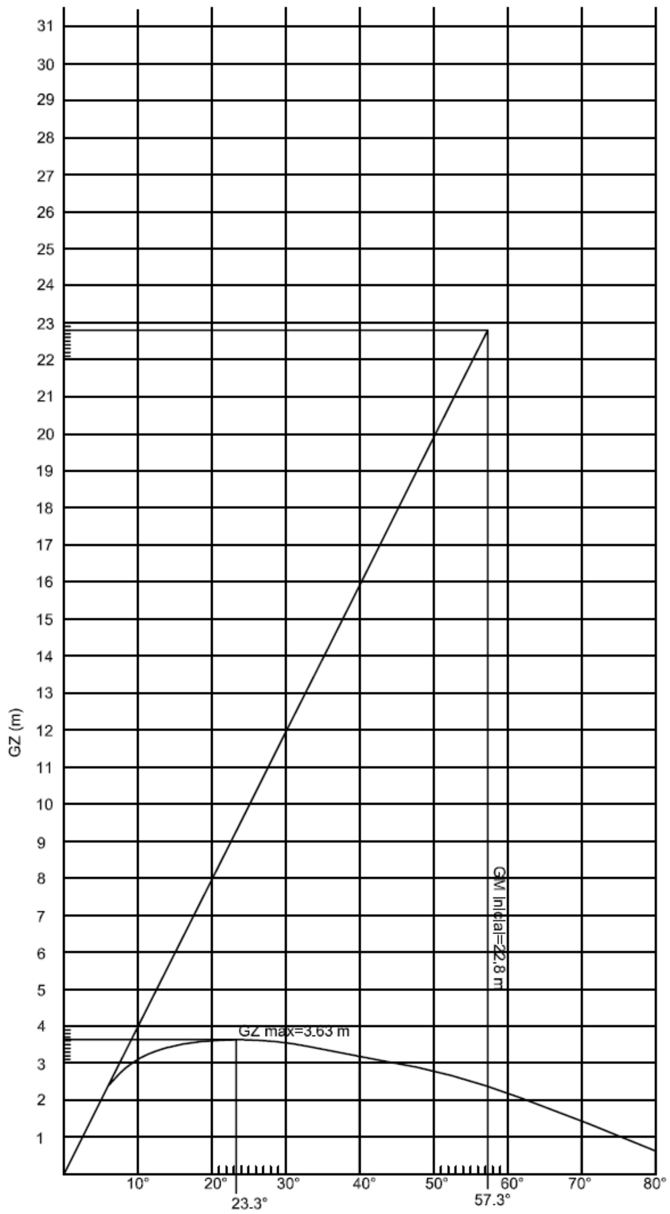
t = Disp x (LCG-LCB) / MTC	=	16.694	cm
dh pr = t x (0,5 +- LCF / L)	=	8.347	cm
dh pp = t x (0,5 +-LCF / L)	=	8.347	cm
H pr = draft +- dh pr	=	0.497	m
H pp = draft +- dh pp	=	0.663	m

From data: Down by the stern

KG assumed from the base line = 0 m (KG real = 2.3m)

Correction of the Stability Curve: $$\mathbf{GZ = KN - (KG_{real} - KG_{assumed})*sen\emptyset}$$

KG real(m)	degrees	KN(m)	**GZ(m)**
2.3	0	0	**0.00**
2.3	10	3.5	**3.10**
2.3	20	4.4	**3.61**
2.3	30	4.7	**3.55**
2.3	40	4.66	**3.18**
2.3	50	4.55	**2.79**
2.3	60	4.18	**2.19**
2.3	70	3.6	**1.44**
2.3	80	2.9	**0.63**



OMI CRITERIA

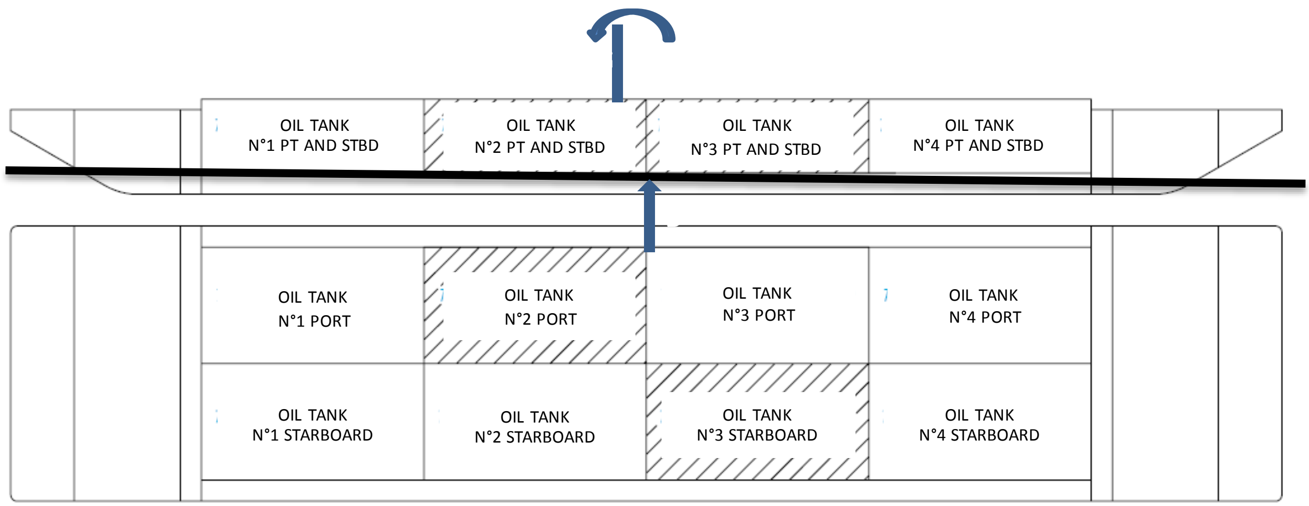
We make a comparison between the criteria set by IMO and our current values.

OMI Criteria	Allowed	Current	CONDITION
Area 0 – 30°	≥ 0.055 m-rad	1.549	MEETS
Area 0 – 40°	≥ 0.090 m-rad	2.153	MEETS
Area 30° – 40°	≥ 0.030 m-rad	0.604	MEETS

GZ (Ø=30°)	≥ 0.2 m	3.55	MEETS
GZ max angle	≥ 25°	23.3°	FAILS
GM	≥ 0.35 m	22.8	MEETS

IMPORTANTE: It does not comply with rule 3.1.2.3 of the IMO-free stability code which states that the maximum GZ should be> 25 °, but the IMO undamaged stability code in regulation 4.5.6.2.4 gives criteria for Vessels whose characteristics prevent them from complying with the provisions of the preceding table are allowed to have the angle at which the maximum GZ is> 15 °, therefore the barge complies with the OMI code, since the angle is 23.3°.

4.3. CONDITION 25% OF CHARGE AND 75% OF CONSUMABLES



Element	Weight (Kg)	KG	M V (Ton.m)	LCG	M L (Ton.m)
Dead weight	390550.71	2.30	897.09	28.91	11292.10
Tank 1 PT	0.00	0.00	0.00	0.00	0.00
Tank 1 STBD	0.00	0.00	0.00	0.00	0.00
Tank 2 PT	186600.00	2.75	513.15	24.75	4618.35
Tank 2 STBD	0.00	0.00	0.00	0.00	0.00
Tank 3 PT	0.00	0.00	0.00	0.00	0.00
Tank 3 STBD	186600.00	2.75	513.15	35.25	6577.65
Tank 4 PT	0.00	0.00	0.00	0.00	0.00
Tank 4 STBD	0.00	0.00	0.00	0.00	0.00
Fuel tank	850.00	1.88	1.59	4.00	3.40
Crew	360.00	4.90	1.76	4.00	1.44
Water tank, crew and engine	750.00	4.38	3.28	7.00	5.25
Total	765710.71		1930.03		22498.19

HYDROSTATIC CURVES		
Displacement	765.71	Ton
Mean draft	1.12	m
MTC	28.40	Ton-m/cm
LCB	0.00	m
LCF	0.00	m

L = 60 m

KG = 2.52 m (From baseline)

LCG = 0.62 m (To stern from midship)

t = DISP x (LCG-LCB) / MTC =	16.660	cm

BMt	13.03	m
KB	0.57	m
KMt	13.60	m
GM	11.08	m
BML	222.43	m
KML	223.00	m
TPC	7.12	Ton/cm

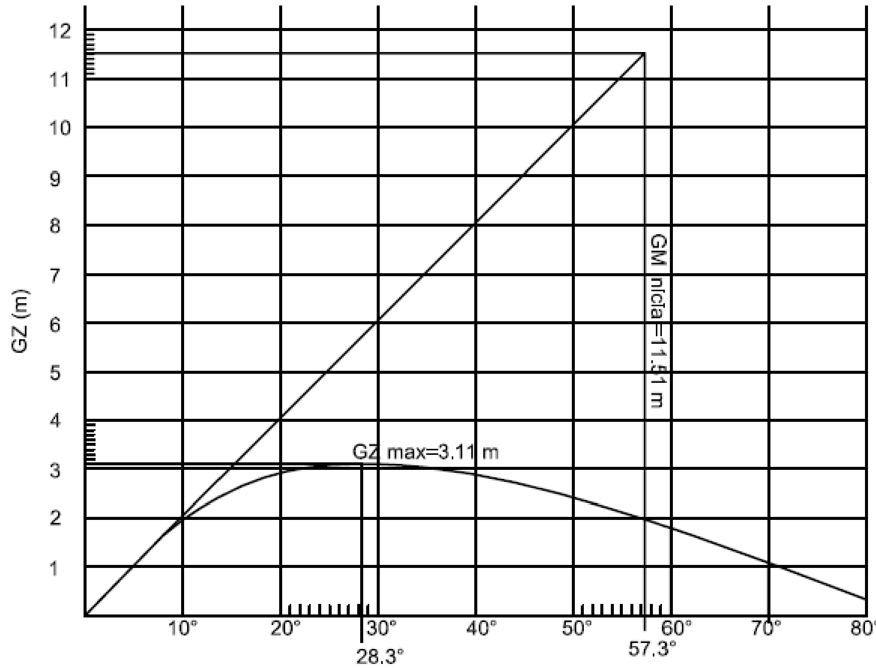
dh pr = t x (0,5 +- LCF / L)	=	8.330	cm
dh pp = t x (0,5 +-LCF / L)	=	8.330	cm
H pr = DRAFT +- dh pr	=	1.037	m
H pp = DRAFT +- dh pp	=	1.203	m

From data: Down by the stern

KG assumed from the base line = 0 m (KG real = 2.52m)

Correction of the Stability Curve: $\mathbf{GZ = KN - (KG_{real} - KG_{asumido})*sen\text{Ø}}$

KG real(m)	DEGREES	KN(m)	GZ
2.52	0	0	**0.00**
2.52	10	2.4	**1.96**
2.52	20	3.78	**2.92**
2.52	30	4.36	**3.10**
2.52	40	4.51	**2.89**
2.52	50	4.35	**2.42**
2.52	60	3.98	**1.80**
2.52	70	3.45	**1.09**
2.52	80	2.81	**0.33**



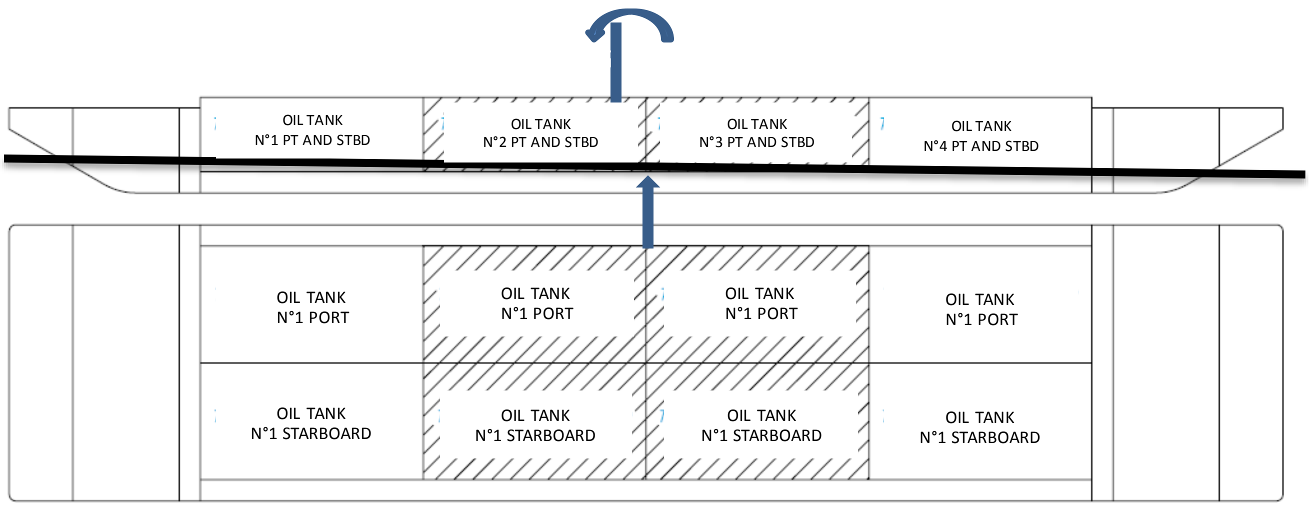
OMI CRITERIA

We make a comparison between the criteria set by IMO and our current values:

OMI Criteria	Allowed	Current	CONDITION
AREA 0 – 30°	≥ 0.055 m-rad	1.161	MEETS
AREA 0 – 40°	≥ 0.090 m-rad	1.685	MEETS
AREA 30° – 40°	≥ 0.030 m-rad	0.524	MEETS
GZ (Ø=30°)	≥ 0.2 m	3.10	MEETS
GZ max angle	≥ 25°	28.3°	MEETS
GM	≥ 0.35 m	11.08	MEETS

The vessel meets the IMO criteria.

