台灣國際造船股份有限公司
CSBC CORPORATION, TAIWAN

主推進系統介紹

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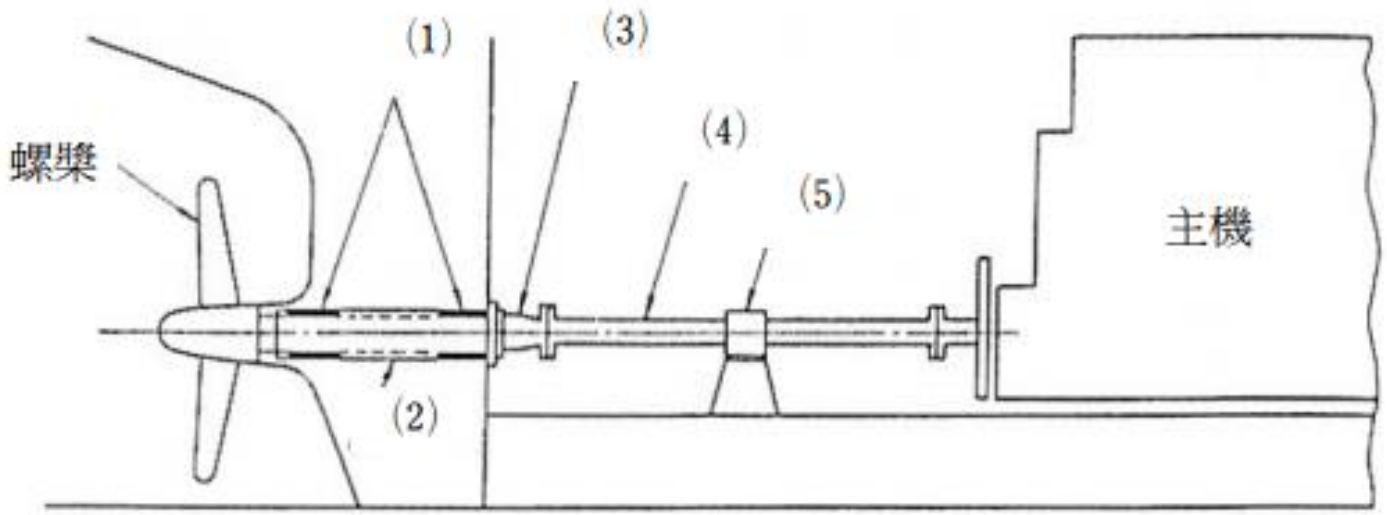
船舶是如何在水中前進?

船舶是如何在水面上航行的?

主機產生旋轉動力，透過大軸帶到螺槳，螺槳轉動將推力藉由大軸帶到主機推力軸承，再由推力軸承推動主機，主機再推動船殼。

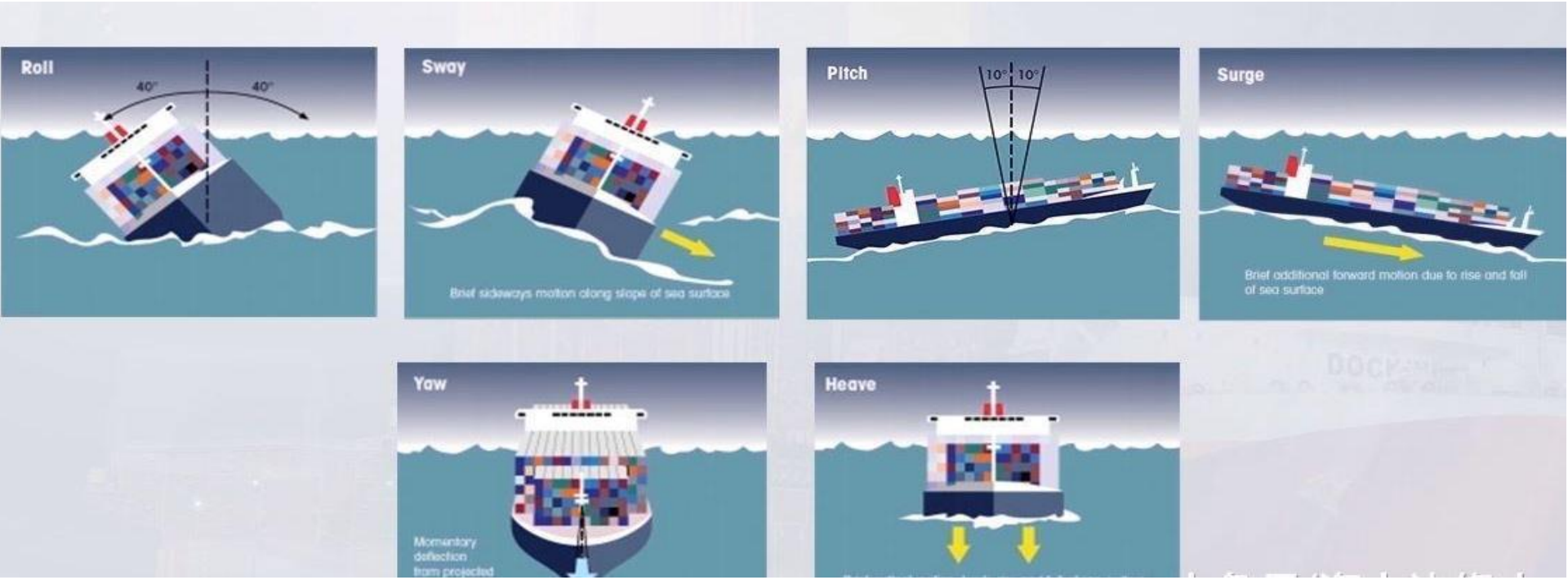


單軸船舶之軸系(二)

推進系統對於船舶的重要性?

若船舶無動力將遭受外力影響，

恐導致人員與船舶貨物損傷。



ROLL 橫搖、SWAY橫盪、PITCH縱搖、SURGE縱盪、YAW艏搖、HEAVE垂盪

軸系計算，從何發展?

由各大船級協會為基準，發展而來。

財團法人中國驗船中心
CR CLASSIFICATION SOCIETY

CR

BUREAU
VERITAS

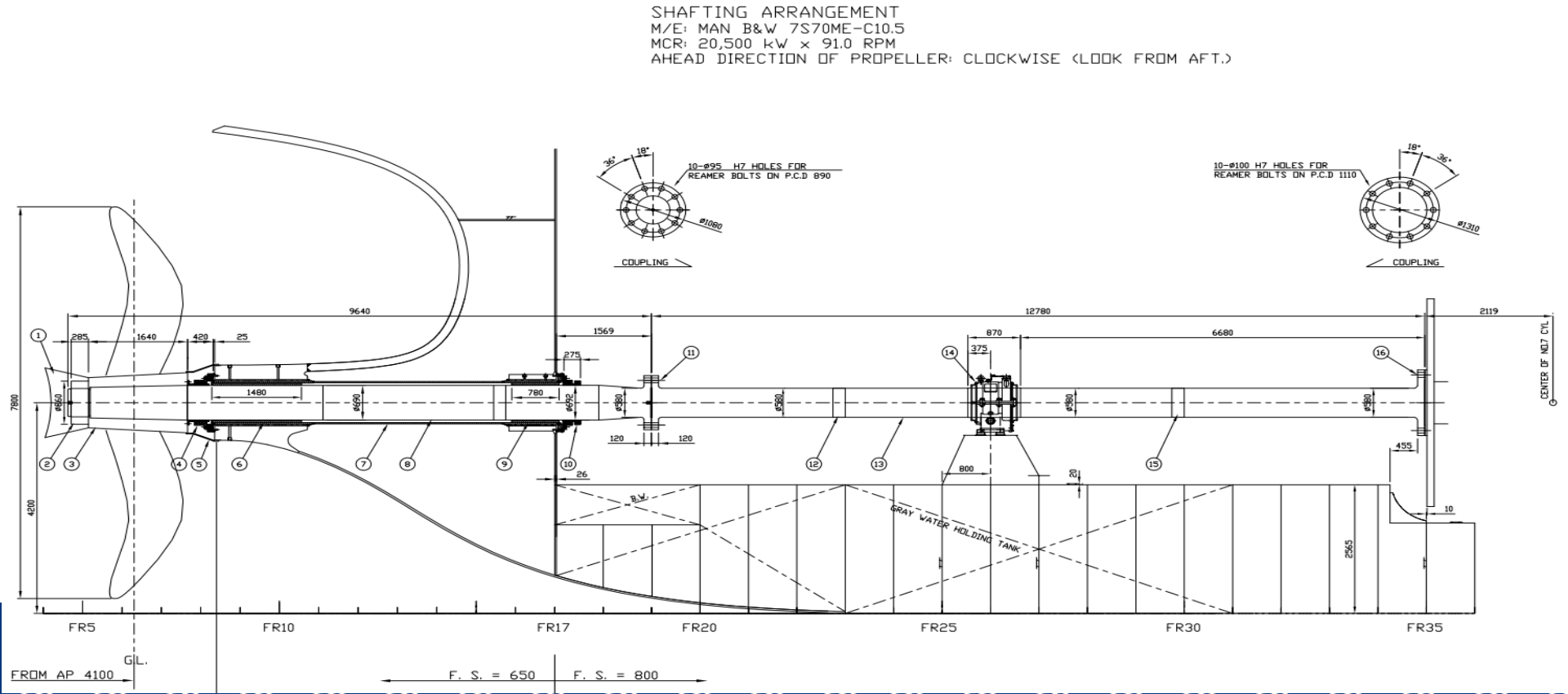
ClassNK

推進系統分類

1. 一般商船推進軸系
2. 高速引擎推進軸系
3. 電力推進軸系
4. 水噴式推進軸系

一般商船推進軸系

固定螺距螺槳(FPP):進倒俥需靠主機正反轉，並由舵機控制轉向。



貨櫃船

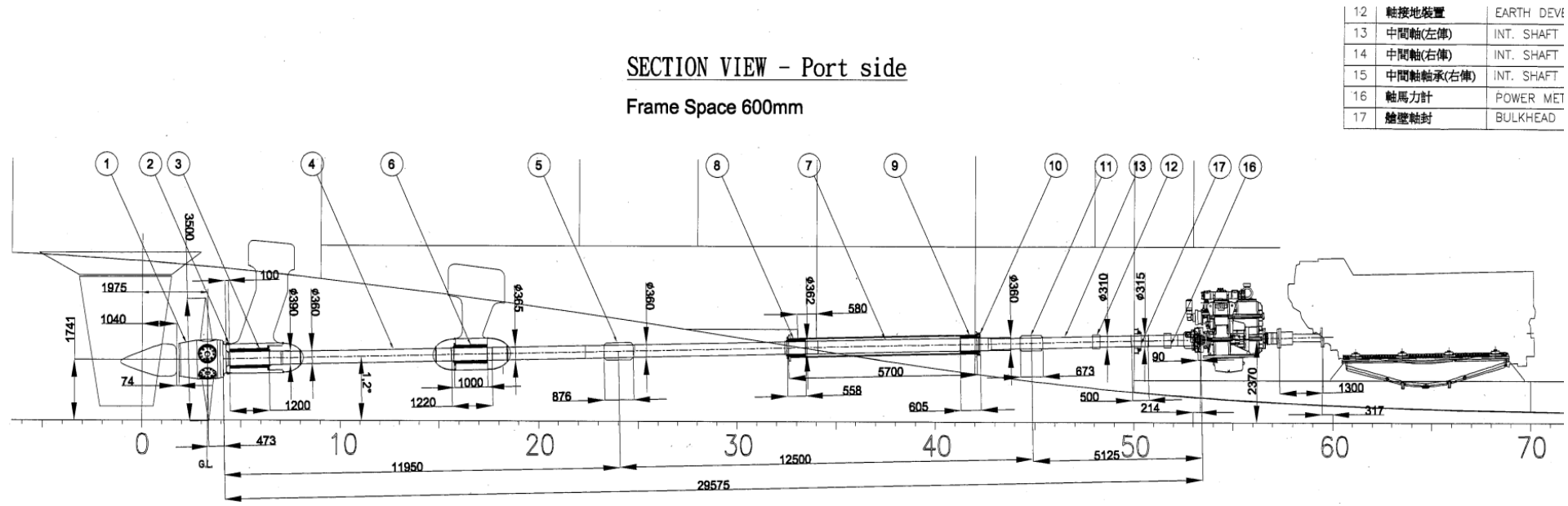
散裝貨船

液化天然氣船　　液化石油氣船

中、高速引擎推進軸系

可變螺距螺槳(CPP):

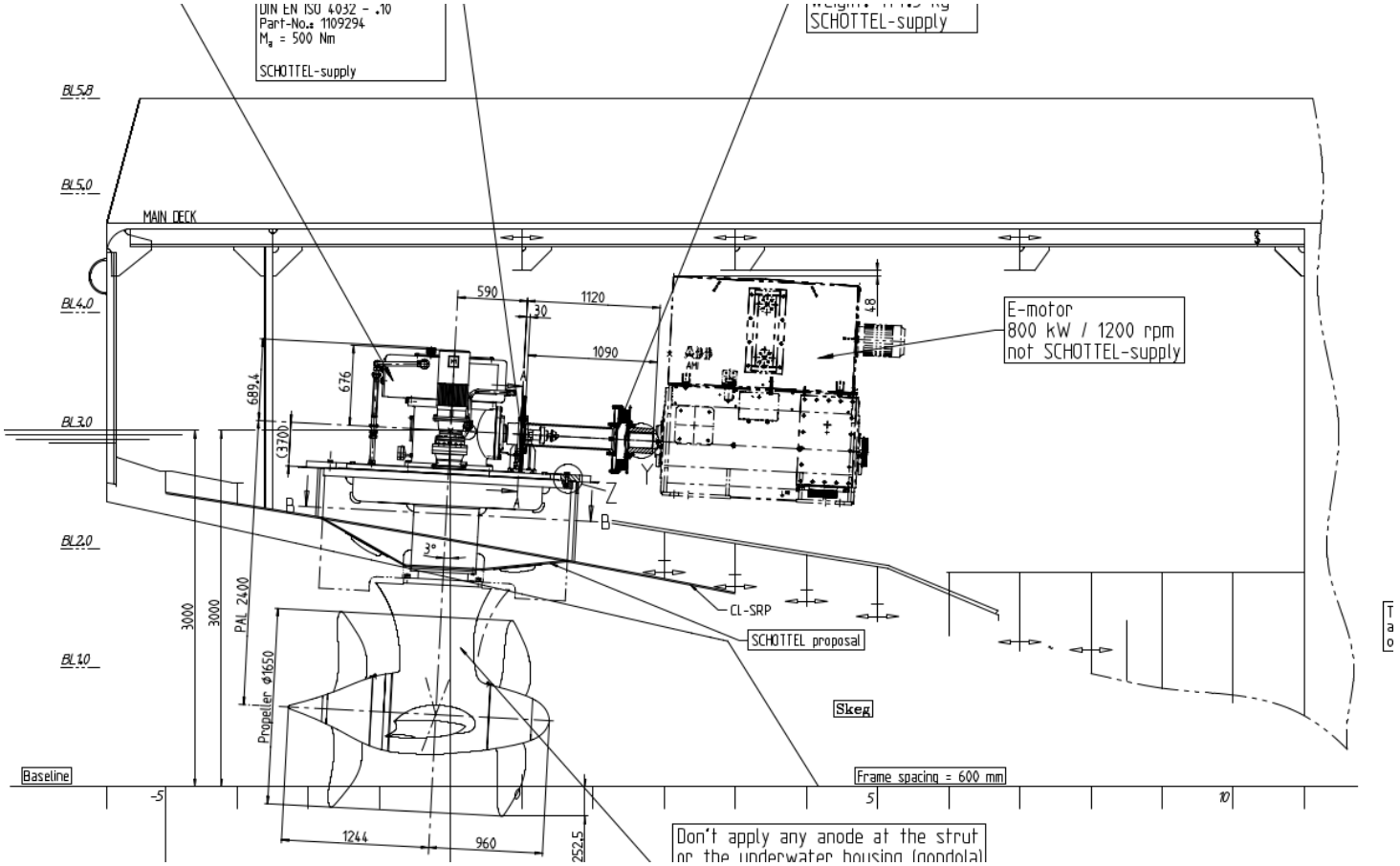
通常主機引擎為中高速引擎配減速機搭配CPP。



海軍光六快艇

電力推進軸系

SRP(STEERING RUDDER PROPELLER)