4.4. CONDITION 50% OF CHARGE AND 50% OF CONSUMABLES



Element	Weight (Kg)	KG	M V (Ton.m)	LCG	M L (Ton.m)
Dead weight	390550.71	2.30	897.09	28.91	11292.10
Tank 1 PT	0.00	0.00	0.00	0.00	0.00
Tank 1 STBD	0.00	0.00	0.00	0.00	0.00
Tank 2 PT	186600.00	2.75	513.15	24.75	4618.35
Tank 2 STBD	186600.00	2.75	513.15	24.75	4618.35
Tank 3 PT	186600.00	2.75	513.15	35.25	6577.65
Tank 3 STBD	186600.00	2.75	513.15	35.25	6577.65
Tank 4 PT	0.00	0.00	0.00	0.00	0.00
Tank 4 STBD	0.00	0.00	0.00	0.00	0.00
Fuel tank	425.00	1.75	0.74	4.00	1.70
Crew	360.00	4.90	1.76	4.00	1.44
Water tank, crew and engine	500.00	4.25	2.13	7.00	3.50
Total	1138235.71		2954.32		33690.74

HYDROSTATIC CURVES		
Displacement	1138.24	Ton
Mean draft	1.65	m
MTC	31.40	Ton-m/cm
LCB	0.00	m
LCF	0.00	m
BMt	9.07	m

L=	**60**	**m**	
KG =	**2.60**	**m**	(From baseline)
LCG =	**0.40**	**m**	(To stern from midship)

t = DISP x (LCG-LCB) / MTC	=	14.533	cm
dh pr = t x (0,5 +- LCF / L)	=	7.266	cm

KB	0.83	m
KMt	9.90	m
GM	7.30	m
BML	164.17	m
KML	165.00	m
TPC	7.36	Ton/cm

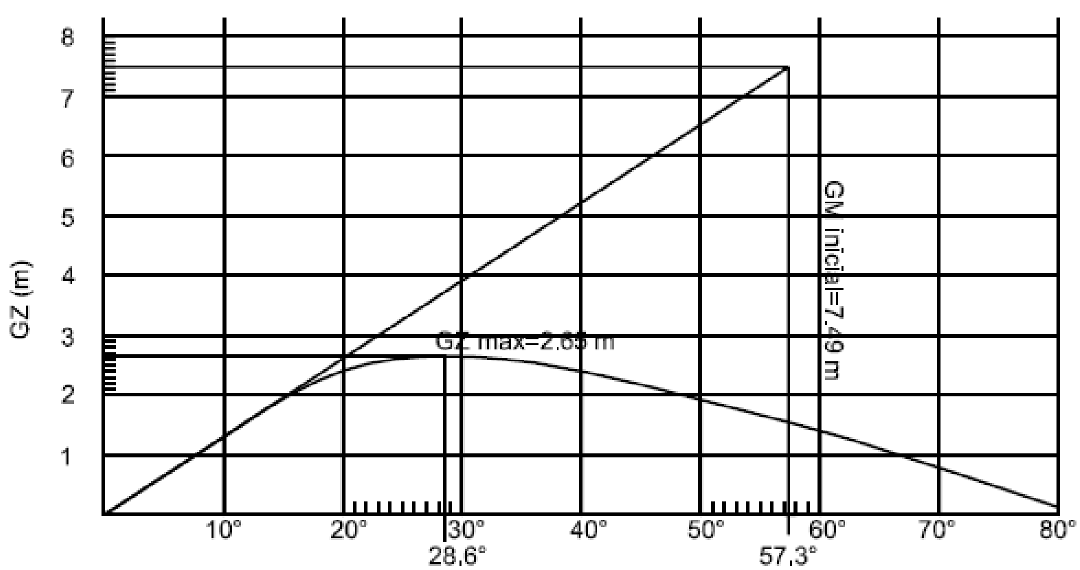
dh pp = t x (0,5 +-LCF / L)	=	7.266	cm
H pr = DRAFT +- dh pr	=	1.577	m
H pp = DRAFT +- dh pp	=	1.723	m

From data: Down by the stern

KG assumed from the base line = 0 m (KG real = 2.60m)

Correction of the Stability Curve: $\mathbf{GZ = KN - (KG_{real} - KG_{assumed})*sen\emptyset}$

KG real(m)	DEGREES	KN(m)	GZ
2.60	0	0	**0.00**
2.60	10	1.75	**1.30**
2.60	20	3.3	**2.41**
2.60	30	3.95	**2.65**
2.60	40	4.07	**2.40**
2.60	50	3.95	**1.96**
2.60	60	3.66	**1.41**
2.60	70	3.23	**0.79**
2.60	80	2.68	**0.12**



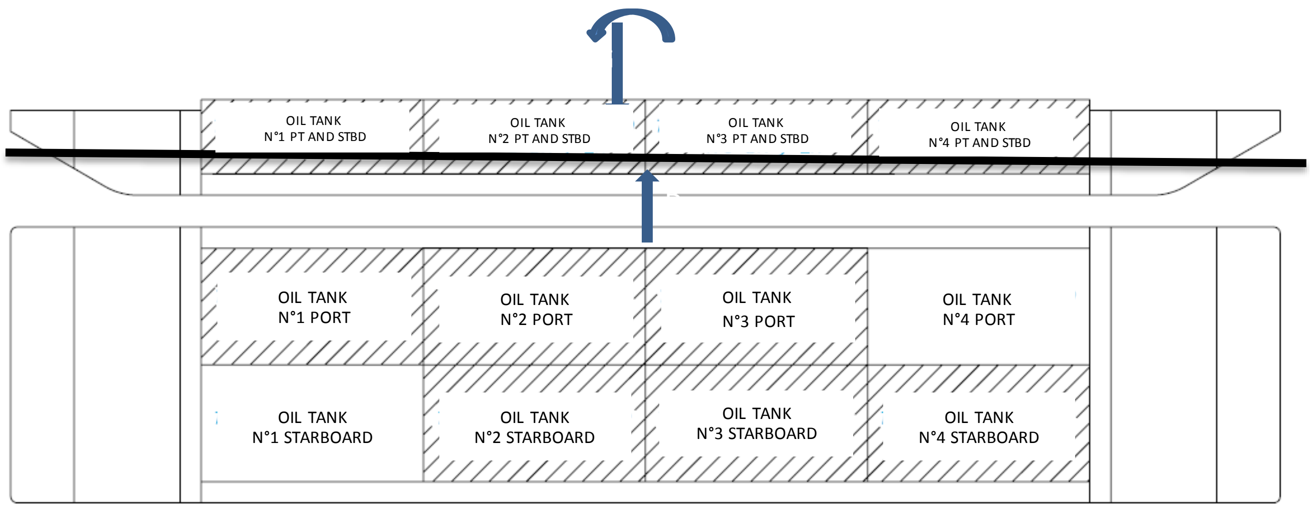
OMI CRITERIA

We make a comparison between the criteria set by IMO and our current values:

OMI Criteria	Allowed	Current	CONDITION
AREA 0 – 30°	$\geq$ 0.055 m-rad	0.902	MEETS
AREA 0 – 40°	$\geq$ 0.090 m-rad	1.339	MEETS
AREA 30° – 40°	$\geq$ 0.030 m-rad	0.437	MEETS
GZ (Ø=30°)	$\geq$ 0.2 m	2.65	MEETS
GZ max ANGLE	$\geq$ 25°	28.6°	MEETS
GM	$\geq$ 0.35 m	7.49	MEETS

The vessel meets the IMO criteria.

4.5. CONDITION 75% OF CHARGE AND 25% OF CONSUMABLES



Element	Weight (Kg)	KG	M V (Ton.m)	LCG	M L (Ton.m)
Dead weight	390550.71	2.30	897.09	28.91	11292.10
Tank 1 PT	186600.00	2.75	513.15	14.25	2659.05
Tank 1 STBD	0.00	0.00	0.00	0.00	0.00
Tank 2 PT	186600.00	2.75	513.15	24.75	4618.35
Tank 2 STBD	186600.00	2.75	513.15	24.75	4618.35
Tank 3 PT	186600.00	2.75	513.15	35.25	6577.65
Tank 3 STBD	186600.00	2.75	513.15	35.25	6577.65
Tank 4 PT	0.00	0.00	0.00	0.00	0.00
Tank 4 STBD	186600.00	2.75	513.15	45.75	8536.95
Fuel tank	212.50	1.63	0.35	4.00	0.85
Crew	360.00	4.90	1.76	4.00	1.44
Water tank, crew and engine	250.00	4.13	1.03	7.00	1.75
Total	1510973.21		3979.13		44884.14

HYDROSTATIC CURVES		
Displacement	1510.97	Ton
Mean draft	2.13	m
MTC	34.50	Ton-m/cm
LCB	0.00	m
LCF	0.00	m
BMt	7.00	m

L= 60 m

KG = 2.63 m (From baseline)

LCG = 0.29 m (To stern from midship)

t = DISP x (LCG-LCB) / MTC	=	12.900	cm
dh pr = t x (0,5 +- LCF / L)	=	6.450	cm

KB	1.10	m
KMt	8.10	m
GM	5.47	m
BML	133.90	m
KML	135.00	m
TPC	7.59	Ton/cm

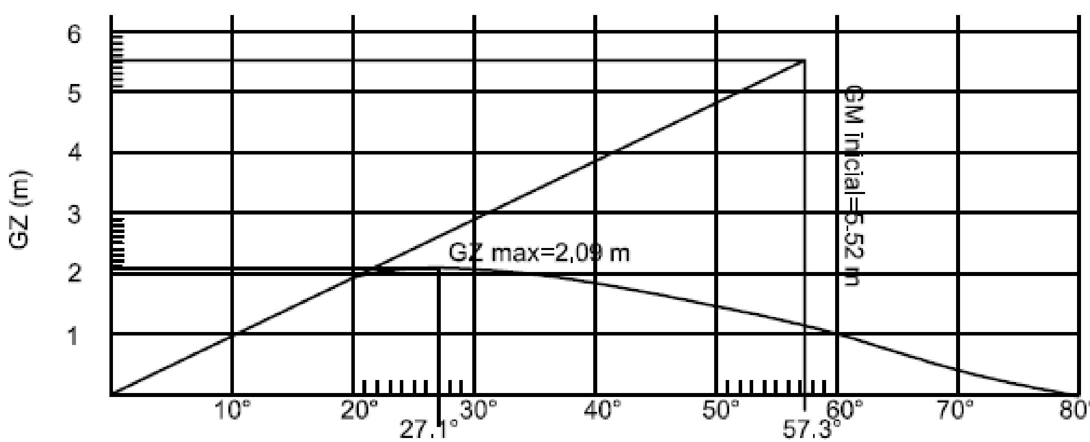
dh pp = t x (0,5 +-LCF / L)	=	6.450	cm
H pr = DRAFT +- dh pr	=	2.065	m
H pp = DRAFT +- dh pp	=	2.195	m

From data: Down by the stern

KG assumed from the base line = 0 m (KG real = 2.63m)

Correction of the Stability Curve : $\mathbf{GZ = KN - (KG_{real} - KG_{assumed})*sen\emptyset}$

KG real(m)	DEGREES	KN(m)	GZ
2.63	0	0	**0.00**
2.63	10	1.44	**0.98**
2.63	20	2.83	**1.93**
2.63	30	3.39	**2.07**
2.63	40	3.53	**1.84**
2.63	50	3.48	**1.46**
2.63	60	3.28	**1.00**
2.63	70	2.87	**0.40**
2.63	80	2.56	**-0.03**



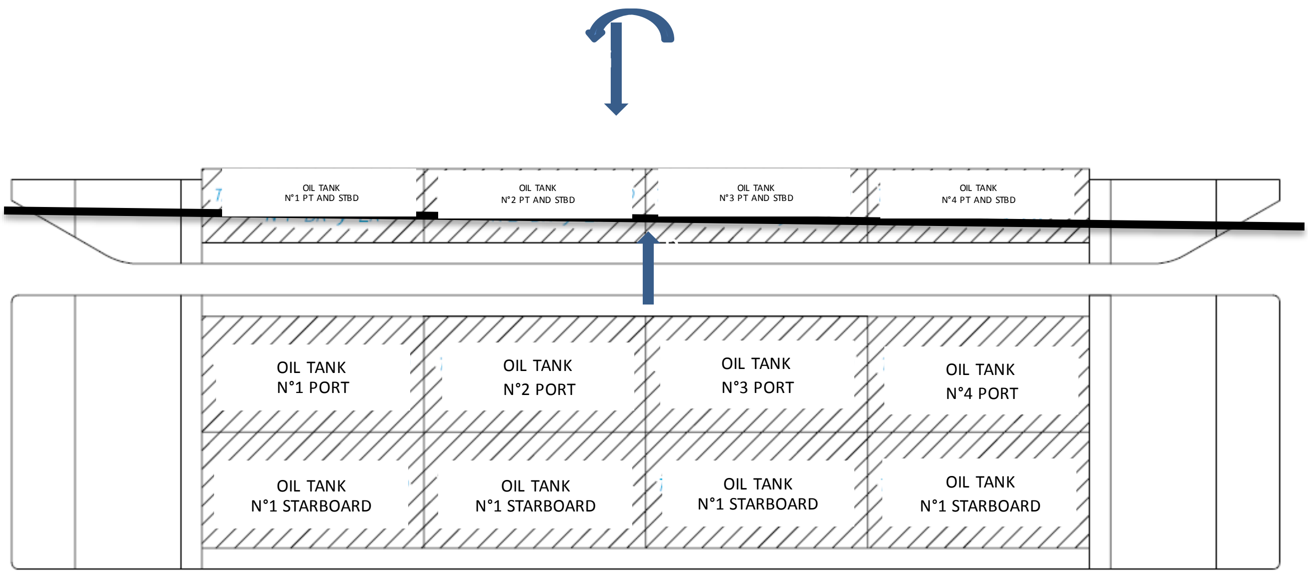
OMI CRITERIA

We make a comparison between the criteria set by IMO and our current values:

OMI Criteria	Allowed	Current	CONDITION
AREA 0 – 30°	≥ 0.055 m-rad	0.707	MEETS
AREA 0 – 40°	≥ 0.090 m-rad	1.041	MEETS
AREA 30° – 40°	≥ 0.030 m-rad	0.334	MEETS
GZ (Ø=30°)	≥ 0.2 m	2.07	MEETS
GZ max ANGLE	≥ 25°	27.1°	MEETS
GM	≥ 0.35 m	5.52	MEETS

The vessel meets the IMO criteria.

4.6. CONDITION 100% OF CHARGE AND 10% OF CONSUMABLES



Element	Weight (Kg)	KG	M V (Ton.m)	LCG	M L (Ton.m)
Dead weight	390550.71	2.30	897.09	28.91	11292.10
Tank 1 PT	186600.00	2.75	513.15	14.25	2659.05
Tank 1 STBD	186600.00	2.75	513.15	14.25	2659.05
Tank 2 PT	186600.00	2.75	513.15	24.75	4618.35
Tank 2 STBD	186600.00	2.75	513.15	24.75	4618.35
Tank 3 PT	186600.00	2.75	513.15	35.25	6577.65
Tank 3 STBD	186600.00	2.75	513.15	35.25	6577.65
Tank 4 PT	186600.00	2.75	513.15	45.75	8536.95
Tank 4 STBD	186600.00	2.75	513.15	45.75	8536.95
Fuel tank	85.00	1.55	0.13	4.00	0.34
Crew	360.00	4.90	1.76	4.00	1.44
Water tank, crew and engine	100.00	4.05	0.41	7.00	0.70
Total	1883895.71		5004.59		56078.58

HYDROSTATIC CURVES		
Displacement	1883.90	Ton
Mean draft	2.61	m
MTC	37.76	Ton-m/cm
LCB	0.00	m

L= 60 m

KG = 2.66 m (From baseline)

LCG = 0.23 m (To stern from midship)

LCF	0.00	m
BMt	5.76	m
KB	1.34	m
KMt	7.10	m
GM	4.44	m
BML	117.66	m
KML	119.00	m
TPC	7.82	Ton/cm

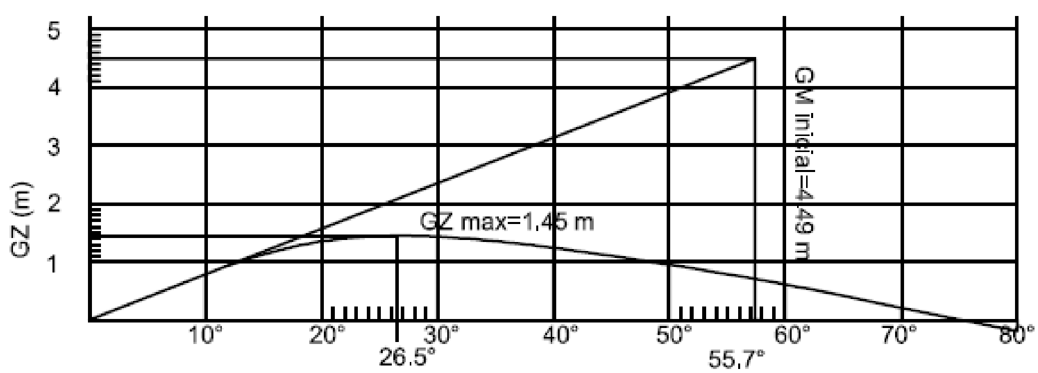
t = DSIP x (LCG-LCB) / MTC	=	11.607	cm
dh pr = t x (0,5 +- LCF / L)	=	5.804	cm
dh pp = t x (0,5 +-LCF / L)	=	5.804	cm
H pr = DRAFT +- dh pr	=	2.552	m
H pp = DRAFT +- dh pp	=	2.668	m

From data: Down by the stern

KG assumed from the base line = 0 m (KG real = 2.66m)

Correction of the Stability Curve: $\mathbf{GZ = KN - (KG_{real} - KG_{assumed})*sen\text{Ø}}$

KG real(m)	DEGREES	KN(m)	GZ
2.66	0	0	**0.00**
2.66	10	1.26	**0.80**
2.66	20	2.26	**1.35**
2.66	30	2.76	**1.43**
2.66	40	2.95	**1.24**
2.66	50	2.99	**0.95**
2.66	60	2.91	**0.61**
2.66	70	2.71	**0.21**
2.66	80	2.43	**-0.19**



OMI CRITERIA

We make a comparison between the criteria set by IMO and our current values:

OMI Criteria	Allowed	Current	CONDITION
AREA 0 – 30°	≥ 0.055 m-rad	0.516	MEETS

AREA 0 – 40°	$\geq$ 0.090 m-rad	0.748	MEETS
AREA 30° – 40°	$\geq$ 0.030 m-rad	0.232	MEETS
GZ (Ø=30°)	$\geq$ 0.2 m	1.43	MEETS
GZ max ANGLE	$\geq$ 25°	26.5°	MEETS
GM	$\geq$ 0.35 m	4.49	MEETS

The vessel meets the IMO criteria.

4.7. ANNEXES

4.7.1. CALCULATION OF WEIGHTS AND CENTER OF GRAVITY

A KG will be taken with respect to the baseline and an LCG relative to the transom.

HULL PLATING

ITEM	DESCRIPTION	TOTAL VOLUME	TOTAL WEIGHT	KG	LCG	Mto(KG) (KG*weight)	Mto(lcg) (LCG*weight)
		m^3	(kg)	m	m	ton-m	ton-m
1	PL SIDE HULL	3.380	26529.232	2.180	30.000	57.834	795.877
2	PL BOTTOM HULL	7.677	60265.628	0.004	30.000	0.241	1807.969
3	PL TRANSOM AND FORWAR TRANSOM	0.248	1944.053	3.500	30.000	6.804	58.322
5	PL SIDE TANK	2.841	22301.458	2.750	30.000	61.329	669.044
6	PL BOTTOM TANK	3.696	29013.600	1.100	30.000	31.915	870.408
8	PL DECK	2.544	19970.400	3.996	30.000	79.802	599.112
9	PL TANK DECK	3.696	29013.600	4.496	30.000	130.445	870.408
	TOTAL ∑		189037.970			368.370	5671.139

TRANSVERSE ELEMENTS

ITEM	DESCRIPTION	TOTAL VOLUME	TOTAL WEIGHT	KG	LCG	Mto (KG)	Mto (LCG)
		m^3	(kg)	m	m	ton-m	ton-m
	FRAME 1						
10	1 REINF. BEAM (L 254x254 8x8 mm)	0.0528	414.48	3.949	3	1.63678	1.24344
11	3 DEPTH REINF.(T 254x152 12.7x8 mm)	0.02798	219.643	2.65	3	0.58205	0.65893
12	1 FLOOR PLATE REINF.(L 279x254 12.7x8 mm)	0.07247	568.8895	1.5	3	0.85333	1.70667
13	4 BRACKETS (250x250x8 mm)	0.001	7.85	1.532	3.05	0.01203	0.02394
	BULKHEAD 1						
14	1 FLAT BULKHEAD (6.35 mm)	0.222	1742.7	2.638	3	4.59724	5.2281
15	22 BULKHEAD STIFF.(L 101.6x88.9x6.35 mm)	0.057	447.45	1.338	3.05	0.59869	1.3647225

16	80 BRACKETS (200x200x8 mm)	0.015	117.75	1.3	3.05	0.15300	0.347
	BULKHEAD 2						
17	1 FLAT BULKHEAD (6.35 mm)	0.3302	2592.07	1.97	8	5.10638	20.73656
18	42 VERT. BULKHEAD STIFF.(L 101.6x88.9x6.35 mm)	0.078	612.3	1.71	8.05	1.04900	2.71500
19	28 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.015	117.75	0.671	8.05	0.08100	0.54800
20	110 BRACKETS (200x200x8 mm)	0.025	196.25	1.412	8.05	0.27200	0.85200
	FRAME 2						
21	1 REINF BEAM. (T 254x203 8x8 mm)	0.0475	372.875	3.79	8	1.41320	2.98300
22	3 DEPTHS (T 203x152 12.7x8 mm)	0.0387	303.795	1.99	8	0.60455	2.43036
23	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	8.05	0.03376	0.63193
	BULKHEAD 3						
24	1 FLAT BULKHEAD (6.35 mm)	0.585	4592.25	2.25	9	10.33256	41.33025
25	23 BULKHEAD STIFF. (L 101x76 12.7x6.35 mm)	0.1766	1386.31	2.45	9	3.39646	12.47679
	FRAME 3						
26	22 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.67	9.05	0.05260	0.71043
27	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	9.05	0.03376	0.71043
	FRAME 4						
28	1 BEAM REINF. (L 203x101 8x8 mm)	0.267	2095.95	4.54	10	9.51561	20.95950
29	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	10	0.23550	4.71000
30	2 DEPTHS(H 152x152x8 mm)	0.017	133.45	2.75	10	0.36699	1.33450
31	23 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	10.05	0.03925	0.78893
32	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	10.08	0.03376	0.79128
	FRAME 5						
33	1 REINF BEAM. (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	12	9.51561	25.15140
34	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	12	0.23550	5.65200
35	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	12	0.36699	1.60140
36	20 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	12.05	0.03925	0.94593
37	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	12.05	0.03376	0.94593
	FRAME 6						
38	1 BEAM REINF. (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	14	9.51561	29.34330
39	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	14	0.23550	6.59400
40	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	14	0.36699	1.86830
41	20 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	14.05	0.03925	1.10293
42	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	14.05	0.03376	1.10293
	FRAME 7						
43	2 REINF. BEAM. (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	16	9.51561	33.53520
44	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	16	0.23550	7.53600