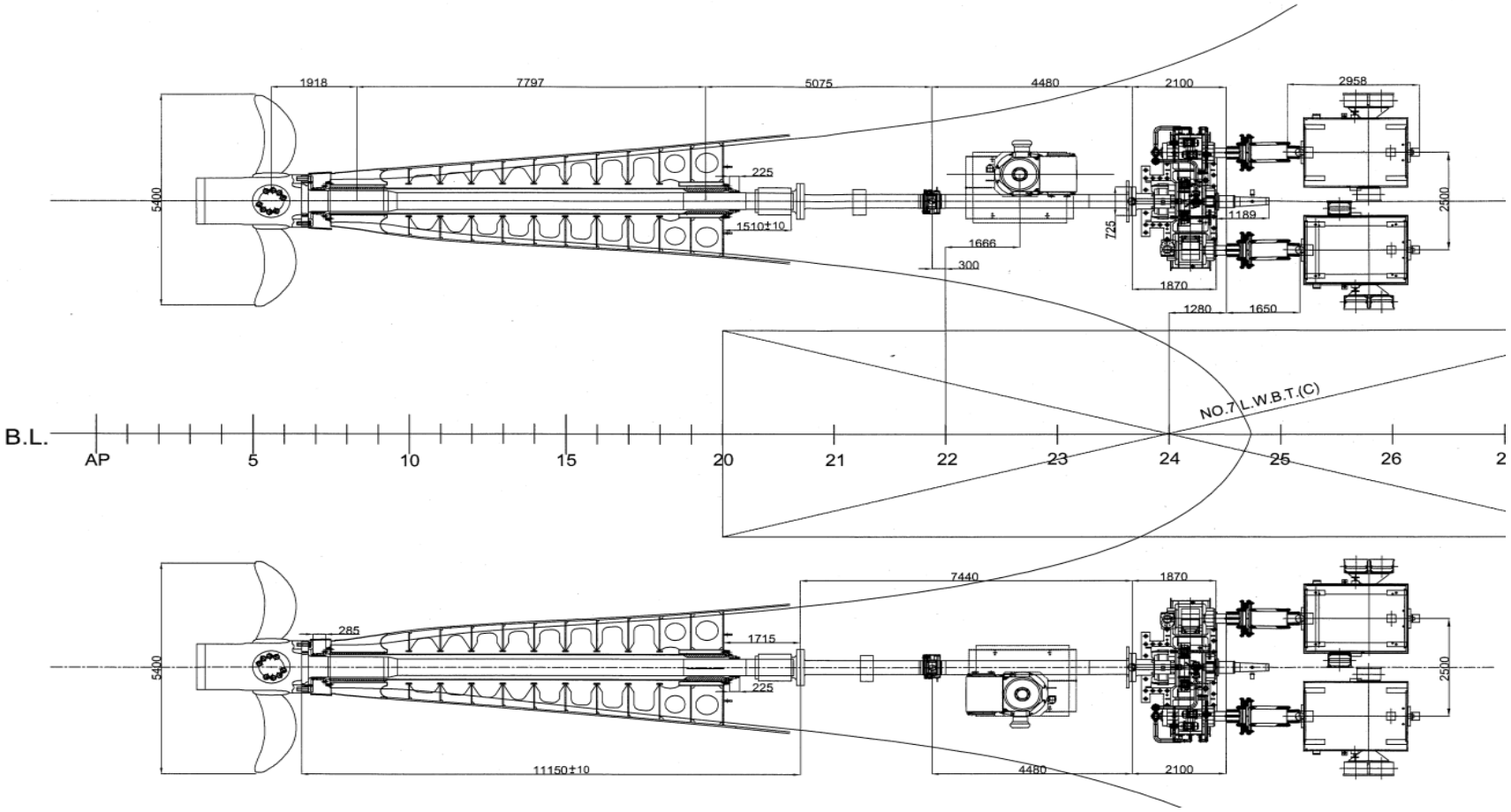


電力推進軸系

海洋研究船

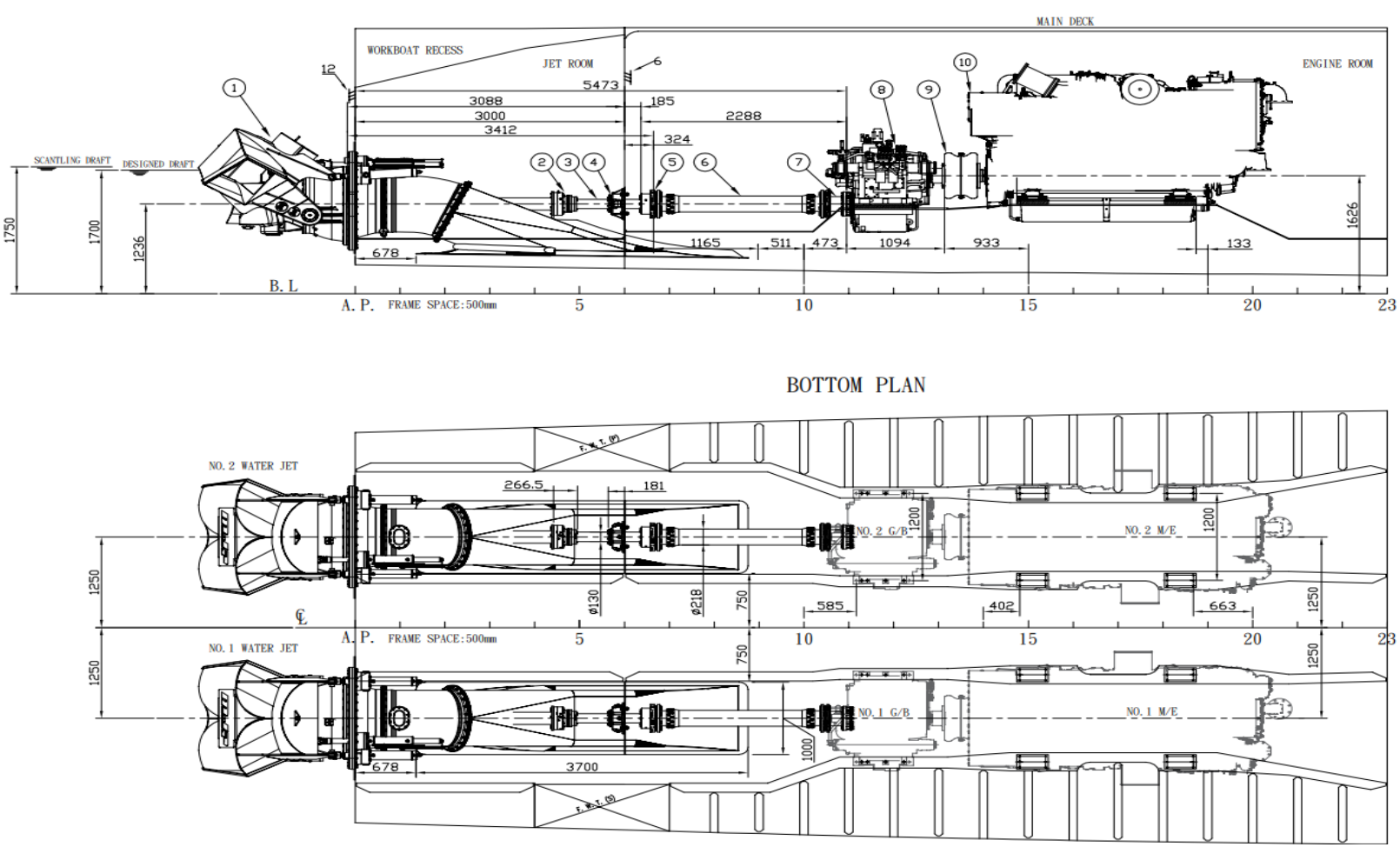
電力推進軸系

電推馬達+CPP



半潛式載重船

水噴式軸系


MAIN DECK
WORKBOAT RECESS
JET ROOM
ENGINE ROOM
SCANTLING DRAFT
DESIGNED DRAFT
1750
1700
1236
3088
3000
3412
5473
185
2288
324
678
1165
511
473
1094
933
133
1626
B. L
A. P.
FRAME SPACE:500mm
5
10
15
20
23
BOTTOM PLAN
NO. 2 WATER JET
NO. 1 WATER JET
266.5
181
NO. 2 G/B
NO. 2 M/E
NO. 1 G/B
NO. 1 M/E
1200
1250
750
585
402
663
1000
3700
678

海軍沱江艦

海巡100噸

噴水推進器

軸系設計的目的

讓推進軸系能安全的在各種營運情況下運轉。

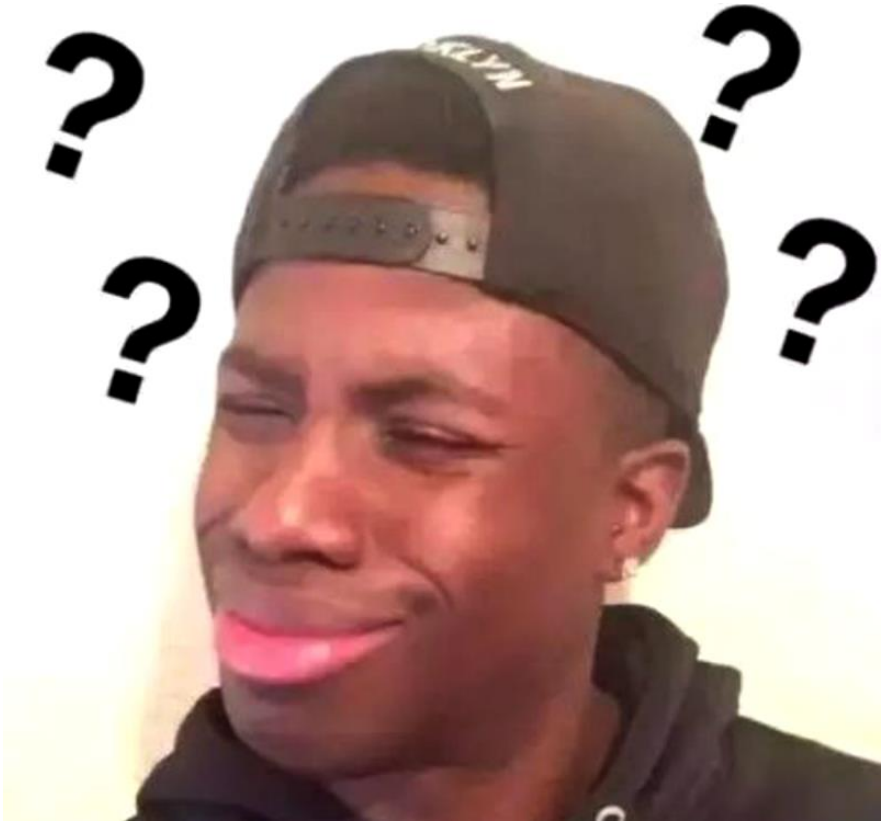
目標:安全的營運。

安全的定義:艉軸套軸承、**中間軸承**和**主機內部軸承**的荷重都在容許範圍內。主機驅動側法蘭的**剪力和彎曲力**距在主機容許範圍內。

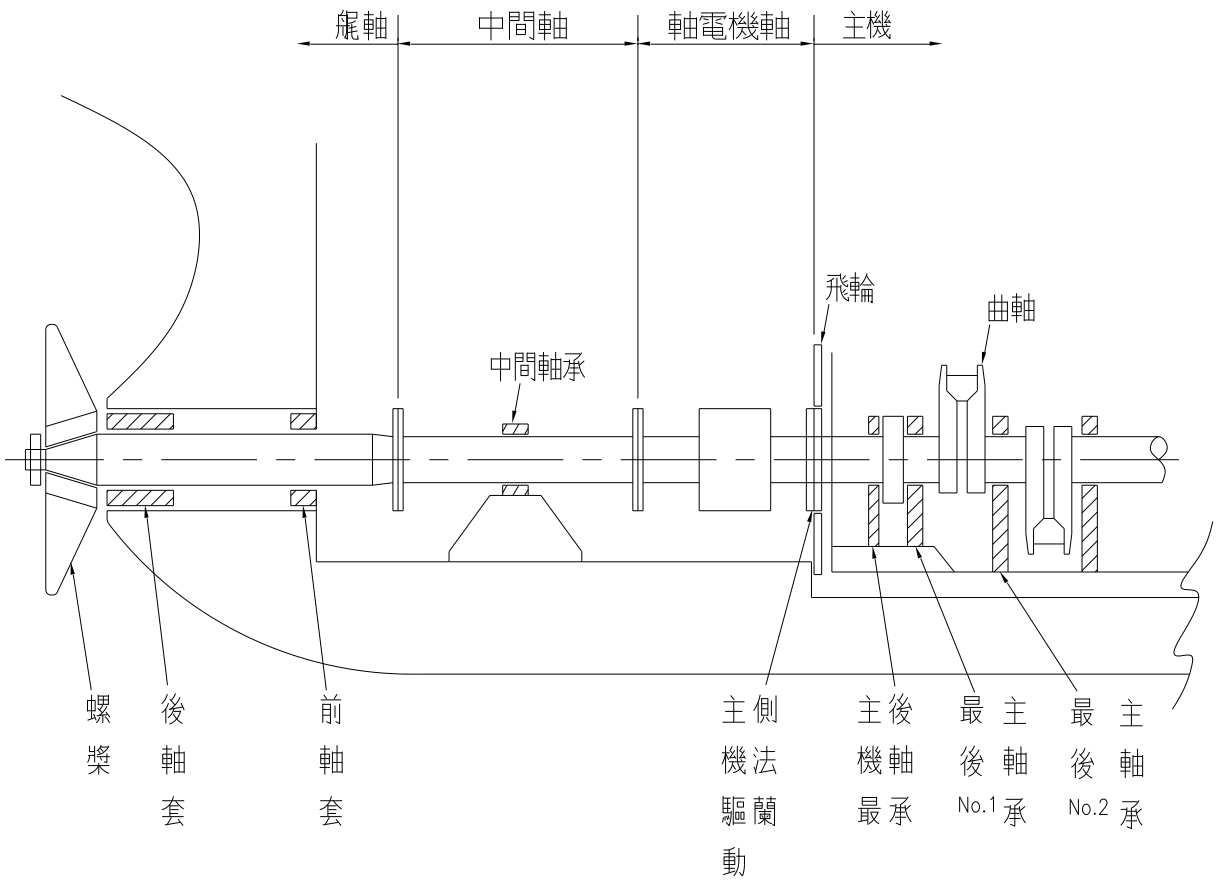
營運的船體情況:船在營運時依應各種需求有輕載、壓載、滿載等不同的裝載情況，不同的裝載會有不同的船體變形量，這些變形量會影響各軸承的垂直高度，導致各軸承的負荷變動。