45	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	16	0.36699	2.13520
46	20 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	16.05	0.03925	1.25993
47	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	16.05	0.03376	1.25993
	FRAME 8						
48	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	18	9.51561	37.72710
49	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	18	0.23550	8.47800
50	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	18	0.36699	2.40210
51	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	18.05	0.03925	1.41693
52	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	18.05	0.03376	1.41693
	FRAME 9						
53	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	19.5	9.51561	40.87103
54	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	19.5	0.23550	9.18450
55	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	19.5	0.36699	2.60228
56	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	19.55	0.03925	1.53468
57	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	19.55	0.03376	1.53468
	BULKHEAD 9						
58	1 FLAT BULKHEAD (6.35 mm)	0.585	4592.25	2.25	19.5	10.33256	89.54888
59	23 BULKHEAD STIFF. (L 101x76 12.7x6.35 mm)	0.1766	1386.31	2.45	19.5	3.39646	27.03305
60	50 BRACKETS (200x200x8 mm)	0.01	78.5	0.65	19.55	0.05103	1.53468
	FRAME 10						
61	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	21	9.51561	44.01495
62	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	21	0.23550	9.89100
63	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	21	0.36699	2.80245
64	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	21.05	0.03925	1.65243
65	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	21.05	0.03376	1.65243
	FRAME 11						
66	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	23	9.51561	48.20685
67	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	23	0.23550	10.83300
68	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	23	0.36699	3.06935
69	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	23.05	0.03925	1.80943
70	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	23.05	0.03376	1.80943
	FRAME 12						
71	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	25	9.51561	52.39875
72	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	25	0.23550	11.77500
73	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	25	0.36699	3.33625
74	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	25.05	0.03925	1.96643
75	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	25.05	0.03376	1.96643
	FRAME 13						

76	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	27	9.51561	56.59065
77	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	27	0.23550	12.71700
78	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	27	0.36699	3.60315
79	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	27.05	0.03925	2.12343
80	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	27.05	0.03376	2.12343
FRAME 14							
81	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	29	9.51561	60.78255
82	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	29	0.23550	13.65900
83	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	29	0.36699	3.87005
84	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	29.05	0.03925	2.28043
85	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	29.05	0.03376	2.28043
FRAME 15							
86	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	30	9.51561	62.87850
87	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	30	0.23550	14.13000
88	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	30	0.36699	4.00350
89	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	30.05	0.03925	2.35893
90	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	30.05	0.03376	2.35893
BULKHEAD 15							
91	1 FLAT BULKHEAD (6.35 mm)	0.585	4592.25	2.25	30	10.33256	137.76750
92	23 BULKHEAD STIFF. (L 101x76 12.7x6.35 mm)	0.1766	1386.31	2.45	30	3.39646	41.58930
93	50 BRACKETS (200x200x8 mm)	0.01	78.5	0.65	30.05	0.05103	2.35893
FRAME 16							
94	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	31	9.51561	64.97445
95	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	31	0.23550	14.60100
96	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	31	0.36699	4.13695
97	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	30.95	0.03925	2.42958
98	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	30.95	0.03376	2.42958
FRAME 17							
99	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	33	9.51561	69.16635
100	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	33	0.23550	15.54300
101	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	33	0.36699	4.40385
102	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	32.95	0.03925	2.58658
103	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	32.95	0.03376	2.58658
FRAME 18							
104	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	35	9.51561	73.35825
105	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	35	0.23550	16.48500
106	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	35	0.36699	4.67075
107	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	34.95	0.03925	2.74358

108	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	34.95	0.03376	2.74358
FRAME 19							
109	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	37	9.51561	77.55015
110	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	37	0.23550	17.42700
111	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	37	0.36699	4.93765
112	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	36.95	0.03925	2.90058
113	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	36.95	0.03376	2.90058
FRAME 20							
114	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	39	9.51561	81.74205
115	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	39	0.23550	18.36900
116	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	39	0.36699	5.20455
117	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	38.95	0.03925	3.05758
118	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	38.95	0.03376	3.05758
FRAME 21							
119	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	40.5	9.51561	84.88598
120	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	40.5	0.23550	19.07550
121	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	40.5	0.36699	5.40473
122	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	40.45	0.03925	3.17533
123	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	40.45	0.03376	3.17533
BULKHEAD 21							
124	1 FLAT BULKHEAD (6.35 mm)	0.585	4592.25	2.25	40.5	10.33256	185.98613
125	23 BULKHEAD STIFF. (L 101x76 12.7x6.35 mm)	0.1766	1386.31	2.45	40.5	3.39646	56.14556
126	50 BRACKETS (200x200x8 mm)	0.01	78.5	0.65	40.45	0.05103	3.17533
FRAME 22							
127	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	42	9.51561	88.02990
128	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	42	0.23550	19.78200
129	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	42	0.36699	5.60490
130	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	41.95	0.03925	3.29308
131	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	41.95	0.03376	3.29308
FRAME 23							
132	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	44	9.51561	92.22180
133	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	44	0.23550	20.72400
134	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	44	0.36699	5.87180
135	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	43.95	0.03925	3.45008
136	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	43.95	0.03376	3.45008
FRAME 24							
137	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	46	9.51561	96.41370
138	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	46	0.23550	21.66600

139	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	46	0.36699	6.13870
140	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	45.95	0.03925	3.60708
141	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	45.95	0.03376	3.60708
	FRAME 25						
142	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	48	9.51561	100.60560
143	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	48	0.23550	22.60800
144	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	48	0.36699	6.40560
145	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	47.95	0.03925	3.76408
146	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	47.95	0.03376	3.76408
	FRAME 26						
147	1 REINF. BEAMS (L 203.2x76.2x8 mm)	0.267	2095.95	4.54	50	9.51561	104.79750
148	1 BOTTOM BULKHEAD (6.35 mm)	0.06	471	0.5	50	0.23550	23.55000
149	2 DEPTHS (H 152x152x8 mm)	0.017	133.45	2.75	50	0.36699	6.67250
150	20 BOTTOM STIFF (L 76.2x50.8x6.35 mm)	0.01	78.5	0.5	49.95	0.03925	3.92108
151	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	49.95	0.03376	3.92108
	BULKHEAD 27						
152	1 FLAT BULKHEAD (6.35 mm)	0.585	4592.25	2.25	51	10.33256	234.20475
153	23 BULKHEAD STIFF. (L 101x76 12.7x6.35 mm)	0.1766	1386.31	2.45	50.95	3.39646	70.63249
	FREAME 27						
154	BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.01	78.5	0.67	51	0.05260	4.00350
155	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	50.95	0.03376	3.99958
	BULKHEAD 28						
156	1 FLAT BULKHEAD (6.35 mm)	0.3302	2592.07	1.97	52	5.10638	134.78764
157	42 VERT. STIFF. BULKHEAD. (L 101.6x88.9x6.35 mm)	0.078	612.3	1.71	51.95	1.04900	2.71500
158	28 BOTTOM STIFF. (L 76.2x50.8x6.35 mm)	0.015	117.75	0.671	51.95	0.08100	0.54800
159	110 BRACKETS (200x200x8 mm)	0.025	196.25	1.412	51.95	0.27200	0.85200
	FRAME 28						
160	1 REINF. BEAM (T 254x203 8x8 mm)	0.0475	372.875	3.79	52	1.41320	19.38950
161	3 DEPTHS (T 203x152 12.7x8 mm)	0.0387	303.795	1.99	52	0.60455	15.79734
162	38 BRACKETS (200x200x8 mm)	0.01	78.5	0.43	51.95	0.03376	4.07808
	FRAME 29						
163	1 REINF. BEAM (L 254x254 8x8 mm)	0.0528	414.48	3.949	57	1.63678	23.62536
164	3 REINF. DEPTH (T 254x152 12.7x8 mm)	0.02798	219.643	2.65	57	0.58205	12.51965
165	1 REINF. FLOOR PLATE (L 279x254 12.7x8 mm)	0.07247	568.8895	1.5	57	0.85333	32.42670
166	4 BRACKETS (250x250x8 mm)	0.001	7.85	1.532	56.95	0.01203	0.44706
	BULKHEAD 29						
167	1FLAT BULKHEAD (6.35 mm)	0.222	1742.7	2.638	57	4.59724	99.33390

168	22 BULKHEAD STIFF. (L 101.6x88.9x6.35 mm)	0.057	447.45	1.338	56.95	0.59869	25.48228
169	80 BRACKETS (200x200x8 mm)	0.015	117.75	1.3	56.95	0.15300	0.34700
	TOTAL ∑		111747.105			337.352327	3298.64289

LONGITUDINAL ELEMENTS

ITEM	DESCRIPTION	TOTAL VOLUME	TOTAL WEIGHT	KG	LCG	Mto KG	Mto LCG
		m^3	(kg)	m	m	ton-m	ton-m
170	LONGITUDINAL CORRUGATED BULKHEAD	1.4	10990	2.75	30	30.22250	329.70000
171	6 DECK LENGHTS (T 254x254x8x8mm)	0.2194	1722.29	3.95	30	6.80305	51.66870
172	40 PEAK LONGITUDINALS (L 76.2x50 12.7x6.35mm)	0.6166	4840.31	3.95	30	19.11922	145.20930
173	18 TANK DECK LONGITUDINALS (L 76.2x50 12.7x6.35mm)	0.9716	7627.06	4.56	30	34.77939	228.81180
174	28 SIDE LONGTITUDINALS (101.6x76.2 6.35x6.35mm)	1.8967	14889.095	2	30	29.77819	446.67285
175	20 LONGITU. FOND- TAN. (101.6x76.2 6.35x6.35mm)	0.9441	7411.185	0.92	30	6.81829	222.33555
176	22 TANK BOTTOM LONGITUDINALS 101.6x76.2 6.35x6.35mm)	1.0385	8152.225	0.08	30	0.65218	244.56675
177	40 PEAK BOTTOM LONGITUDINALS (L 76.2x50 12.7x6.35mm)	0.4617	3624.345	0.585	30	2.12024	108.73035
178	VERTICAL TRANSOM STIFFENERS	0.09525	747.7125	3.5	30	2.61699	22.43138
179	KEEL	0.4	3140	0.5	30	1.57000	94.20000
180	6 PEAK FLOOR PLATES	0.3832	3008.12	0.833	30	2.50576	90.24360
	TOTAL ∑		66152.3425			136.9858	1984.5702

DECKHOUSE

DESCRIPTION	AREA	THICKNESS	TOTAL WEIGHT	KG	LCG	Mto (KG) (KG*weight)	Mto (LCG) (LCG*weight)
	m^2	mm	(kg)	m	m	ton-m	ton-m

FRONT BULKHEAD	6	6.35	299.085	4.95	7	1.48047	2.09360
2 SIDE BULKHEADS	9	6.35	448.6275	4.95	5	2.22071	2.24314
BACK BULKHEAD	9	6.35	448.6275	4.95	3	2.22071	1.34588
DECKHOUSE ROOF	20.25	6.35	1009.41188	5.9	5	5.95553	5.04706
STIFFENERS			400	5.7	5	2.28000	2.00000
TOTAL ∑			**2605.75188**			**14.15741**	**12.72967**