營運的主機情況:主機運轉或停止機體會有溫度變化產生熱態和冷態不同情況。不同的軸系轉速下螺旋槳會產生不同的升力。致使各軸承的負荷隨之變動。

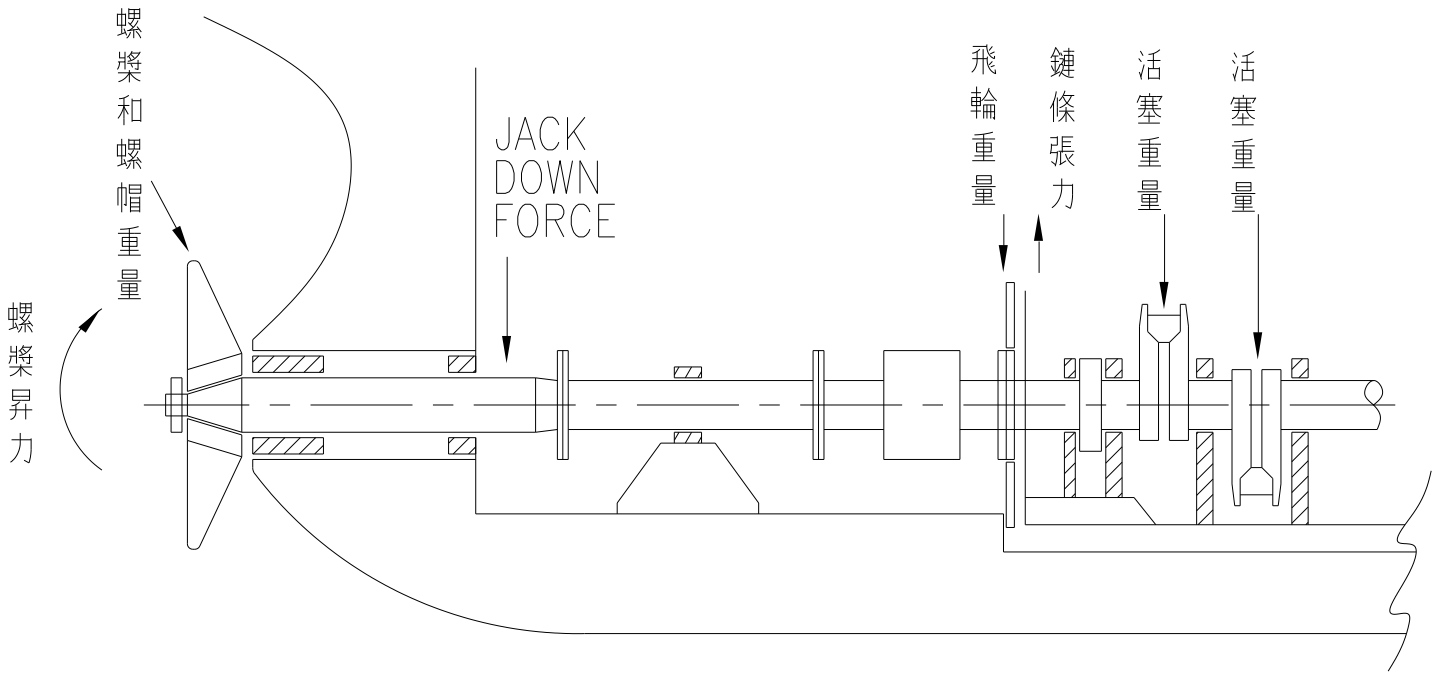
軸系設計需考慮?



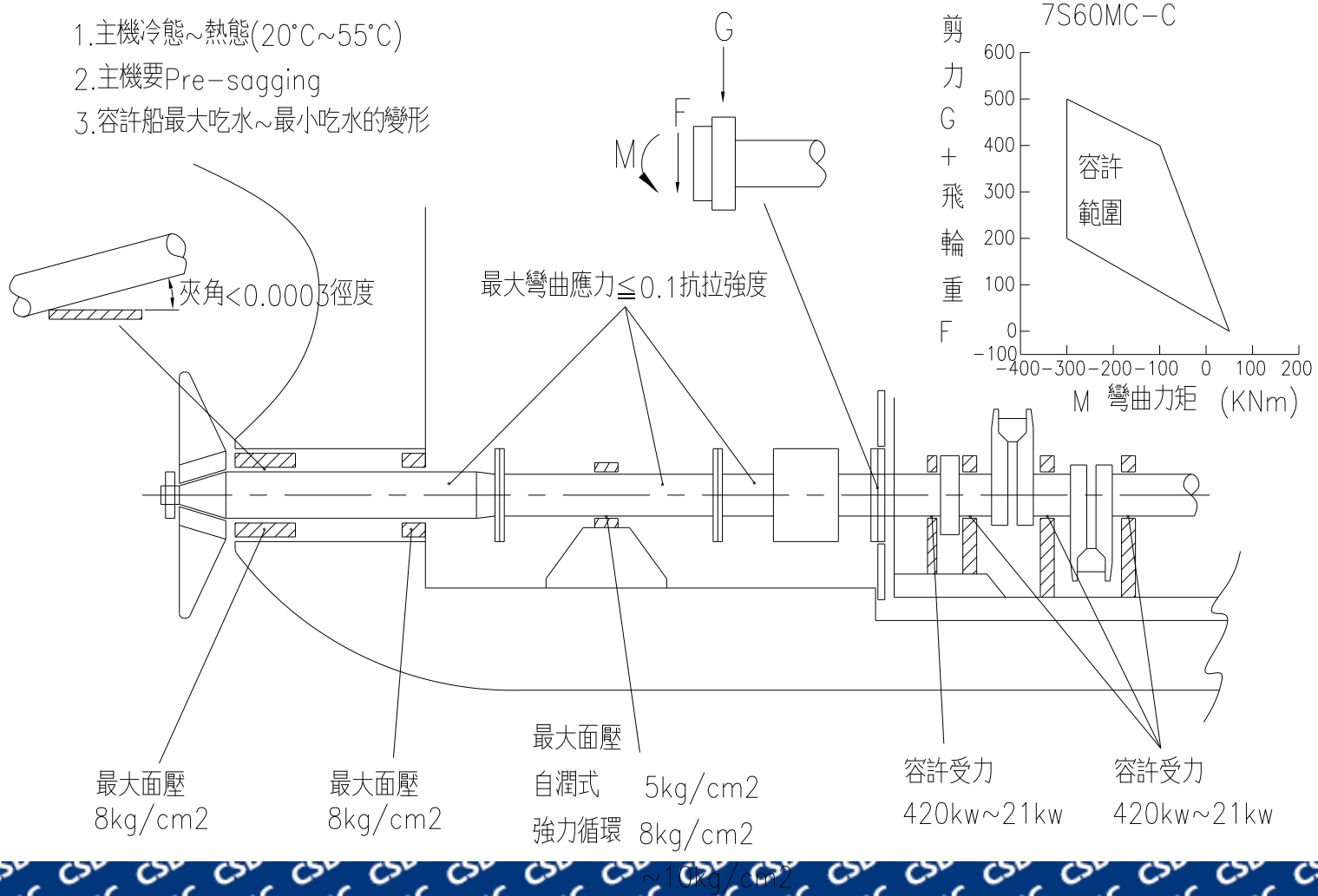
典型的軸系佈置


艉軸
中間軸
軸電機軸
主機
飛輪
曲軸
中間軸承
螺槳
後軸套
前軸套
主機驅動側法蘭
主機最後軸承
最後No.1主軸承
最後No.2主軸承

作用於軸系的外力

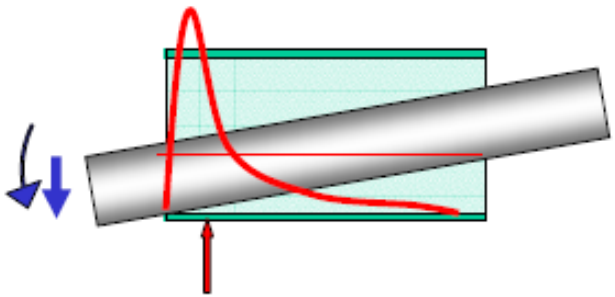


限制條件


1.主機冷態~熱態(20°C~55°C)
2.主機要Pre-sagging
3.容許船最大吃水~最小吃水的變形
G
F
M
夾角<0.0003徑度
最大彎曲應力≦0.1抗拉強度
7S60MC-C
剪力G+飛輪重F
600
500
400
300
200
100
0
-100
-400 -300 -200 -100 0 100 200
容許範圍
M 彎曲力矩 (KNm)
最大面壓
8kg/cm2
最大面壓
8kg/cm2
最大面壓
自潤式 5kg/cm2
強力循環 8kg/cm2
~10kg/cm2
容許受力
420kw~21kw
容許受力
420kw~21kw

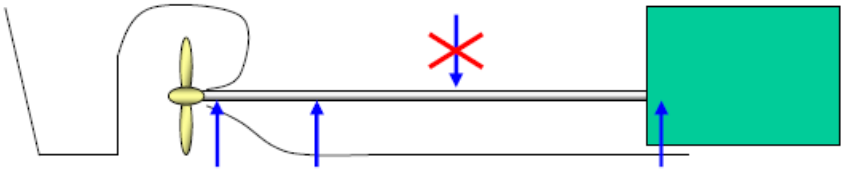
排軸規劃要求

- 軸系排列必須使各軸承的受力、軸的彎曲力距和剪應力最適化。
- 軸系排列應避免，在正常轉速和最低轉速時，造成後軸套的負荷分佈產生過度集中的情況發生。(應特別注意艉端部位)



排軸規劃要求

- 所有軸承均須有合理的負荷，不可懸空。



- 所有軸上的應力均須在合理的容許範圍內。
- 船舶航行時軸上的彎曲應力是以動態變動呈現，對材料的疲勞壽命有影響。

排軸規劃要求

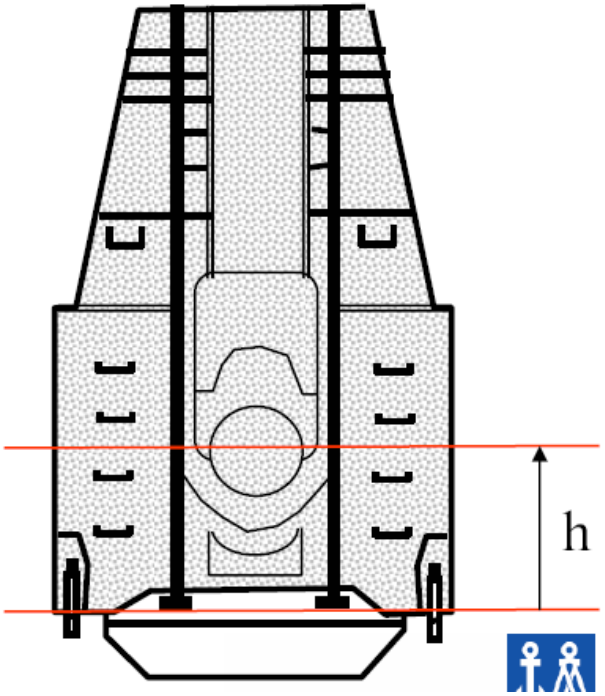
- 軸系規劃設計時，必須讓軸系具有足夠的撓性並留有適當的強度裕度，以容許不明的錯誤、船體變形和熱效應的影響。
- 軸系規劃必須滿足主機設計者的規範要求：
  - 滿足主機接軸處的彎曲力距和剪力要求。
  - 滿足曲柄軸撓曲要求。
  - 讓引擎內各軸承在引擎熱態運轉時有良好的負載分佈。

- 從主機機底到軸中心的高度，會隨主機結構在冷態和熱態時的熱膨脹而變動。

- **Thermal linear expansion of an engine:**

$$\Delta h = h\,(t2 - t1)\,\alpha\;\; C$$

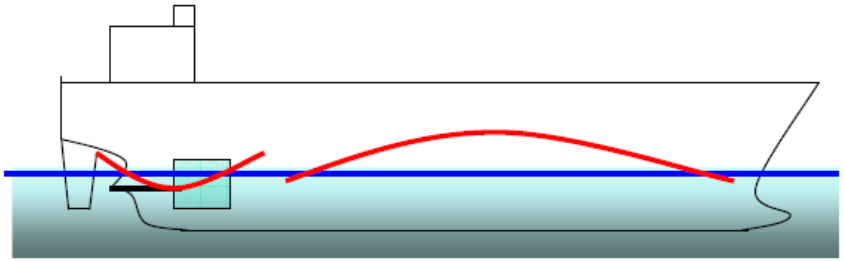
t2= hot engine temp. approx. lub. oil temp. 50oC
t1= cold engine temp. approx. lub. oil temp. 20oC
α = 11.5 x 10-6 [K-1]
C = corr. factor 2-stroke engines (experience 0.3 - 0.5)