MACHINE ROOM

DESCRIPTION	WEIGHT	KG	LCG	Momentum(kg)	Momentum(lcg)
	(kg)	(m)	(m)	(Ton-m)	(Ton-m)
D41563 ROPER PUMP	200	1.8	4.55	0.36000	0.91000
62 KW ENGINE AND BASE	496	1.8	5.49	0.89280	2.72304
FUEL TANK	100	2.5	6	0.25000	0.60000
STAIRS AND RAILING	80	4	30	0.32000	2.40000
TOTAL	**876**			**1.82280**	**6.63304**

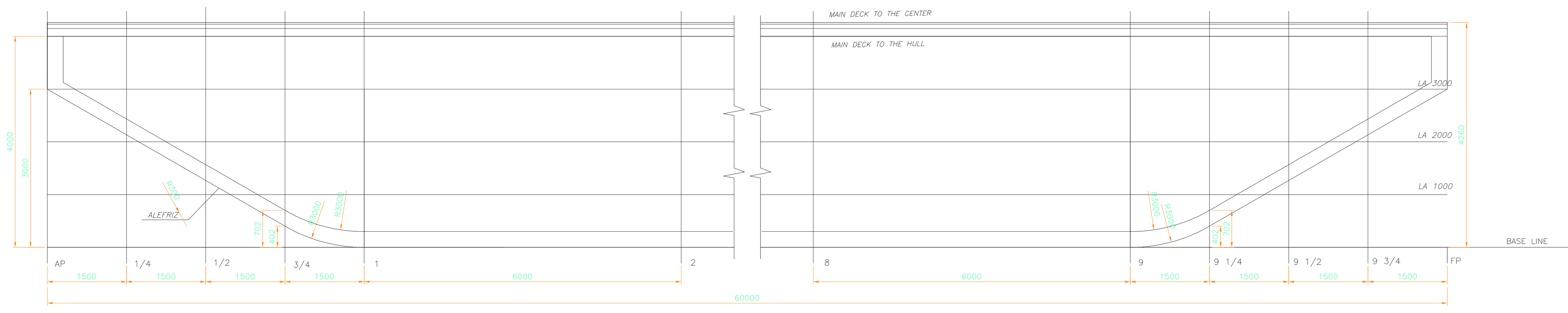
PIPE SYSTEM

DESCRIPTION	Weight	KG	LCG	Momentum(KG)	Momentum(LCG)
	(kg)	(m)	(m)	(Ton-m)	(Ton-m)
10” PIPES	9066.65	1.8	18.26	16.31997	165.55703
15 10” LONG ELBOWS	904.35	2.75	13.25	2.48696	11.98264
32 10” WELDING NECK FLANGES	1920	1.8	8	3.45600	15.36000
32 10” WELDING NECK FLANGES	1920	1.8	9	3.45600	17.28000
16 10” WELDING NECK FLANGES	960	1.8	7.2	1.72800	6.91200
12 10” WELDING NECK FLANGES	720	1.8	13.32	1.29600	9.59040
24 10” WELDING NECK FLANGES	1440	1.8	19.5	2.59200	28.08000
8 10” WELDING NECK FLANGES	480	1.8	24.5	0.86400	11.76000
16 10” WELDING NECK FLANGES	1280	1.8	30.5	2.30400	39.04000
13 10” GATE VALVES	361.8	1.8	7.23	0.65124	2.61581
2 12” GATE VALVES	55.68	1.8	5.5	0.10022	0.30624
12” SUCTION PIPES	232.724	1.8	5.5	0.41890	1.27998
10” DISCHARGE PIPES	540.34	4.22	6.7	2.28023	3.62028
10” PIPE SUPPORT	250	1.8	20	0.45000	5.00000
TOTAL	**20131.544**			**38.40353**	**318.38438**

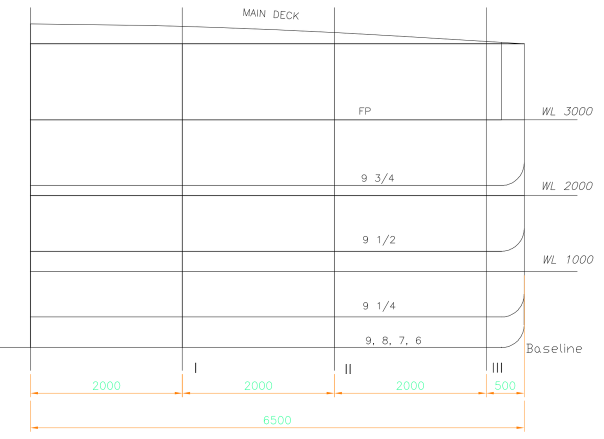
4.8. SUMMARY

DESCRIPTION	WEIGHT (kg)	Momentum(KG) (Ton-m)	Momentum(LCG) (Ton-m)
HULL PLATING	189037.97	368.37	5671.14
TRANSVERSE ELEMENTS	111747.11	337.35	3298.64
LONGITUDINAL ELEMENTS	66152.34	136.99	1984.57
DECKHOUSE	2605.75	14.16	12.73
MACHINE ROOM	876.00	1.82	6.63
PIPE SYSTEM	20131.54	38.40	318.38
TOTAL	390550.71	897.09	11292.10
KG (From baseline)=	2.30	m	
LCG (From stern)=	28.91	m	
LCG (From midship)=	1.09 to Stern	m	

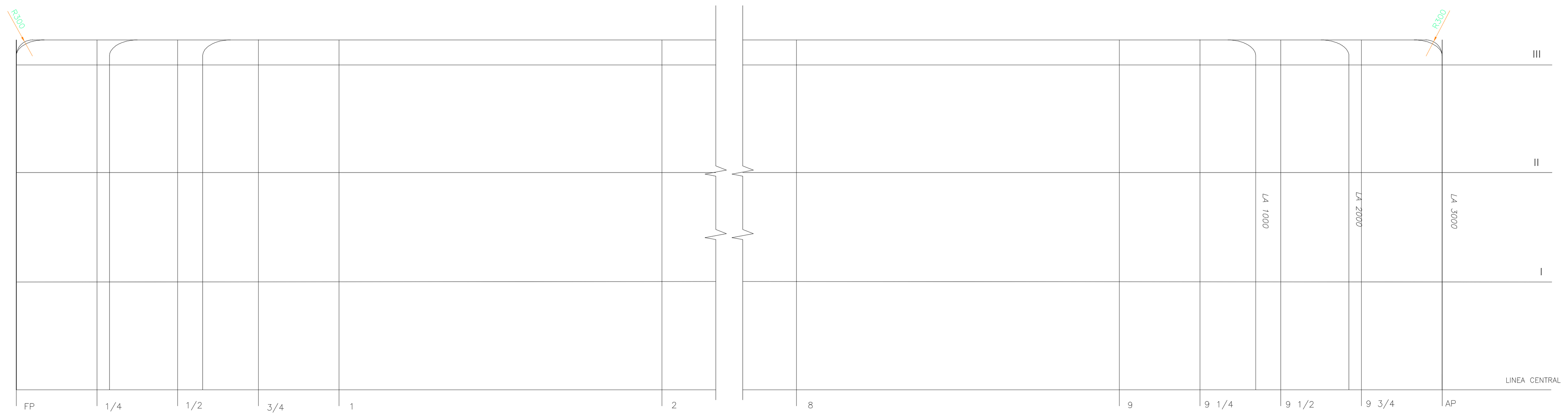
5. ANNEXES



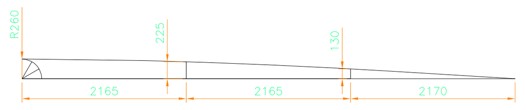
LONGITUDINAL ELEVATION



CROSS SECTIONS
BOW AND STERN



TOP VIEW



ROUND OF BEAM

MAIN CHARACTERISTICS

OVERALL LENGHT ———— 60,00 m
MOLDED BREADTH ———— 13,00 m
MOLDED DEPTH ———— 4,00 m

POINT CHART IN MILLIMETERS

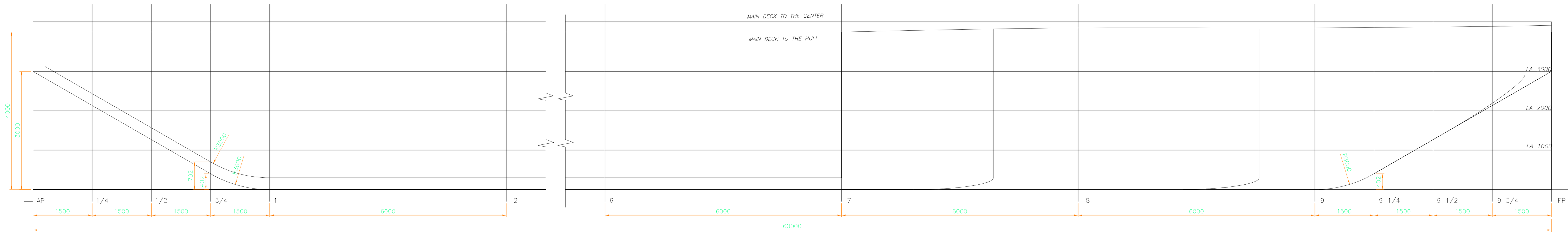
HEIGHTS FROM BASE LINE						HALF BREADTH FROM CENTER LINE				
ST	RABBET	LONG. "I"	LONG. "II"	LONG. "III"	DECK HULL	W.L. 1000	W.L. 2000	W.L. 3000	DECK HULL	ST
AP	3000	3000	3000	3000	4000	---	---	6200	6200	AP
1/4	2134	2134	2134	2134	4000	---	---	6500	6500	1/4
1/2	1268	1268	1268	1268	4000	---	6500	6500	6500	1/2
3/4	402	402	402	402	4000	6500	6500	6500	6500	3/4
1	0	0	0	0	4000	6500	6500	6500	6500	1
2	0	0	0	0	4000	6500	6500	6500	6500	2
8	0	0	0	0	4000	6500	6500	6500	6500	8
9	0	0	0	0	4000	6500	6500	6500	6500	9
9 1/4	402	402	402	402	4000	6500	6500	6500	6500	9 1/4
9 1/2	1268	1268	1268	1268	4000	---	6500	6500	6500	9 1/2
9 3/4	2134	2134	2134	2134	4000	---	---	6500	6500	9 3/4
FP	3000	3000	3000	3000	4000	---	---	6200	6200	FP

NATIONAL UNIVERSITY OF ENGINEERING

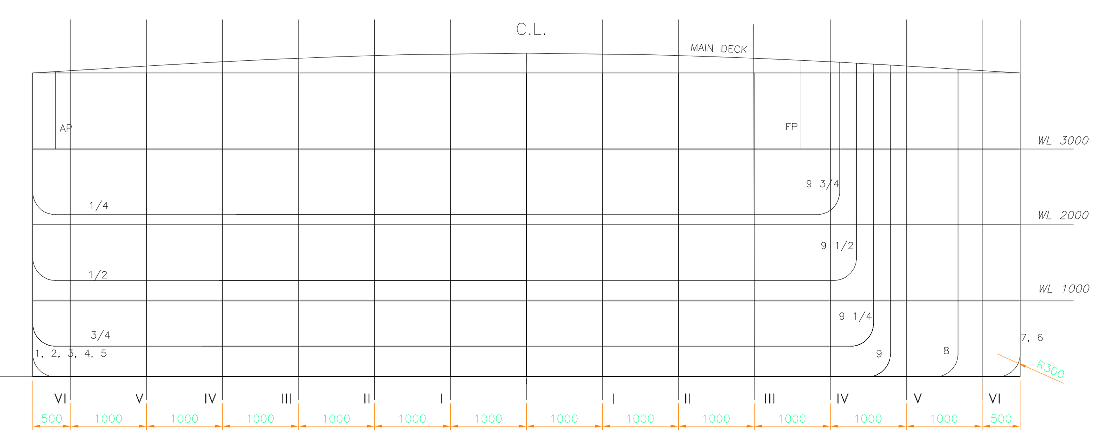
OIL BARGE CAPACITY 1600 M3

SHAPE LINES

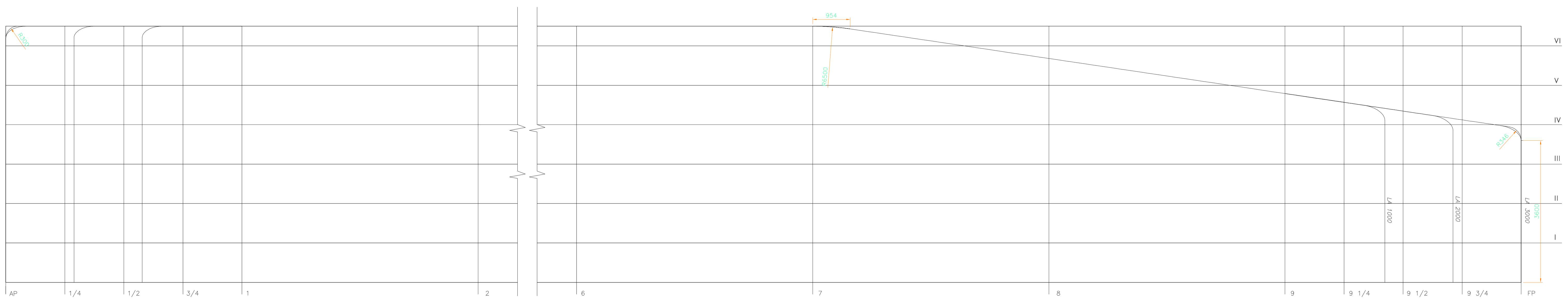
DESIGNED: EDWARD VALERO			
DRAWN: EDWARD VALERO			
REVIEWED: OSCAR BERNABE			
DATE: 14/04/2016	PLAN N°: 1	REV.:	
SCALE: 1:75	PROJECT:	SHEET:	OF:



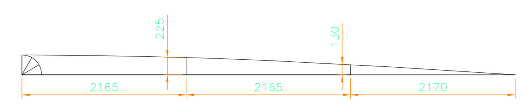
LONGITUDINAL ELEVATION



CROSS SECTIONS



TOP VIEW



ROUND OF BEAM

MAIN CHARACTERISTICS

OVERALL LENGHT ———— 60,00 m
MOLDED BREADHT ———— 13,00 m
MOLDED DEPTH ———— 4,00 m

POINT CHART IN MILLIMETERS

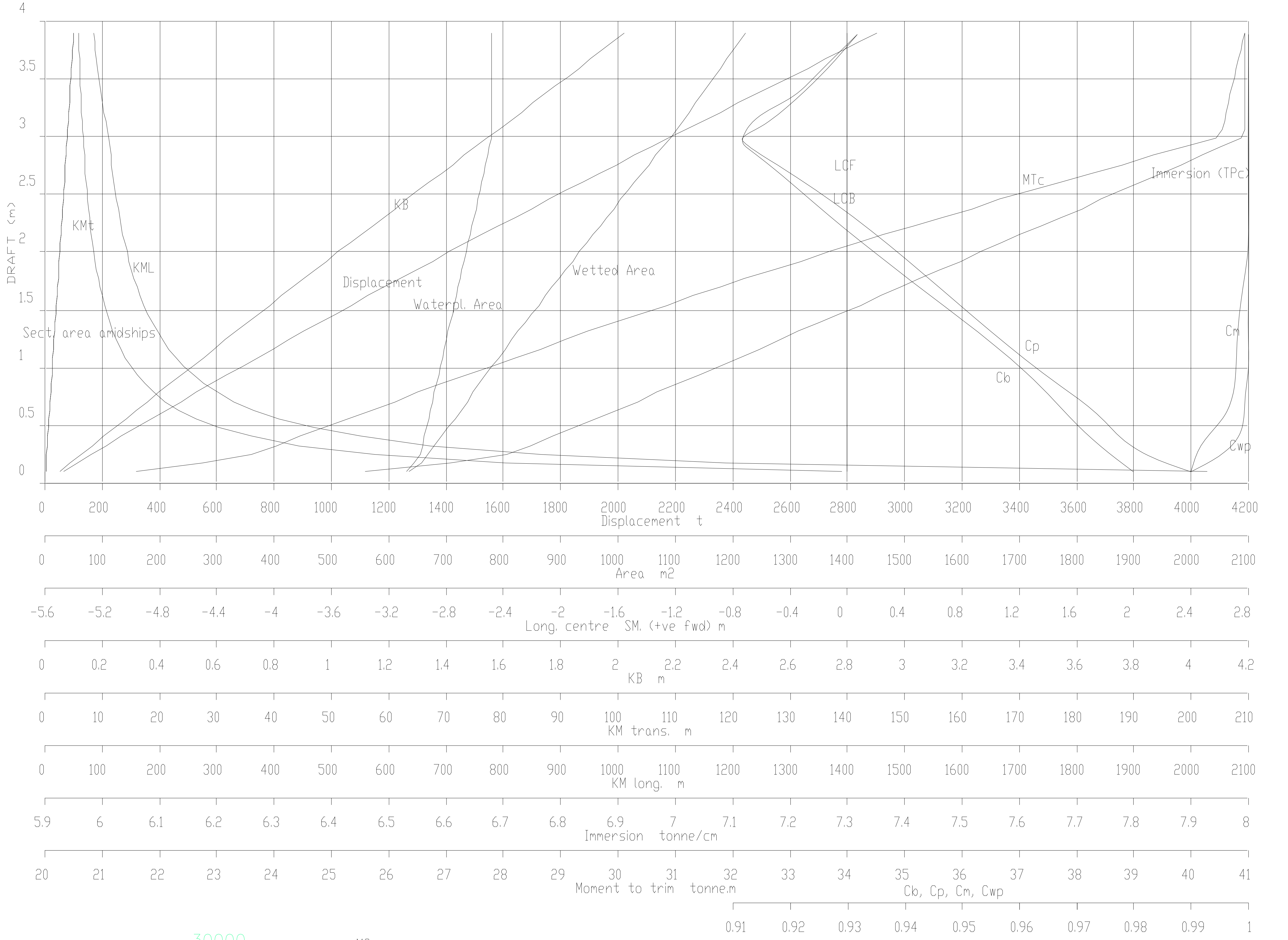
HEIGHTS FROM BASEL LINE									HALF BREADTH FROM CENTER LINE				
ST	RABBET	LONG. "I"	LONG. "II"	LONG. "III"	LONG. "IV"	LONG. "V"	LONG. "VI"	DECK HULL	W.L. 1000	W.L. 2000	W.L. 3000	DECK HULL	ST
AP	3000	3000	3000	3000	3000	3000	3000	4000	---	---	6200	6200	AP
1/4	2134	2134	2134	2134	2134	2134	2134	4000	---	---	6500	6500	1/4
1/2	1268	1268	1268	1268	1268	1268	1268	4000	---	6500	6500	6500	1/2
3/4	402	402	402	402	402	402	402	4000	6500	6500	6500	6500	3/4
1	0	0	0	0	0	0	0	4000	6500	6500	6500	6500	1
2	0	0	0	0	0	0	0	4000	6500	6500	6500	6500	2
6	0	0	0	0	0	0	0	4000	6500	6500	6500	6500	6
7	0	0	0	0	0	0	0	4000	6500	6500	6500	6500	7
8	0	0	0	0	0	0	---	4104	5680	5680	5680	5680	8
9	0	0	0	0	0	---	---	4104	4790	4790	4790	4790	9
9 1/4	402	402	402	402	402	---	---	4116	4568	4568	4568	4568	9 1/4
9 1/2	1268	1268	1268	1268	1268	---	---	4130	4345	4345	4345	4345	9 1/2
9 3/4	2134	2134	2134	2134	2192	---	---	4141	---	4125	4125	4125	9 3/4
FP	3000	3000	3000	3000	---	---	---	4168	---	---	3600	3600	FP

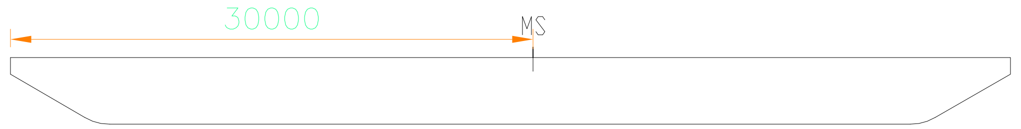
NATIONAL UNIVERSITY OF ENGINEERING

OIL BARGE CAPACITY 1600 M3

SHAPE LINES

DESIGNED: EDWARD VALERO			
DRAWN: EDWARD VALERO			
REVIEWED: OSCAR BERNABE			
DATE: 14/04/2016	PLAN N°: 1	REV.:	
SCALE: 1:75	PROJECT:	SHEET:	OF:

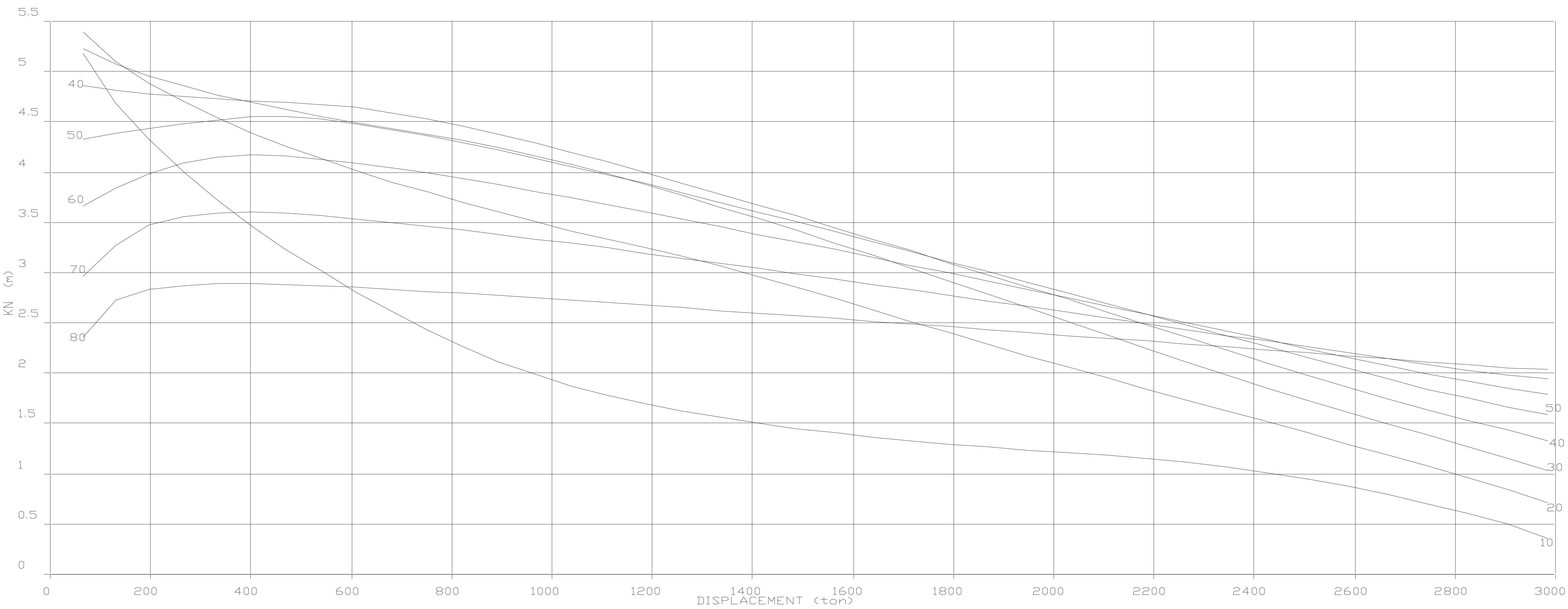


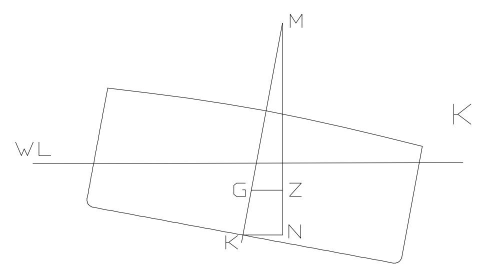


0.5 m = 1 cm

200 ton = 1 cm

NATIONAL UNIVERSITY OF ENGINEERING			
DESIGNED: EDWARD VALERO	OIL BARGE CAPACITY 1600 M3 HYDROSTATIC CURVES		
DRAWN: EDWARD VALERO			
REVIEWED: OSCAR BERNABE			
DATE: 14/04/2016	PLAN N°: 1	REV.:	
SCALE: 1:50	PROJECT:	SHEET:	OF:





200 ton = 2 cm
0.5 m = 1 cm
KG ALLEGED = 0 M

NATIONAL UNIVERSITY OF ENGINEERING			
DESIGNED: EDWARD VALERO	OIL BARGE CAPACITY 1600 M3 CROSS CURVES		
DRAWN: EDWARD VALERO			
REVIEWED: OSCAR BERNABE			
DATE: 14/04/2016	PLAN N°: 1		REV.:
SCALE: 1:50	PROJECT:	SHEET:	OF:

MAIN CHARACTERISTICS

OVERALL LENGTH		65.60 m
MOLDED BREADTH	:	13.50 m
MOLDED DEPTH	:	4.00 m
DISTANCE BETWEEN STATIONS	:	6.56 m

NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING

NAVAL_PROJECTS_I

OIL_BARGE

STRUCTURE PLAN

REVIEWED: OSCAR BERNABE

DRAWN: EDWARD VALERO

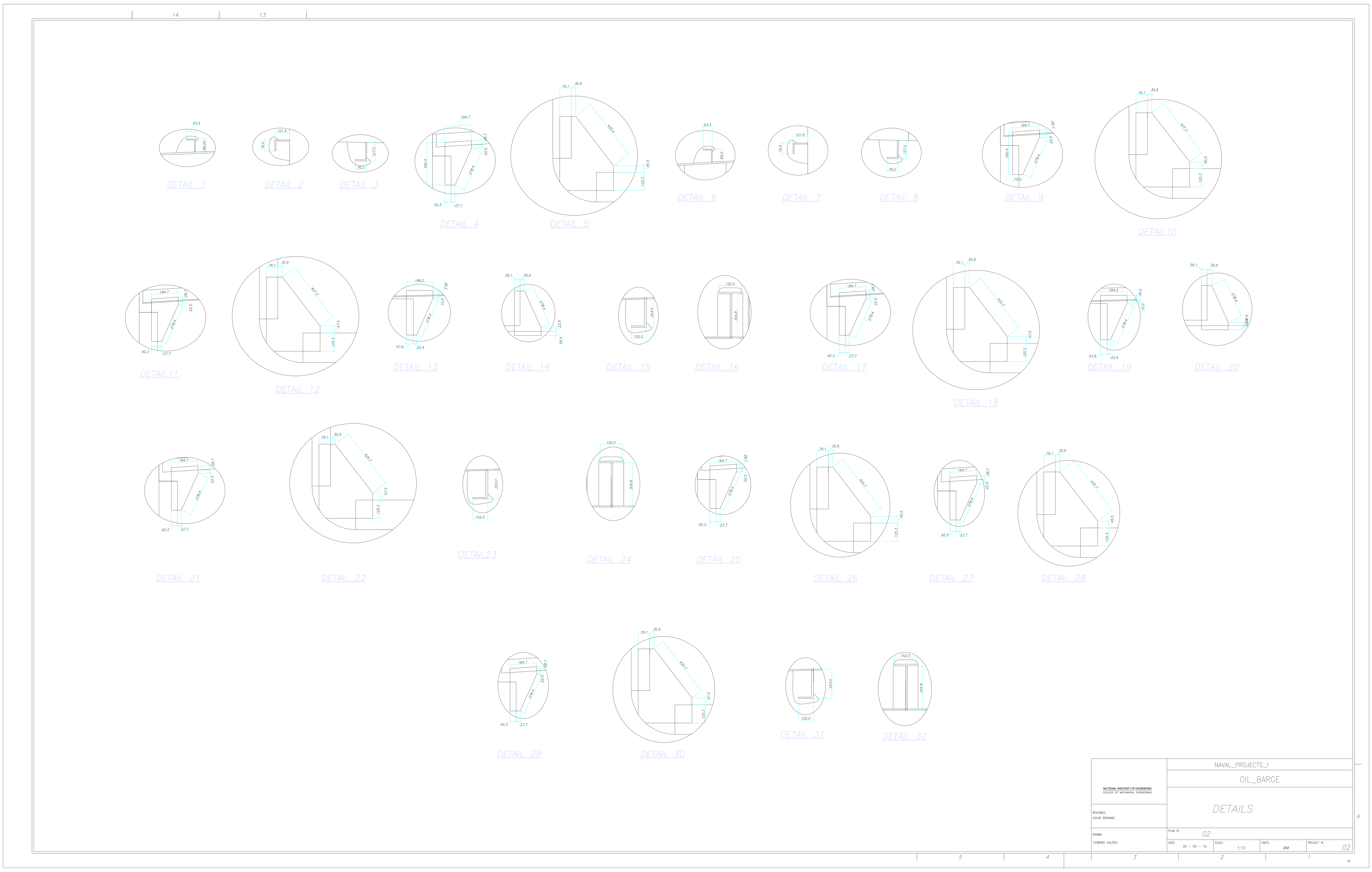
PLAN N°: 01

DATE: 30 - 09 - 16

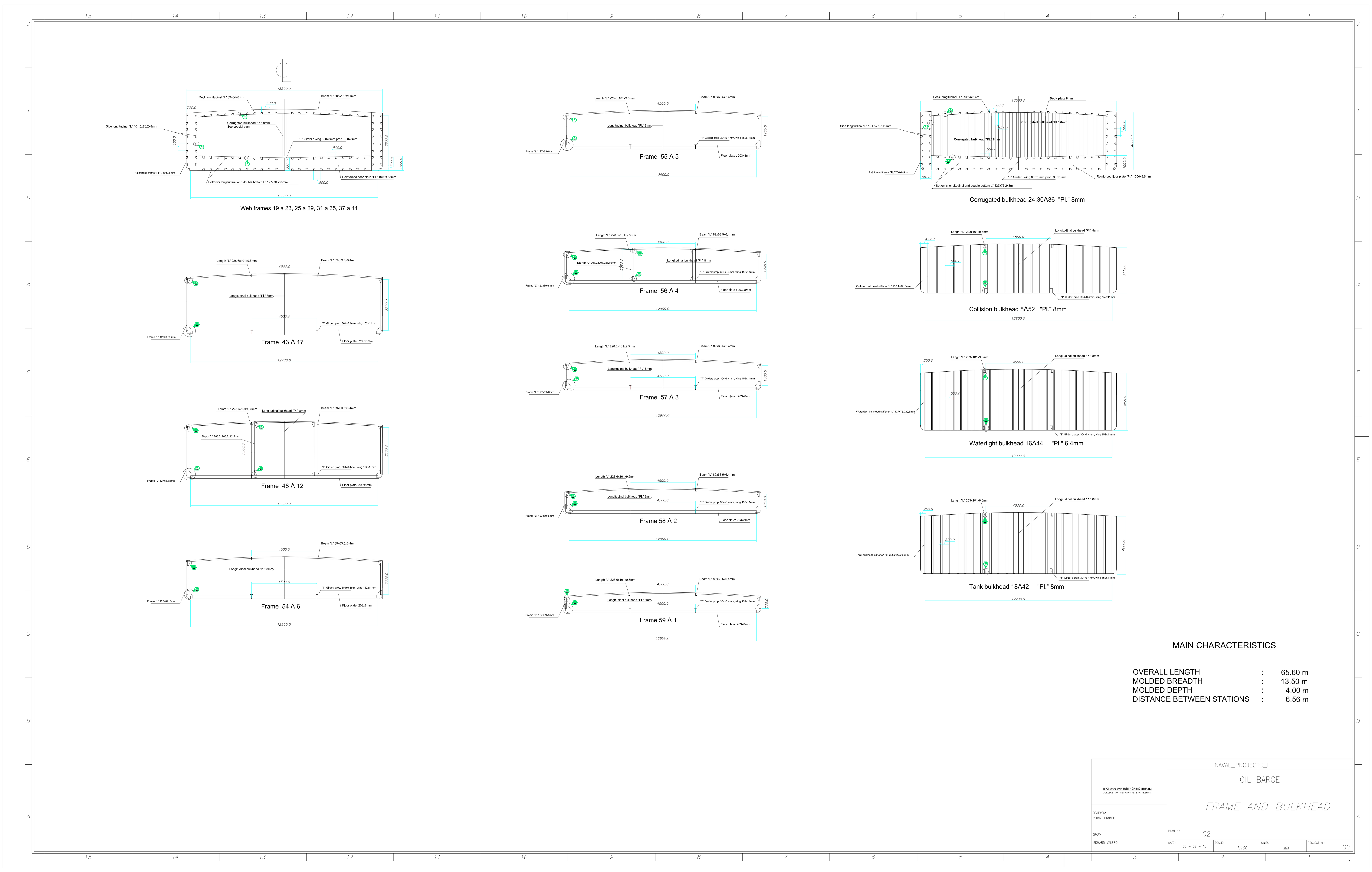
SCALE: 1/100

UNITS: MM

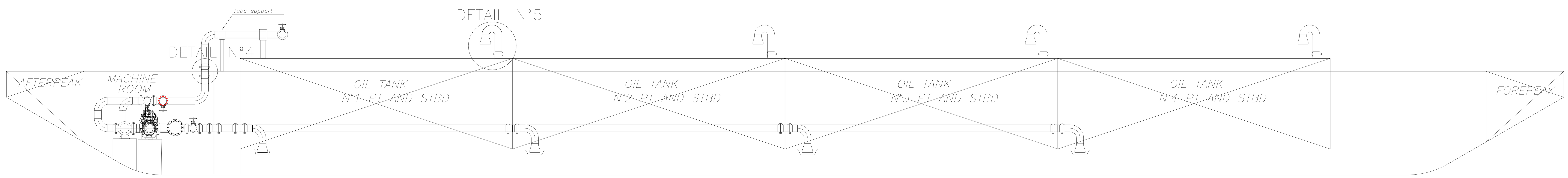
PROJECT N°: 02



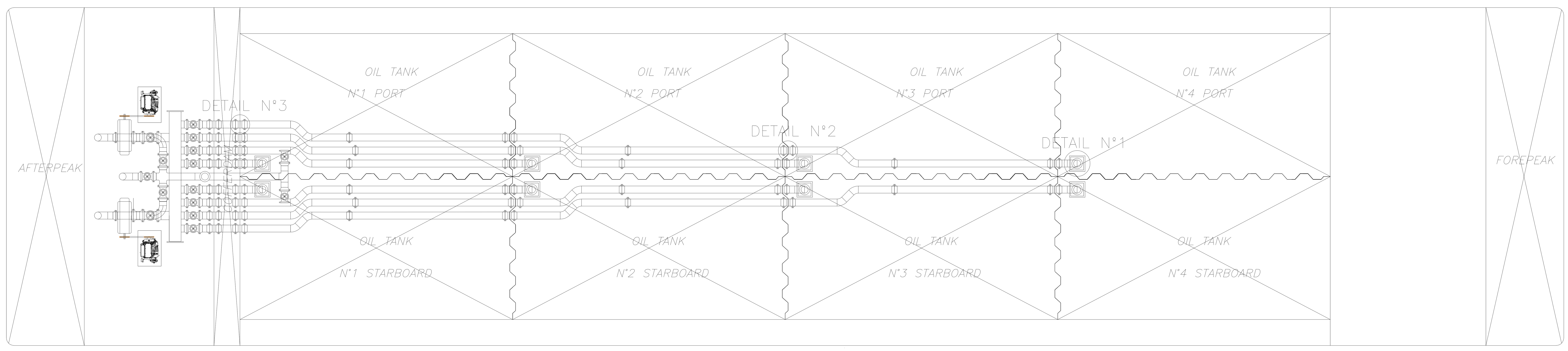
DETAIL 1
DETAIL 2
DETAIL 3
DETAIL 4
DETAIL 5
DETAIL 6
DETAIL 7
DETAIL 8
DETAIL 9
DETAIL10
DETAIL11
DETAIL 12
DETAIL 13
DETAIL 14
DETAIL 15
DETAIL 16
DETAIL 17
DETAIL 18
DETAIL 19
DETAIL 20
DETAIL 21
DETAIL 22
DETAIL23
DETAIL 24
DETAIL 25
DETAIL 26
DETAIL 27
DETAIL 28
DETAIL 29
DETAIL 30
DETAIL 31
DETAIL 32
NACTIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
REVIEWED:
OSCAR BERNABE
DRAWN:
EDWARD VALERO
NAVAL_PROJECTS_I
OIL_BARGE
DETAILS
PLAN N°: 02
DATE: 30 - 09 - 16
SCALE: 1:10
UNITS: MM
PROJECT N°: 02