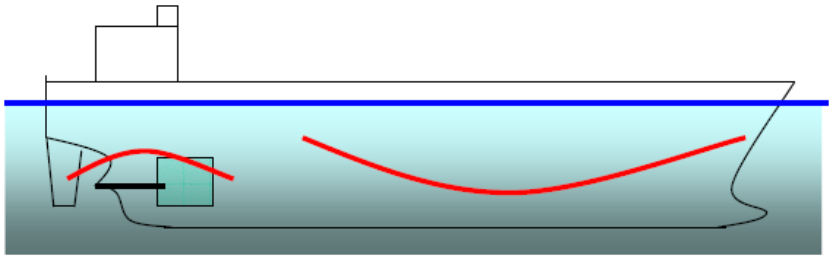
吃水的影響

- 不同吃水時，船體垂直方向變形的趨勢如下：

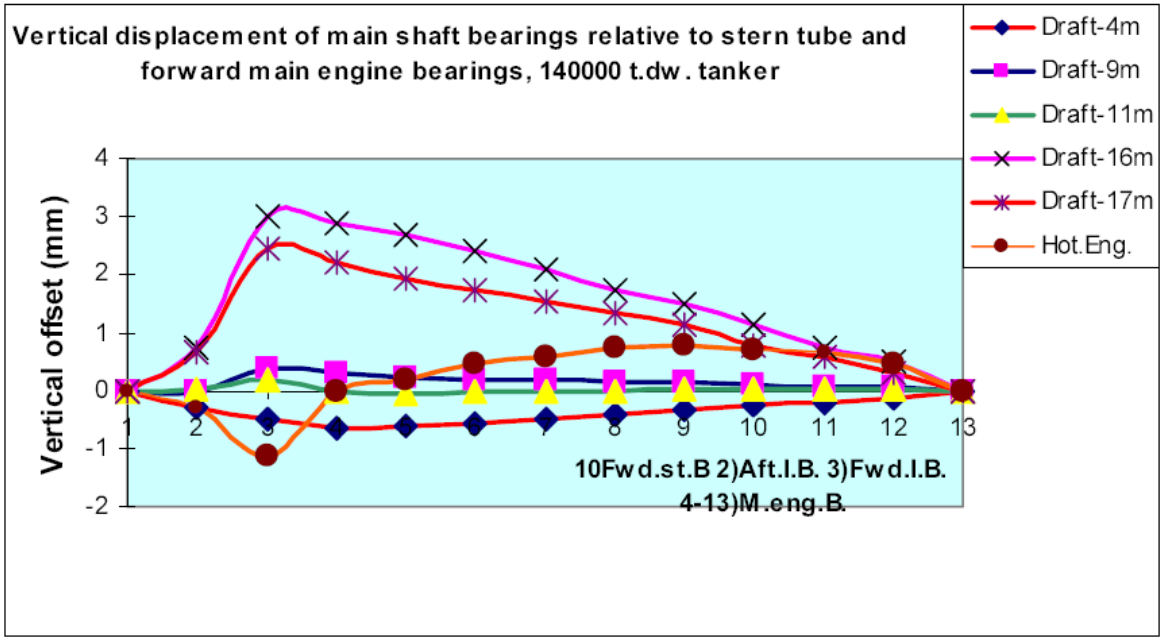
壓載情況：貨艙段會有凸起的撓曲，機艙段會有下凹的撓曲。

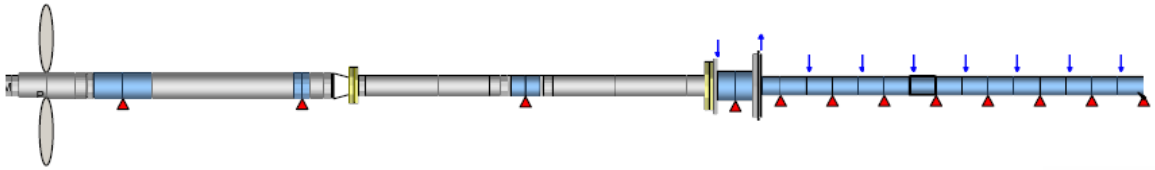


滿載情況：貨艙段會有下凹的撓曲，機艙段會有凸起的撓曲。



吃水變動導致軸承高度變動的例子：





扭轉震動

MAN Diesel & Turbo GTORSI 3.6.1/WIN32 Hitachi	TORSIONAL VIBRATION CALCULATION	Page 12 29 Feb 2016 16:48:05
6S60ME-C	MCR 12050 kW @ 105 r/min	
	DE S60ME-C MARK8_5 : FSB THROW245379 IS. 455mm FW 18750 kgm^2 TW 10000 kgm^2	
ENGINE LOAD : kW r/min Propeller 12050 105 Gas harmonic components : 249886	COMBUSTION CONDITION : Normal	

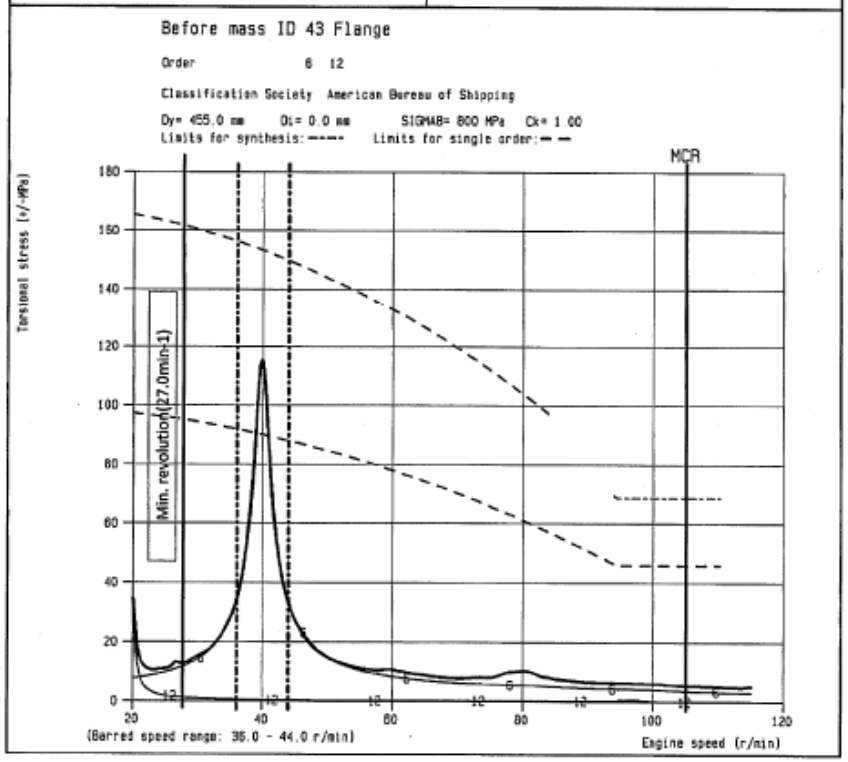


Fig.1-2 Torsional stress in the Intermediate shaft

軸向震動

1. Criteria

Permissible vibratory amplitude at fore end of cranshaft (ID38 in calculation model) is follow.

Need to be overhauled:	1.125 mm
Alarm:	1.500 mm
Slow down:	1.875 mm

(zero to peak)

2. Opinion

When axial vibration damper is active and normal, all resonances are small enough owing to the damper.

The engine speed 33 min-1 is upper limit in case damper inactive because vibratory amplitude exceeds the level of "need to be overhauled" of axial vibration damper.

Periodical check of amplitude is recommended using axial vibration monitor.

If the amplitude exceeds the line 'Damper to be overhauled,' overhaul of the damper should be taken soon.

設計軸尺寸

依照船舶入級的船級規範中的標準，計算出軸徑等相關部件需求。

SHAFTING STRENGTH CALCULATION OF MAIN SHAFT BY ABS RULE (2018)

H : POWER AT RATED SPEED (KW) (MCR) = 20500 KW = 27872 PS
R : RATED SPEED (RPM) = 91 RPM

1) DIA. OF INTERMEDIATE SHAFT (D_i) :

$$D_i = 100K_3\sqrt{\frac{H}{R}\left(\frac{c_1}{U+c_2}\right)}$$

REQUIRED (mm) DESIGN (mm)

= 549.6 580

K=1 , c_1=560 , c_2=160 *U =* 600 N/mm²

2) DIA. OF PROPELLER SHAFT (D_P) :

$$D_s = 100K_3\sqrt{\frac{H}{R}\left(\frac{c_1}{U+c_2}\right)}$$

= 670.5 690

K=1.22 , c_1=560 , c_2=160 *U =* 600 N/mm²

INBOARD END (D_f) :

$$D_f = 100K_3\sqrt{\frac{H}{R}\left(\frac{c_1}{U+c_2}\right)}$$

= 549.6 580

K=1 , c_1=560 , c_2=160 *U =* 600 N/mm²

3) DIA. OF COUPLING BOLT (d_b) :

$$d_b = 0.65\sqrt{\frac{D^2(U+c)}{NBU_b}}$$

a) CRANK SHAFT & INTERMEDIATE SHAFT: – 71.9 100

N= 10 *B=* 1110 mm

U_b = 930 N/mm²

b) INTERMEDIATE SHAFT & PROPELLER SHAFT: – 80.2 95

N= 10 *B=* 890 mm

U_b = 930 N/mm²

4) THICKNESS OF FLANGE (*Ti*) : ($T_i \geq d_b$ *and* $\geq 0.2D_i$)

a) INTERMEDIATE SHAFT :

d_b = 71.9 mm $0.2D_i$ = 109.9 mm FWD PART = 109.9 120

d_b = 80.2 mm $0.2D_i$ = 109.9 mm AFT PART = 109.9 120

b) PROPELLER SHAFT :

d_b = 80.2 mm $0.2D_i$ = 109.9 mm FWD PART = 109.9 120

5) FILLET RADIUS AT BASE OF FLANGE (Rf) : $R_f=0.08D_a$ D_a : ACTUAL THROAT DIA.

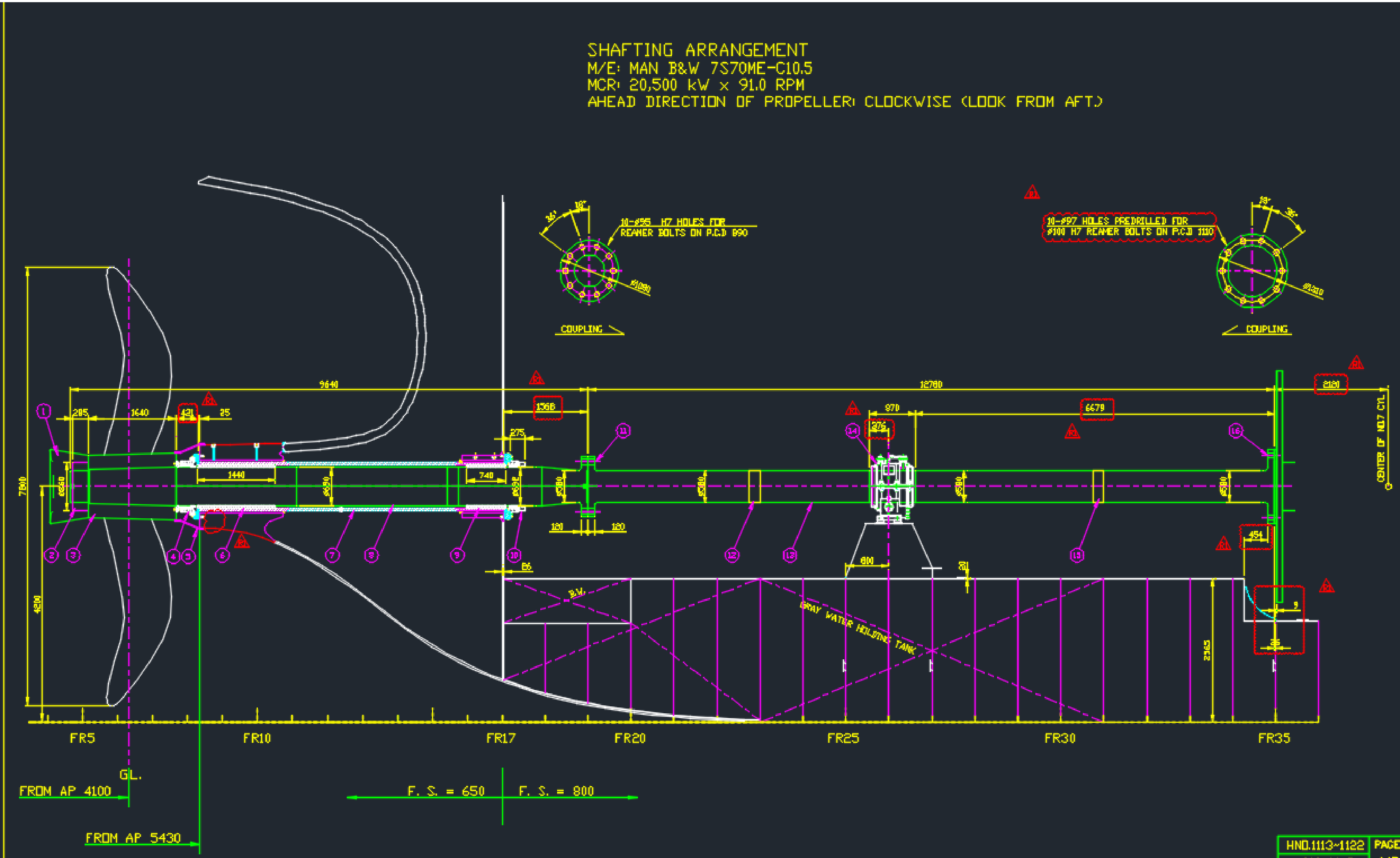
a) INTERMEDIATE SHAFT : – 46.4 50

b) PROPELLER SHAFT : – 46.4 50

6) EFFECT. LENGTH OF STERN TUBE BEARING :

$L_b=2D_p$ (AFT) – 1341.0 1400

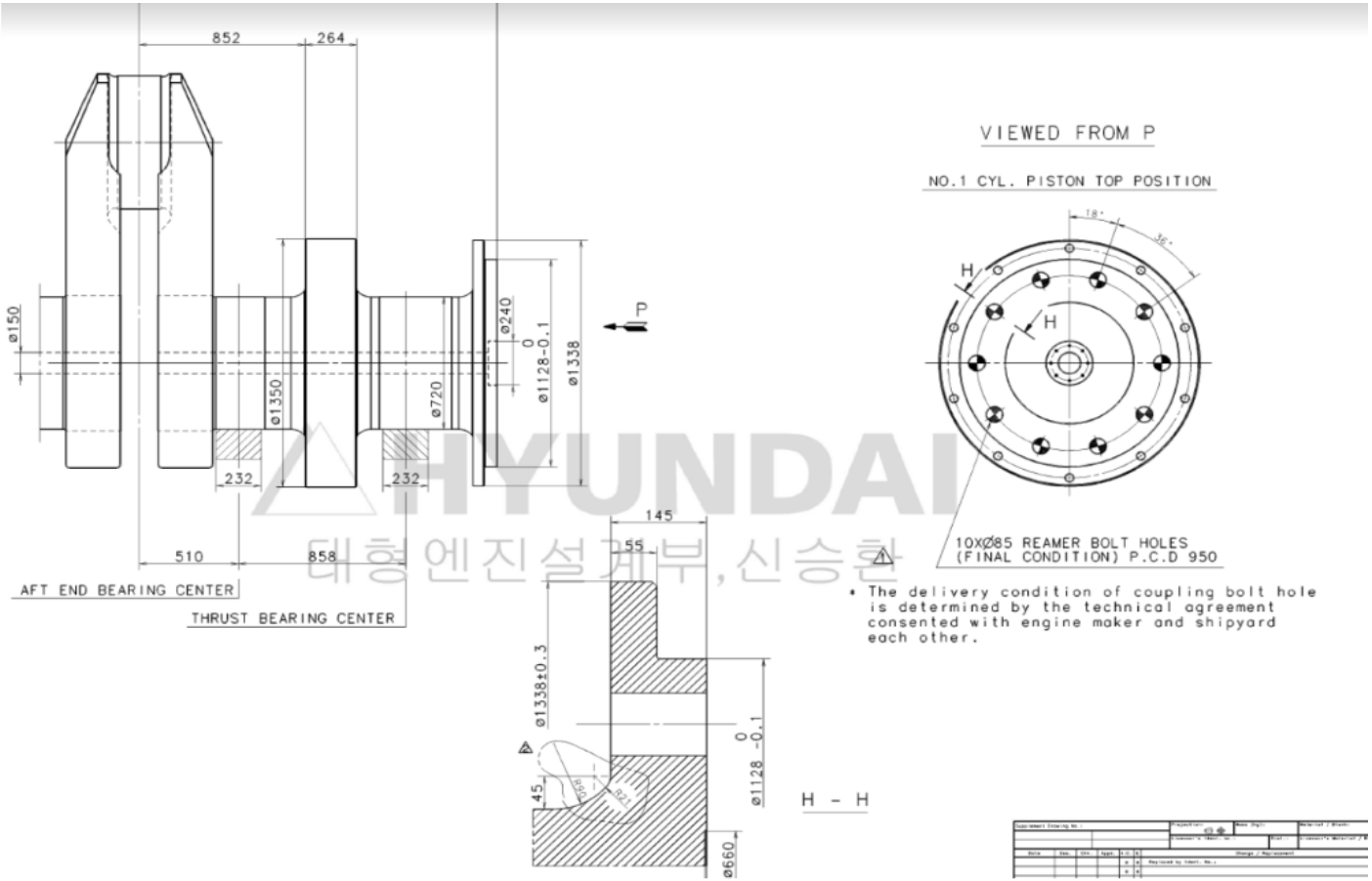
軸系佈置圖



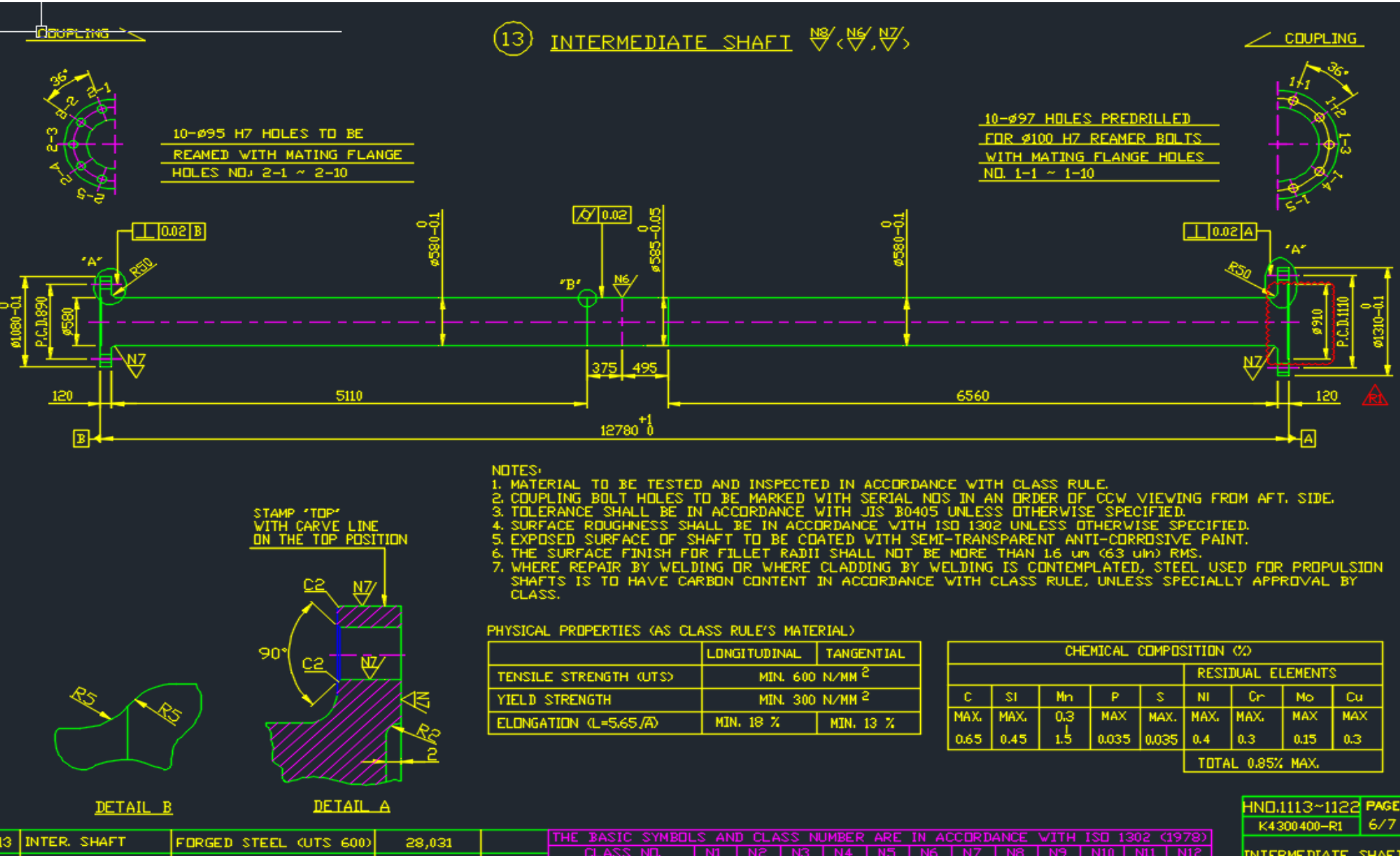
SHAFTING ARRANGEMENT
M/E: MAN B&W 7S70ME-C10.5
MCR: 20,500 kW x 91.0 RPM
AHEAD DIRECTION OF PROPELLER: CLOCKWISE (LOOK FROM AFT)
10-ø55 H7 HOLES FOR REAMER BOLTS ON P.C.D 890
COUPLING
10-ø97 HOLES PREDRILLED FOR ø100 H7 REAMER BOLTS ON P.C.D 1110
COUPLING
9640
12780
CENTER OF NO7 CYL
GRAY WATER HOLDING TANK
FR5
FR10
FR17
FR20
FR25
FR30
FR35
G.L.
FROM AP 4100
FROM AP 5430
F. S. = 650
F. S. = 800
HNO.1113~1122
PAGE

主機法蘭

中間軸主機端法蘭孔位及孔徑會配合主機廠家提供尺寸。



中間軸



NOTES:
1. MATERIAL TO BE TESTED AND INSPECTED IN ACCORDANCE WITH CLASS RULE.
2. COUPLING BOLT HOLES TO BE MARKED WITH SERIAL NOS IN AN ORDER OF CCW VIEWING FROM AFT. SIDE.
3. TOLERANCE SHALL BE IN ACCORDANCE WITH JIS B0405 UNLESS OTHERWISE SPECIFIED.
4. SURFACE ROUGHNESS SHALL BE IN ACCORDANCE WITH ISO 1302 UNLESS OTHERWISE SPECIFIED.
5. EXPOSED SURFACE OF SHAFT TO BE COATED WITH SEMI-TRANSPARENT ANTI-CORROSIVE PAINT.
6. THE SURFACE FINISH FOR FILLET RADII SHALL NOT BE MORE THAN 1.6 um (63 uin) RMS.
7. WHERE REPAIR BY WELDING OR WHERE CLADDING BY WELDING IS CONTEMPLATED, STEEL USED FOR PROPULSION SHAFTS IS TO HAVE CARBON CONTENT IN ACCORDANCE WITH CLASS RULE, UNLESS SPECIALLY APPROVAL BY CLASS.

STAMP 'TOP' WITH CARVE LINE ON THE TOP POSITION

DETAIL B

DETAIL A

PHYSICAL PROPERTIES (AS CLASS RULE'S MATERIAL)

	LONGITUDINAL	TANGENTIAL
TENSILE STRENGTH (UTS)	MIN. 600 N/MM^2	
YIELD STRENGTH	MIN. 300 N/MM^2	
ELONGATION (L=5.65√A)	MIN. 18 %	MIN. 13 %

CHEMICAL COMPOSITION (%)

					RESIDUAL ELEMENTS			
C	SI	Mn	P	S	NI	Cr	Mo	Cu
MAX. 0.65	MAX. 0.45	0.3 ~ 1.5	MAX 0.035	MAX. 0.035	MAX. 0.4	MAX. 0.3	MAX 0.15	MAX 0.3
					TOTAL 0.85% MAX.			

13	INTER. SHAFT	FORGED STEEL (UTS 600)	28,031	

THE BASIC SYMBOLS AND CLASS NUMBER ARE IN ACCORDANCE WITH ISO 1302 (1978)

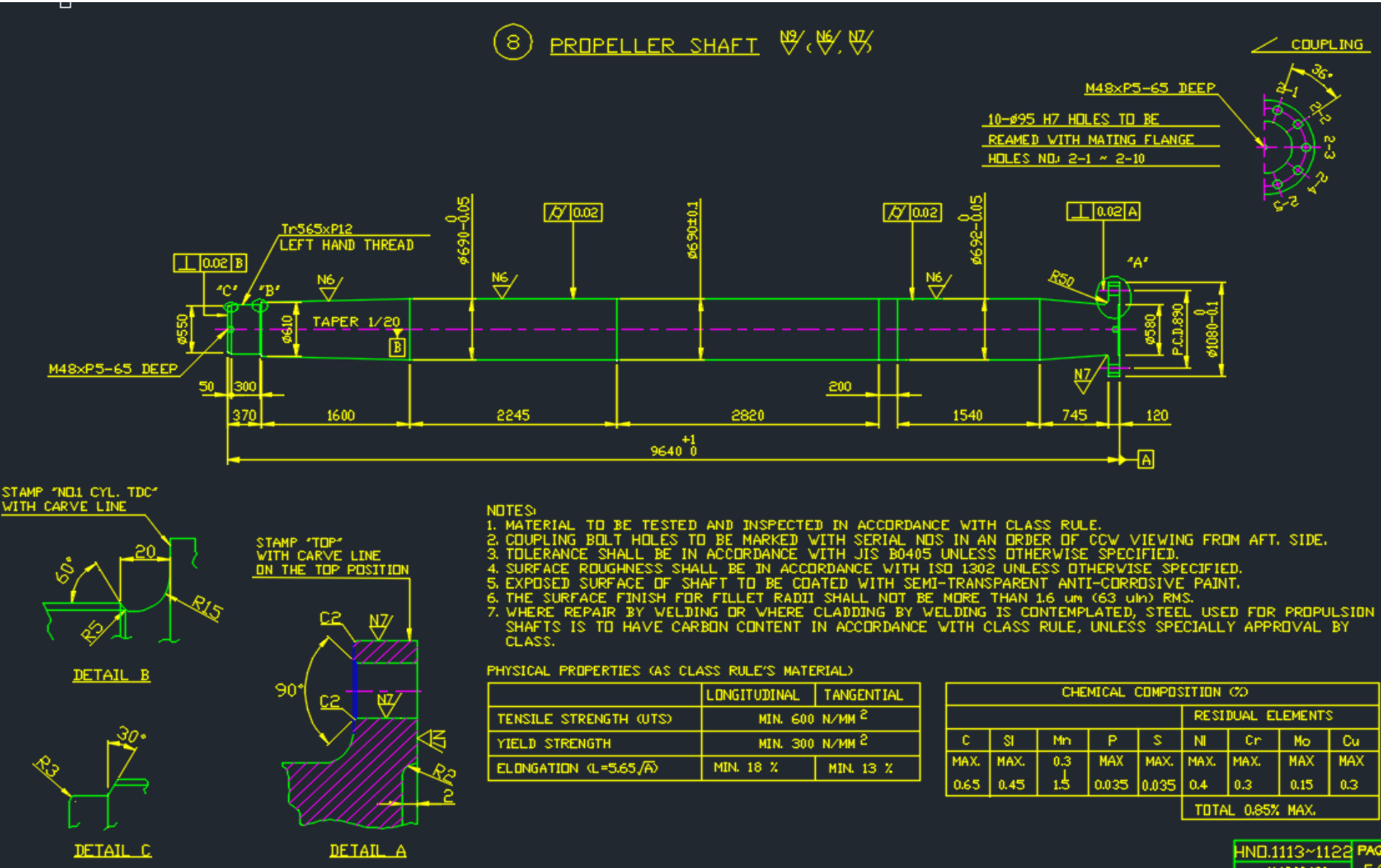
CLASS NO.	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12

HNO.1113~1122	PAGE
K4300400-R1	6/7

INTERMEDIATE SHAFT

中間軸

艉軸



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	LONGITUDINAL	TANGENTIAL
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ELONGATION (L=5.65$\sqrt{A}$)	MIN. 18 %	MIN. 13 %

CHEMICAL COMPOSITION (%)

					RESIDUAL ELEMENTS			
C	Si	Mn	P	S	Ni	Cr	Mo	Cu
MAX. 0.65	MAX. 0.45	0.3 ~ 1.5	MAX 0.035	MAX. 0.035	MAX. 0.4	MAX. 0.3	MAX 0.15	MAX 0.3
					TOTAL 0.85% MAX.			

HN0.1113~1122 PAC

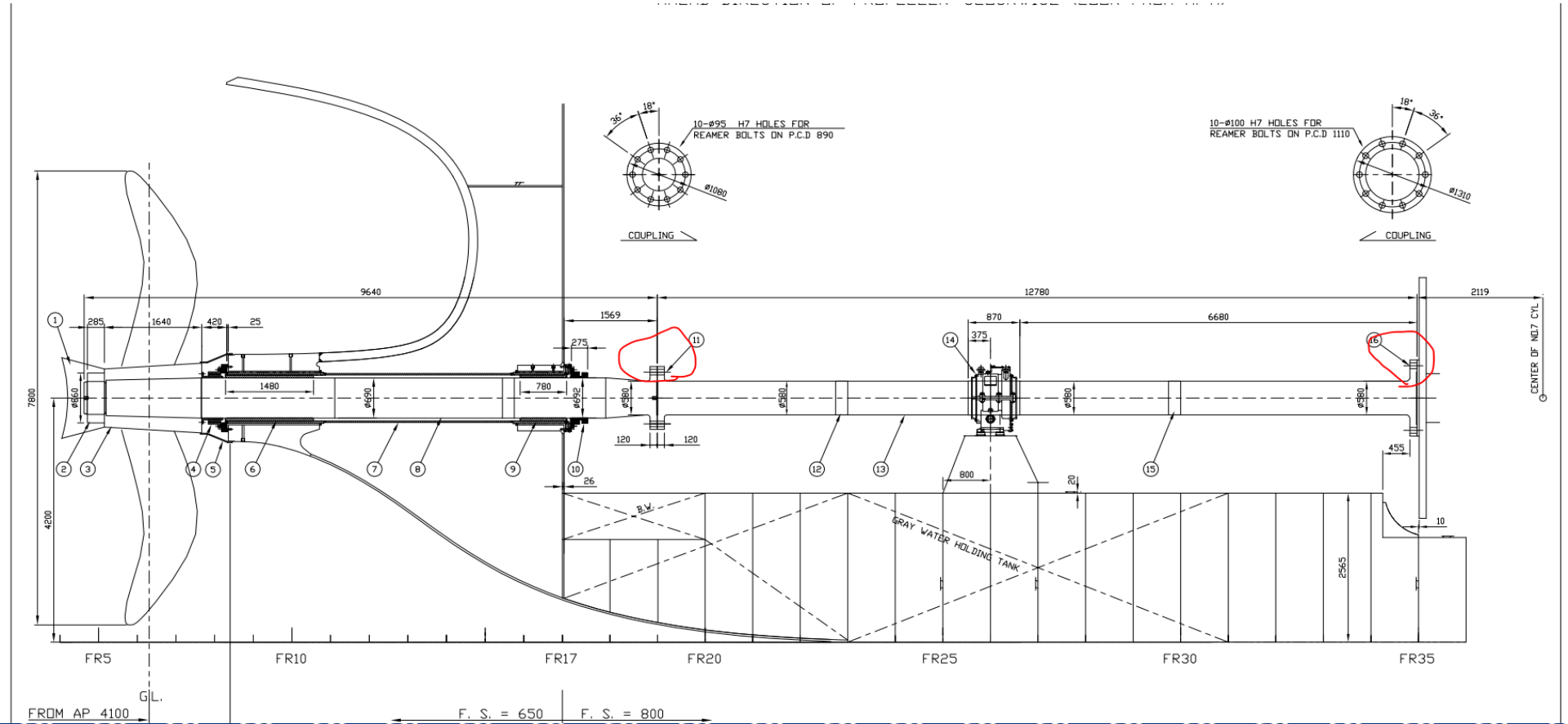
艉軸

軸系相關部件

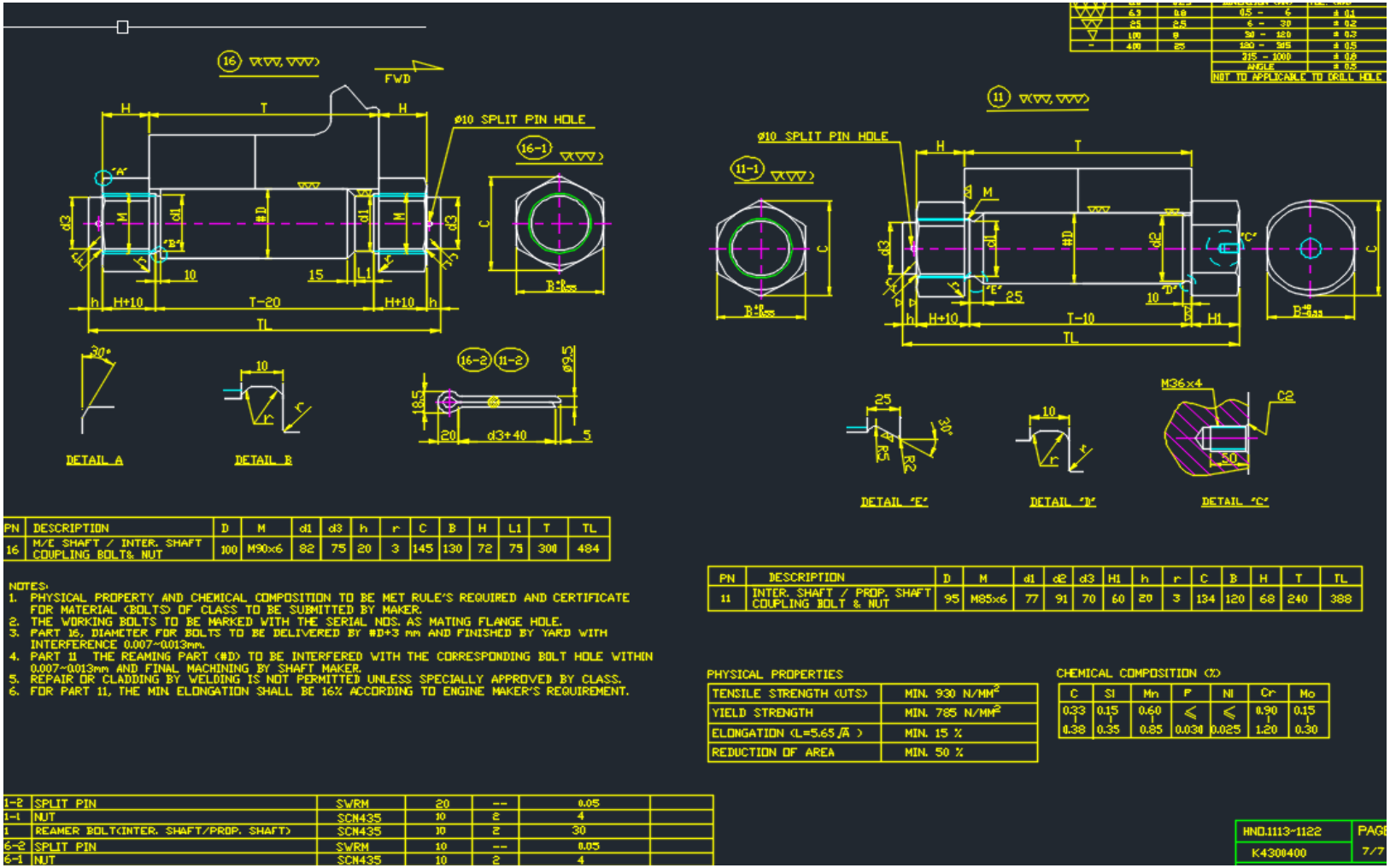
軸系不是只有大軸一根，
一個完整的軸系為許多設備、配件組合。

聯軸裝置

1. 傳統式螺栓
2. 液壓式螺栓
3. 液壓聯軸器



傳統式大軸螺栓



PN	DESCRIPTION	D	M	d1	d3	h	r	C	B	H	L1	T	TL
16	M/E SHAFT / INTER. SHAFT COUPLING BOLT& NUT	100	M90x6	82	75	20	3	145	130	72	75	300	484

PN	DESCRIPTION	D	M	d1	d2	d3	H1	h	r	C	B	H	T	TL
11	INTER. SHAFT / PROP. SHAFT COUPLING BOLT & NUT	95	M85x6	77	91	70	60	20	3	134	120	68	240	388

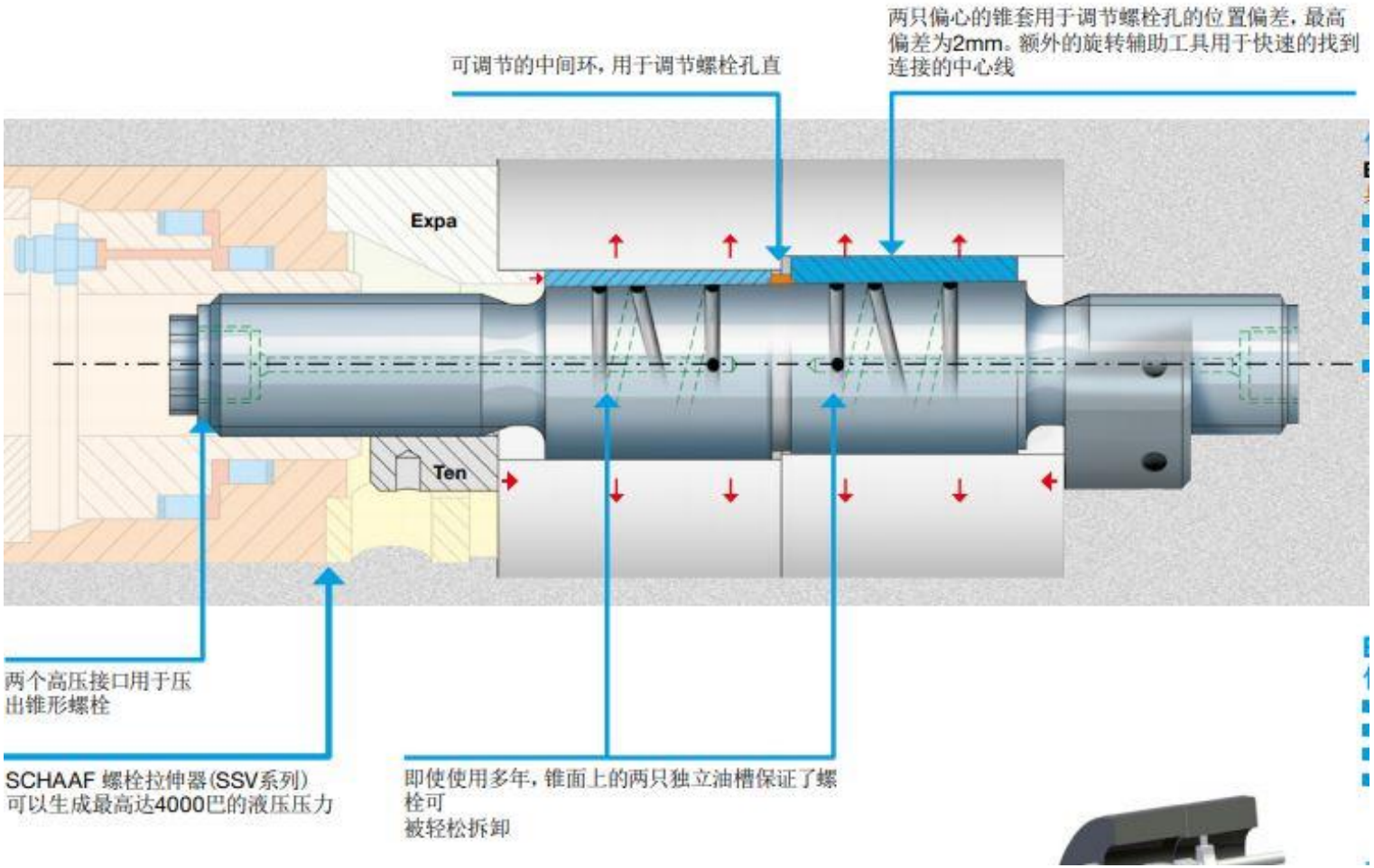
1-2	SPLIT PIN	SWRM	20	--	0.05	
1-1	NUT	SCM435	10	2	4	
1	REAMER BOLT(INTER. SHAFT/PROP. SHAFT)	SCM435	10	2	30	
6-2	SPLIT PIN	SWRM	10	--	0.05	
6-1	NUT	SCM435	10	2	4	

PHYSICAL PROPERTIES	
TENSILE STRENGTH (UTS)	MIN. 930 N/MM^2
YIELD STRENGTH	MIN. 785 N/MM^2
ELONGATION (L=5.65√A)	MIN. 15 %
REDUCTION OF AREA	MIN. 50 %

C	Si	Mn	P	Ni	Cr	Mo
0.33 ~ 0.38	0.15 ~ 0.35	0.60 ~ 0.85	≤ 0.030	≤ 0.025	0.90 ~ 1.20	0.15 ~ 0.30

傳統式大軸螺栓

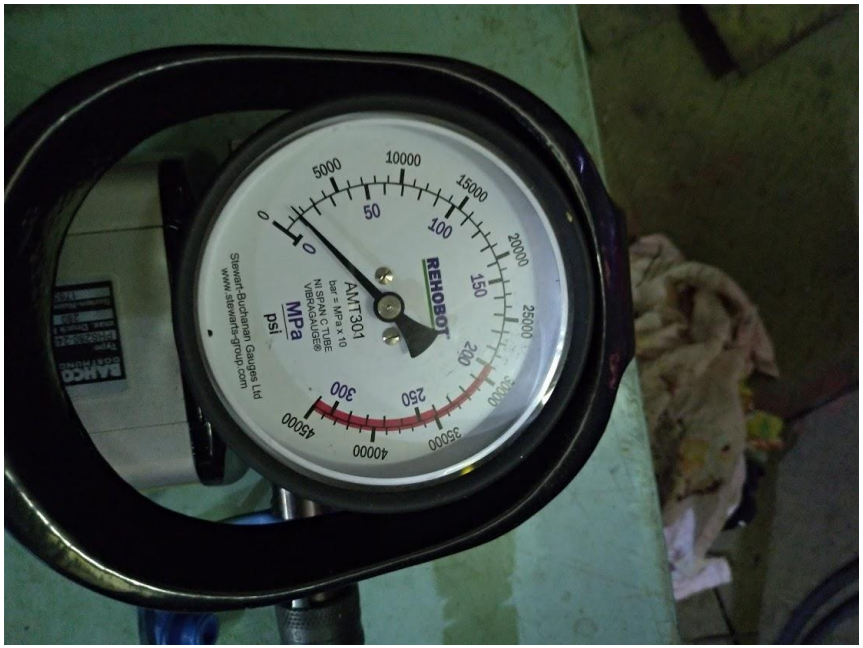
液壓式大軸螺栓


可调节的中间环，用于调节螺栓孔直
两只偏心的锥套用于调节螺栓孔的位置偏差，最高偏差为2mm。额外的旋转辅助工具用于快速的找到连接的中心线
Expa
Ten
两个高压接口用于压出锥形螺栓
SCHAAF 螺栓拉伸器(SSV系列)可以生成最高达4000巴的液压压力
即使使用多年，锥面上的两只独立油槽保证了螺栓可被轻松拆卸

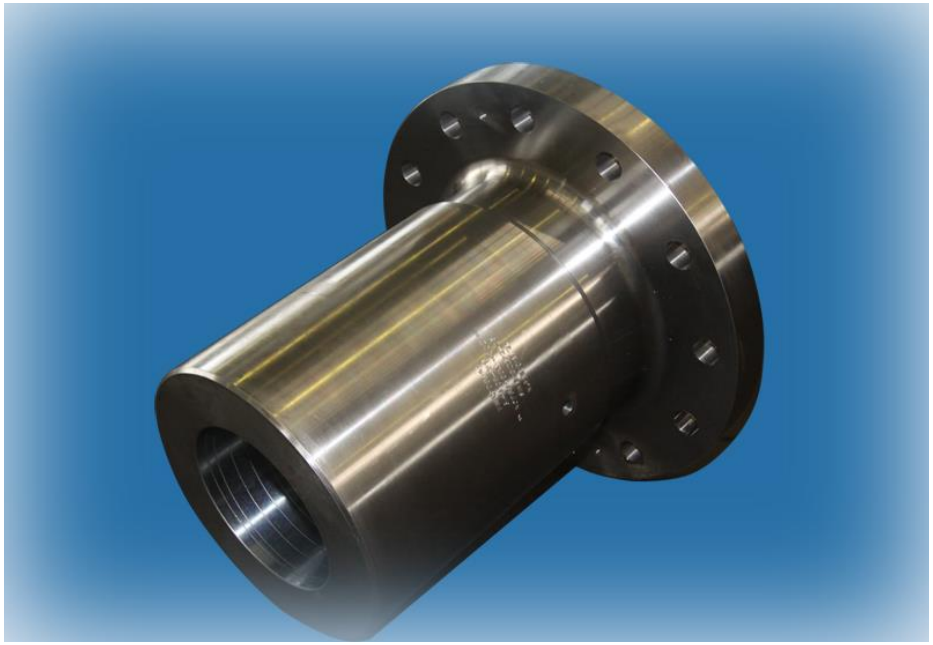
液壓式大軸螺栓

液壓式大軸螺栓

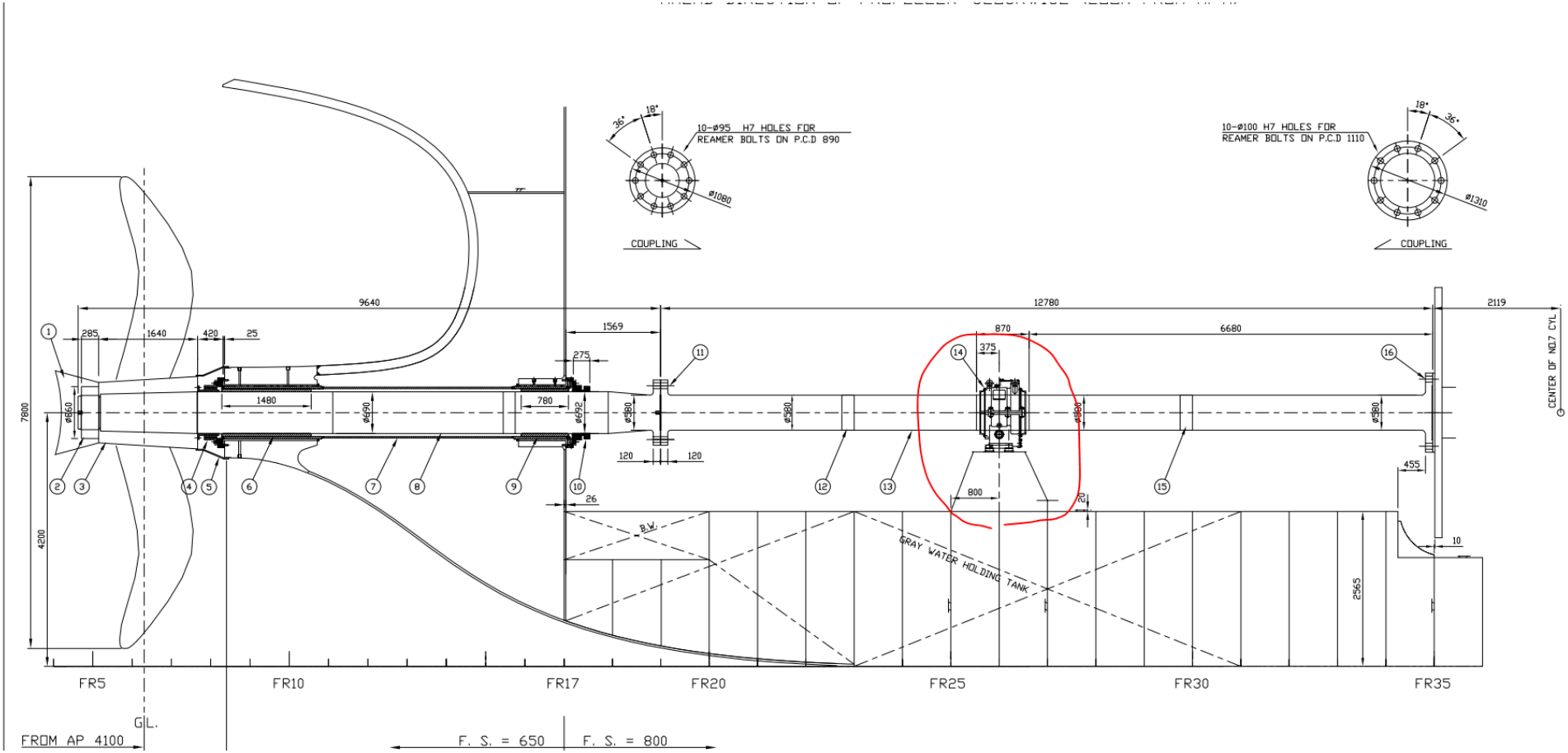
手動加壓安裝液壓螺栓



液壓聯軸器



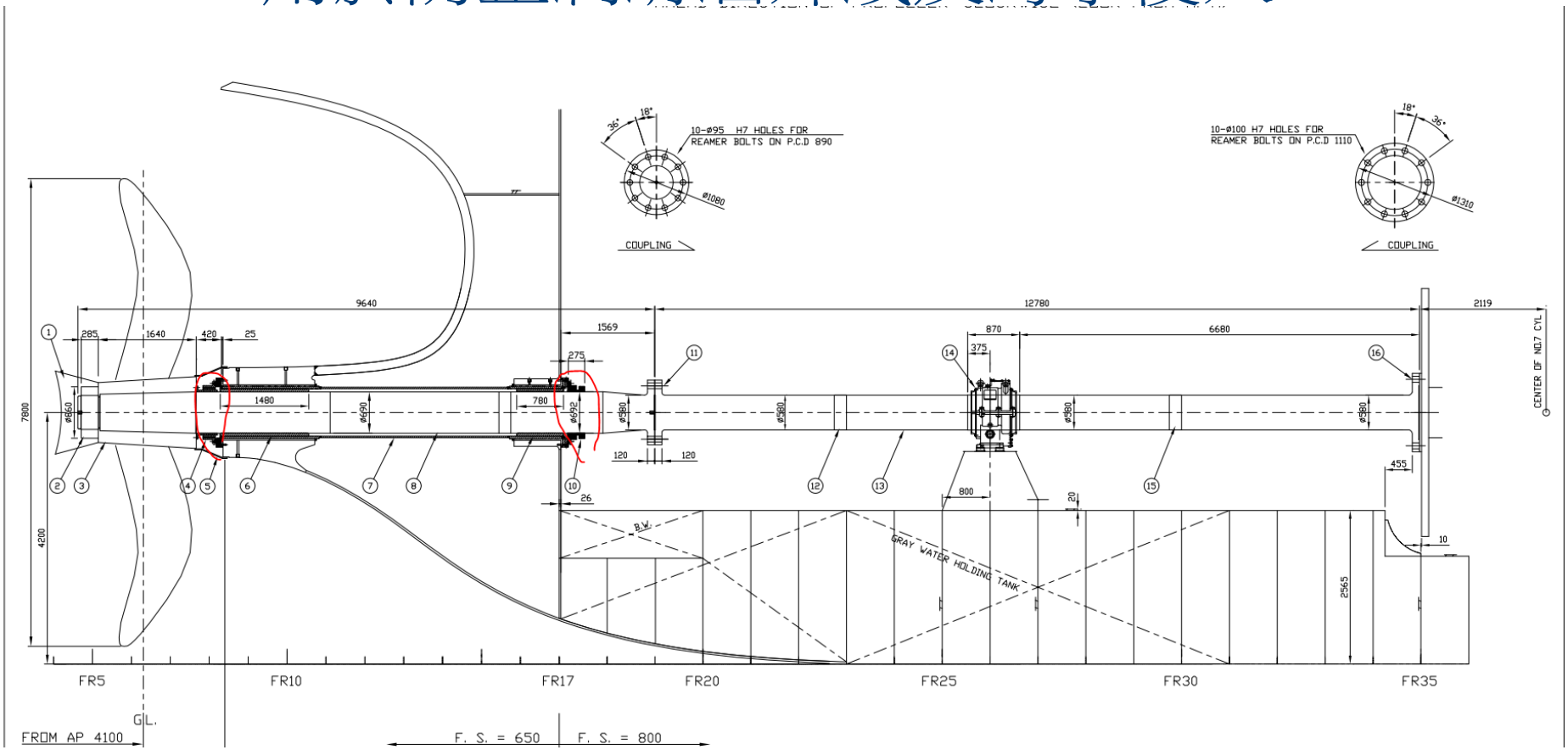
中間軸承
INTERMEDIATE SHAFT BEARING



中間軸承
INTERMEDIATE SHAFT BEARING

軸封 SEAL

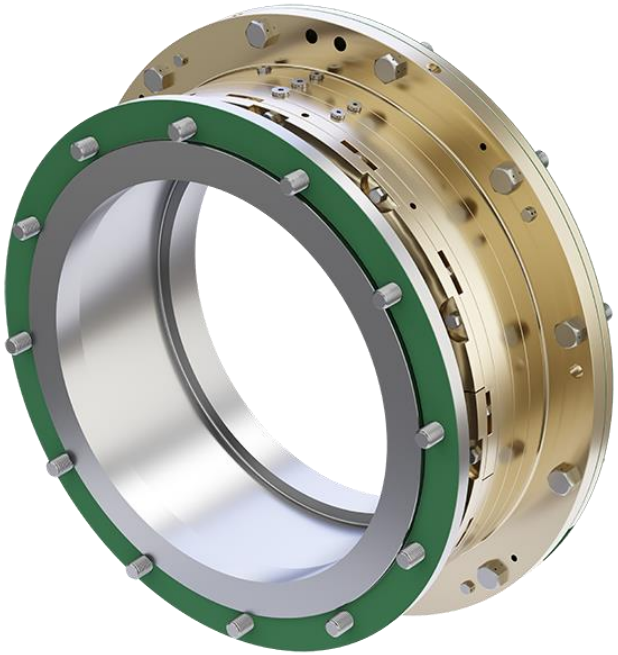
- 用於防止潤滑油外洩及海水侵入

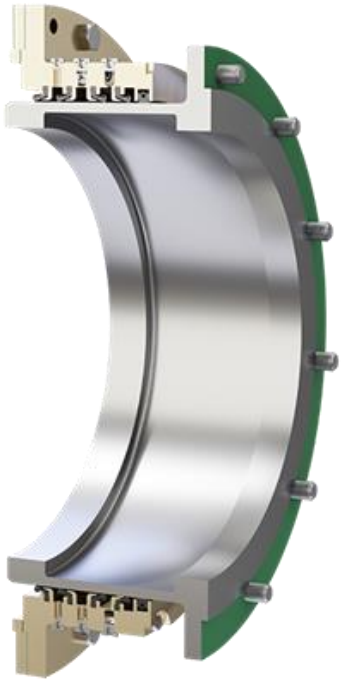


軸封 SEAL

艉軸封，

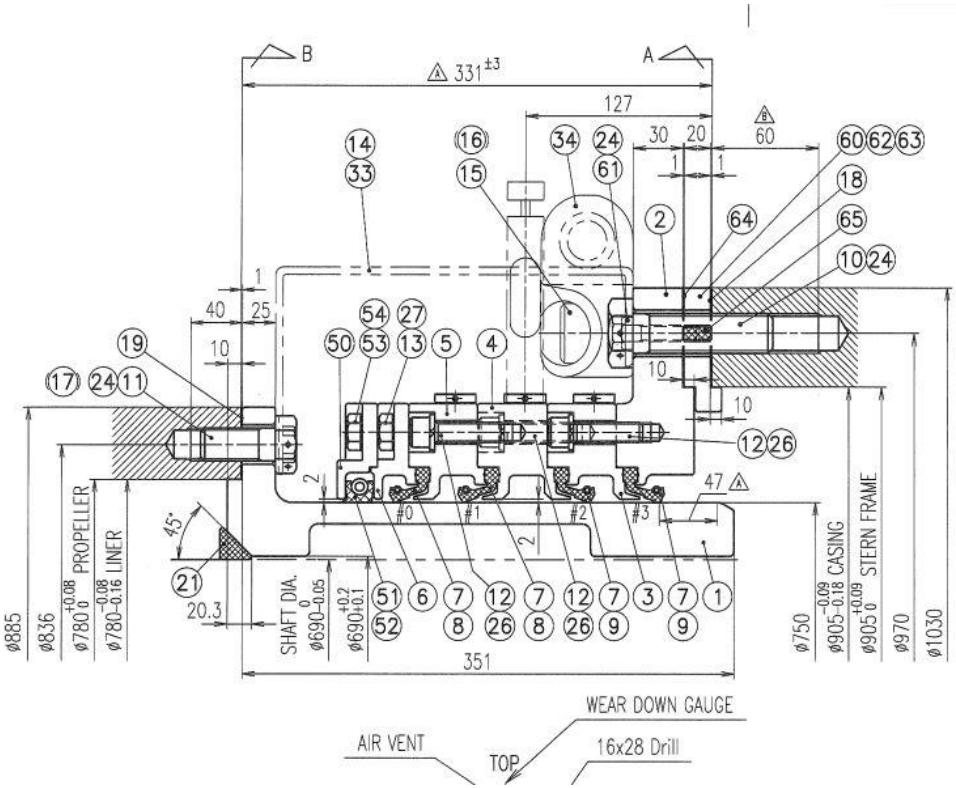
須配合吃水壓力打入空氣，防止海水侵入及滑油漏出。

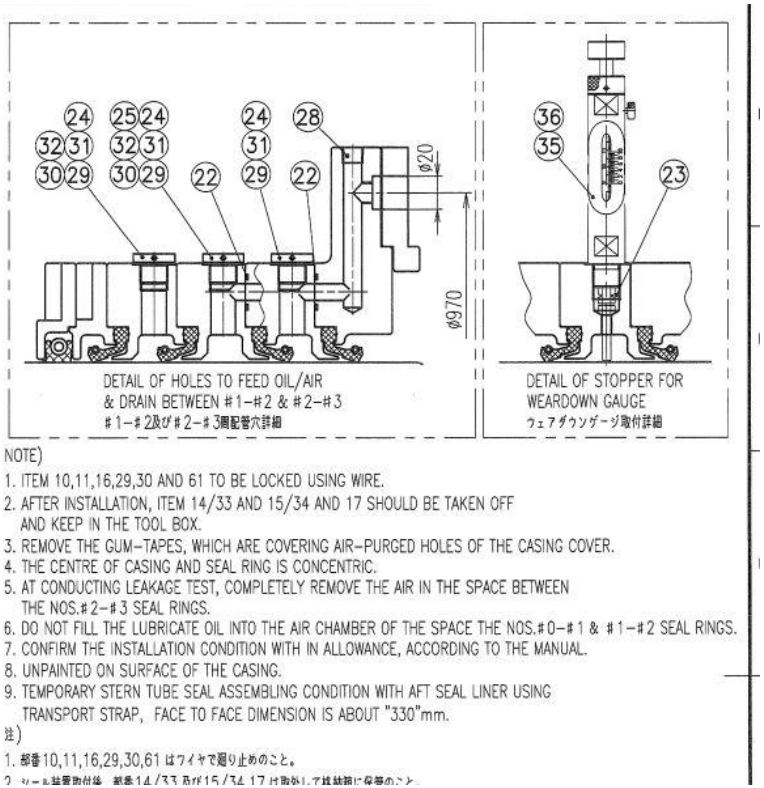




軸封 SEAL

後軸封





NOTE)

1. ITEM 10,11,16,29,30 AND 61 TO BE LOCKED USING WIRE.
2. AFTER INSTALLATION, ITEM 14/33 AND 15/34 AND 17 SHOULD BE TAKEN OFF AND KEEP IN THE TOOL BOX.
3. REMOVE THE GUM−TAPES, WHICH ARE COVERING AIR−PURGED HOLES OF THE CASING COVER.
4. THE CENTRE OF CASING AND SEAL RING IS CONCENTRIC.
5. AT CONDUCTING LEAKAGE TEST, COMPLETELY REMOVE THE AIR IN THE SPACE BETWEEN THE NOS.#2−#3 SEAL RINGS.
6. DO NOT FILL THE LUBRICATE OIL INTO THE AIR CHAMBER OF THE SPACE THE NOS.#0−#1 & #1−#2 SEAL RINGS.
7. CONFIRM THE INSTALLATION CONDITION WITH IN ALLOWANCE, ACCORDING TO THE MANUAL.
8. UNPAINTED ON SURFACE OF THE CASING.
9. TEMPORARY STERN TUBE SEAL ASSEMBLING CONDITION WITH AFT SEAL LINER USING TRANSPORT STRAP, FACE TO FACE DIMENSION IS ABOUT "330"mm.

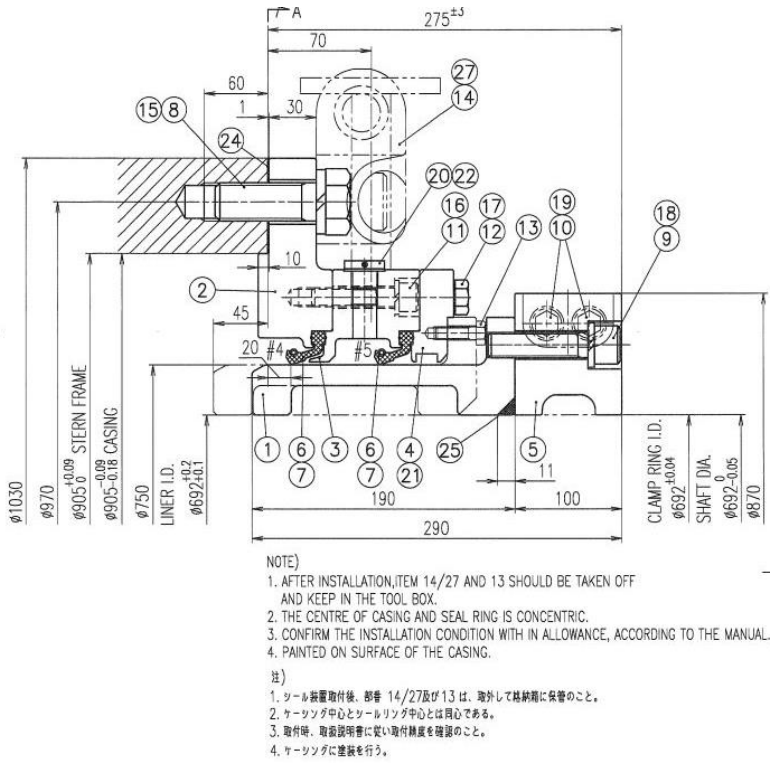
注)

1. 部番10,11,16,29,30,61 はワイヤで廻り止めのこと。

軸封 SEAL

軸封 SEAL

前軸封



NOTE)
1. AFTER INSTALLATION,ITEM 14/27 AND 13 SHOULD BE TAKEN OFF AND KEEP IN THE TOOL BOX.
2. THE CENTRE OF CASING AND SEAL RING IS CONCENTRIC.
3. CONFIRM THE INSTALLATION CONDITION WITH IN ALLOWANCE, ACCORDING TO THE MANUAL.
4. PAINTED ON SURFACE OF THE CASING.

注)
1. シール装置取付後、部番 14/27及び13は、取外して格納箱に保管のこと。
2. ケーシング中心とシールリング中心とは同心である。
3. 取付時、取扱説明書に従い取付精度を確認のこと。
4. ケーシングに塗装を行う。

軸封 SEAL

艙壁軸封用於，需水密艙壁。

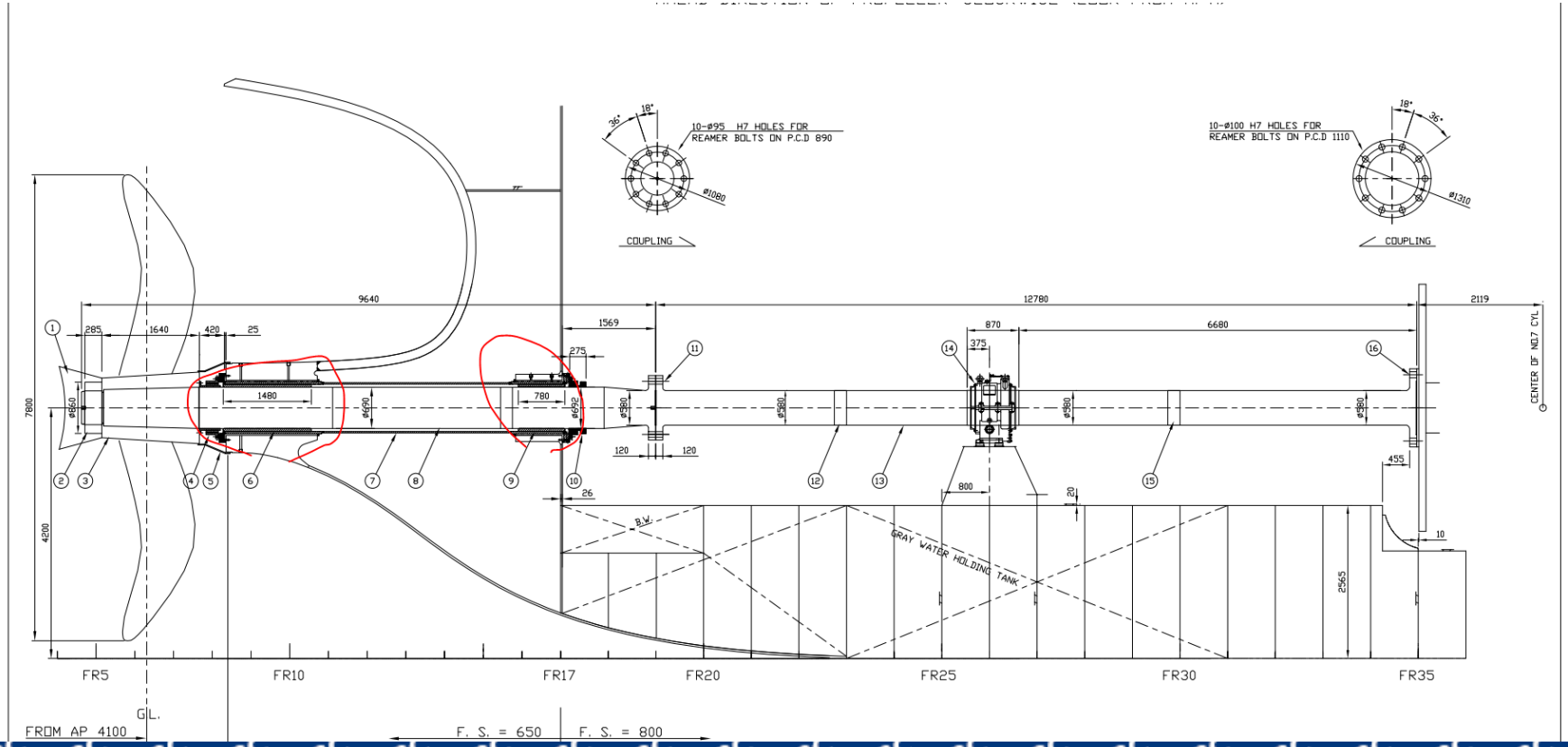
有的設計需連接冷卻水作沖洗、冷卻。

有的設計有橡膠氣球需連接空氣，避免軸封橡膠損壞，導致失去水密效果。

艉軸承 STERN BUSH(BEARING)

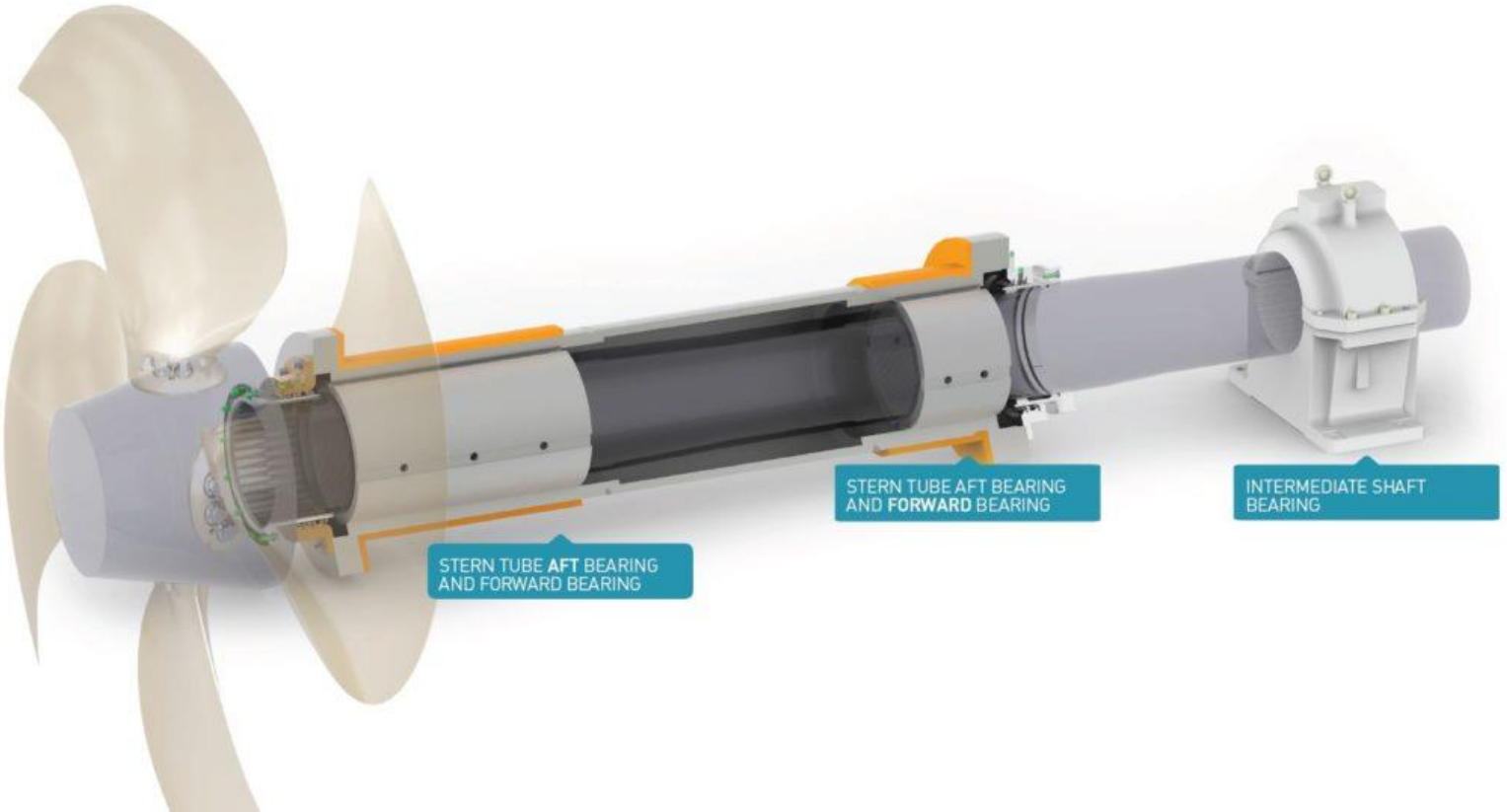
1. 傳統式艉軸承
2. 整合式艉軸管

材質分為:白合金(油潤)、橡膠(水潤)



艉軸承 STERN BUSH(BEARING)

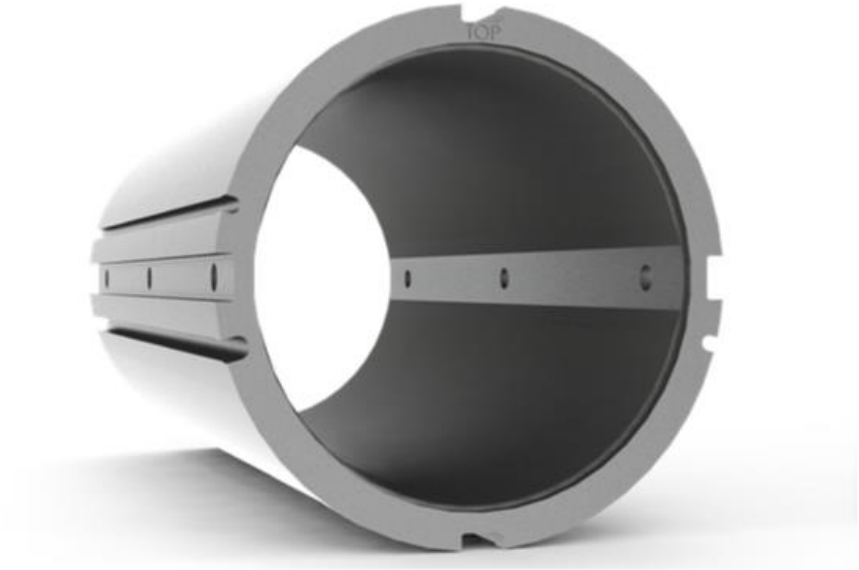
基本軸承佈置