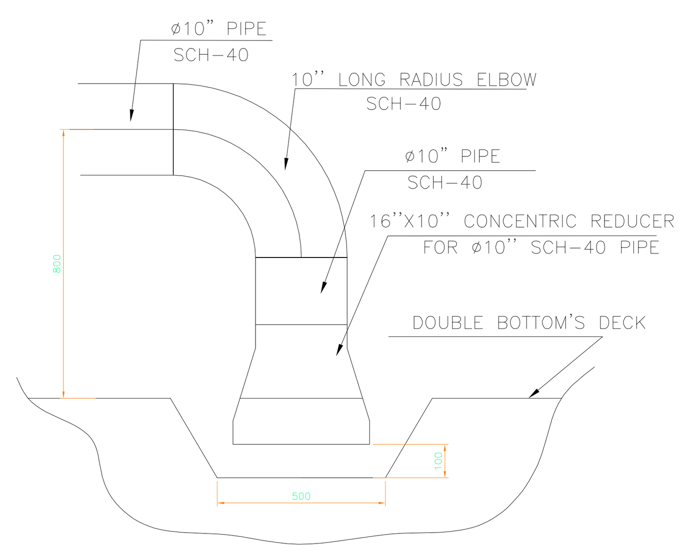
Web frames 19 a 23, 25 a 29, 31 a 35, 37 a 41
Frame 43 Λ 17
Frame 48 Λ 12
Frame 54 Λ 6
Frame 55 Λ 5
Frame 56 Λ 4
Frame 57 Λ 3
Frame 58 Λ 2
Frame 59 Λ 1
Corrugated bulkhead 24,30Λ36 "Pl." 8mm
Collision bulkhead 8Λ52 "Pl." 8mm
Watertight bulkhead 16Λ44 "Pl." 6.4mm
Tank bulkhead 18Λ42 "Pl." 8mm
MAIN CHARACTERISTICS
OVERALL LENGTH : 65.60 m
MOLDED BREADTH : 13.50 m
MOLDED DEPTH : 4.00 m
DISTANCE BETWEEN STATIONS : 6.56 m
NACTIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
REVIEWED:
OSCAR BERNABE
DRAWN:
EDWARD VALERO
NAVAL_PROJECTS_I
OIL_BARGE
FRAME AND BULKHEAD
PLAN N°: 02
DATE: 30 - 09 - 16
SCALE: 1:100
UNITS: MM
PROJECT N°: 02



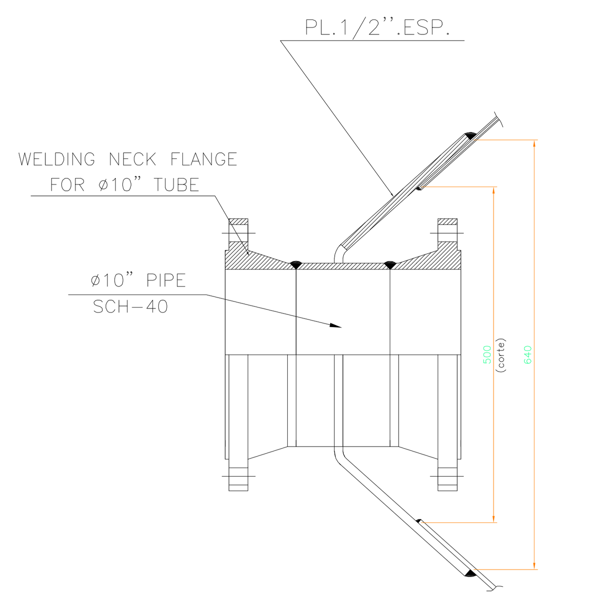
LONGITUDINALVIEW



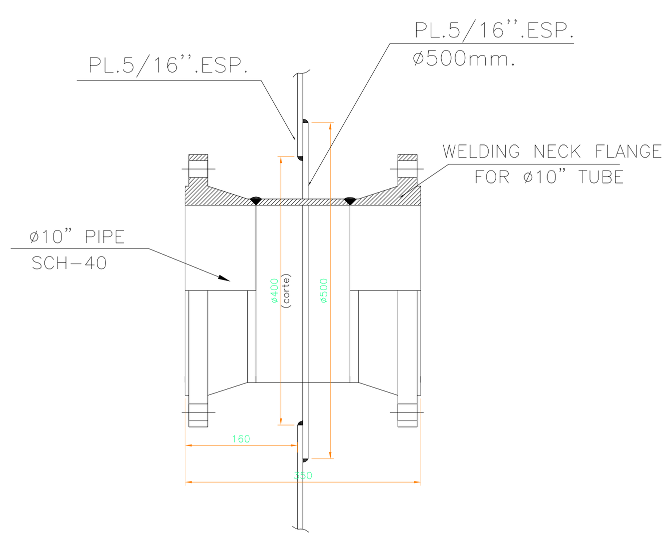
TOP VIEW
BELOW DECK



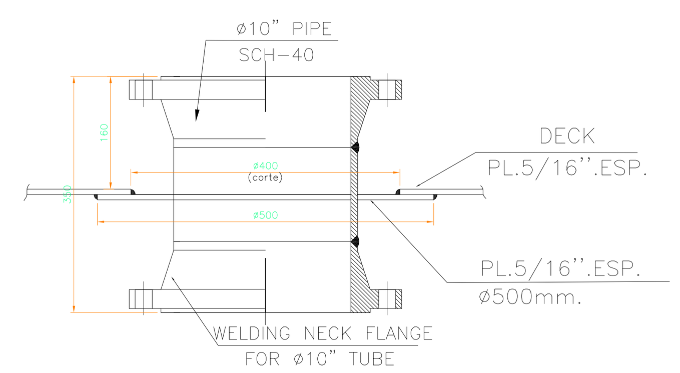
SUCTION BELL
SCALE 1:20
DETAIL N°1



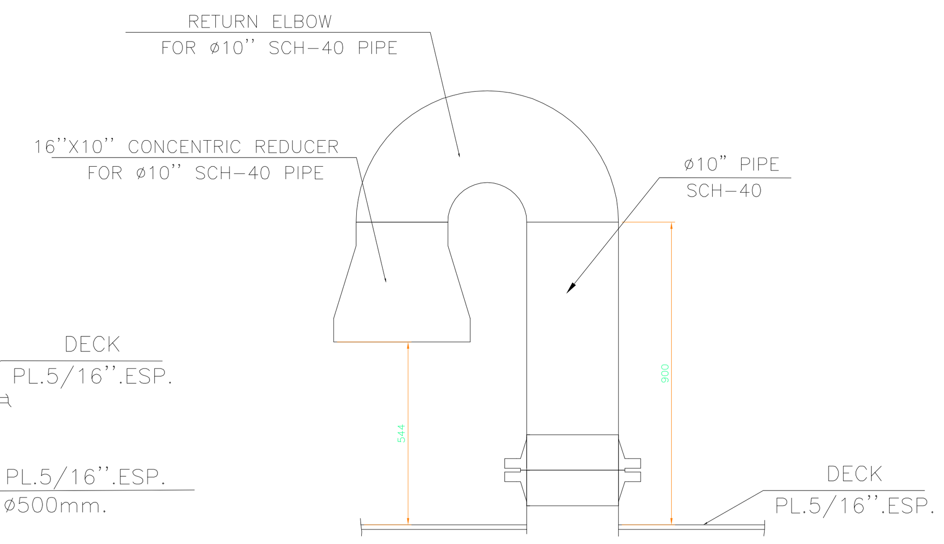
CORRUGATED BULKHEAD FEEDTHROUGH
SCALE 1:10
DETAIL N°2



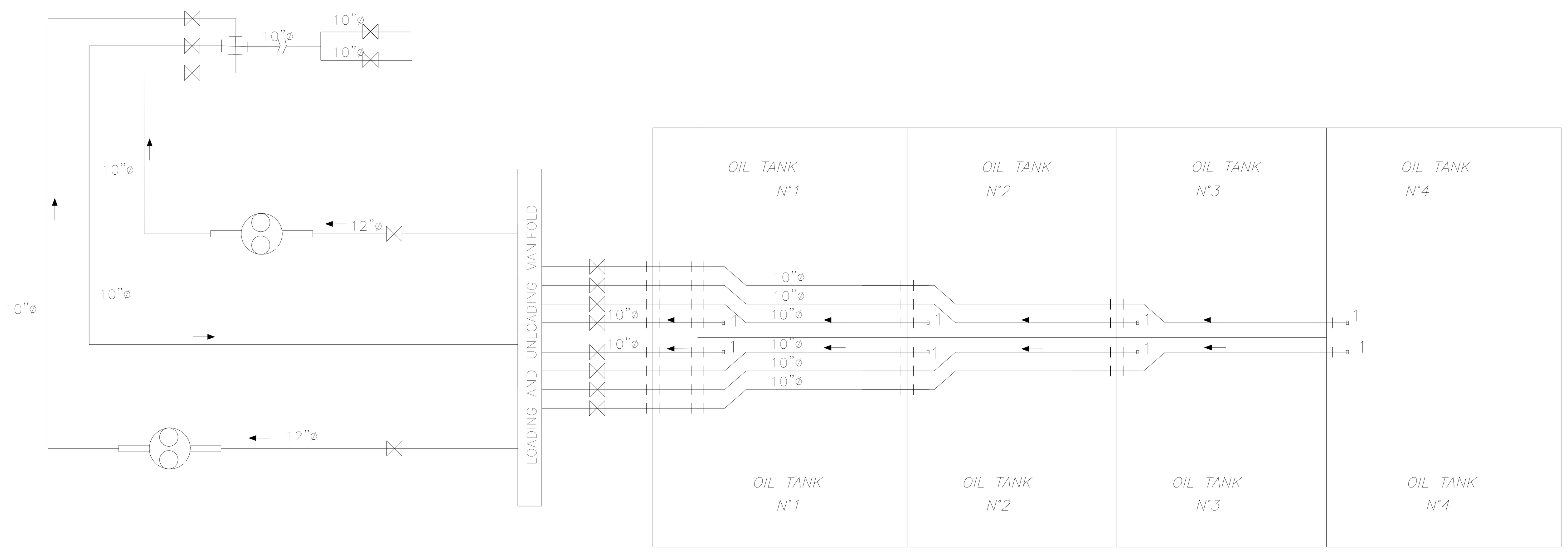
COMMON BULKHEAD FEEDTHROUGH
SCALE 1:10
DETAIL N°3



DECKCONDUIT
SCALE 1:10
DETAIL N°4



VENT PIPE
SCALE 1:5
DETAIL N°4



ELECTRIC SCHEME

GENERAL CHARACTERISTICS

OVERALL LENGTH	60.00 m
BREADTH	13.00 m
DEPTH	4.00 m.

POS	AMT.	DESCRIPTION
13	08	10"(SHORT RADIUS) RETURN ELBOW
12	02	D41563 ROGER PUMP
11	02	6BTA5.9-DM 100HP@3600 CUMMINS ENGINE
10	01	10" DECK MANIFOLD
09	01	18" MAIN MANIFOLD
08	02	ø12" GATE VALVE.
07	06	WELDING NECK FLANGE ø12" TUBE.
06	16	16"ø @ ø10" CONCCENTRIC REDUCER
05	24	ø10" x 45°(Long radius) ELBOW
04	13	ø10"-ANSI GATE VALVE
03	18	ø10" x 90°(Long radius) ELBOW
02	22	WELDING NECK FLANGE ø10" TUBE.
01	12	ø10" SCH-40 x 6000 LENGTH PIPE

MATERIAL LISTING

NATIONAL UNIVERSITY OF ENGINEERING

OIL BARGE 1600 M3 CAPACITY

LOADING AND UNLOADING SYSTEM

DESIGNED: EDWAR VALERO
DRAWN: EDWARD VALERO
REVIEWED: OSCAR BERNABE
DATE: 27/10/2016
SCALE: 1:100
PLAN N°:
REV.:
PROJECT:
SHEET:
OF: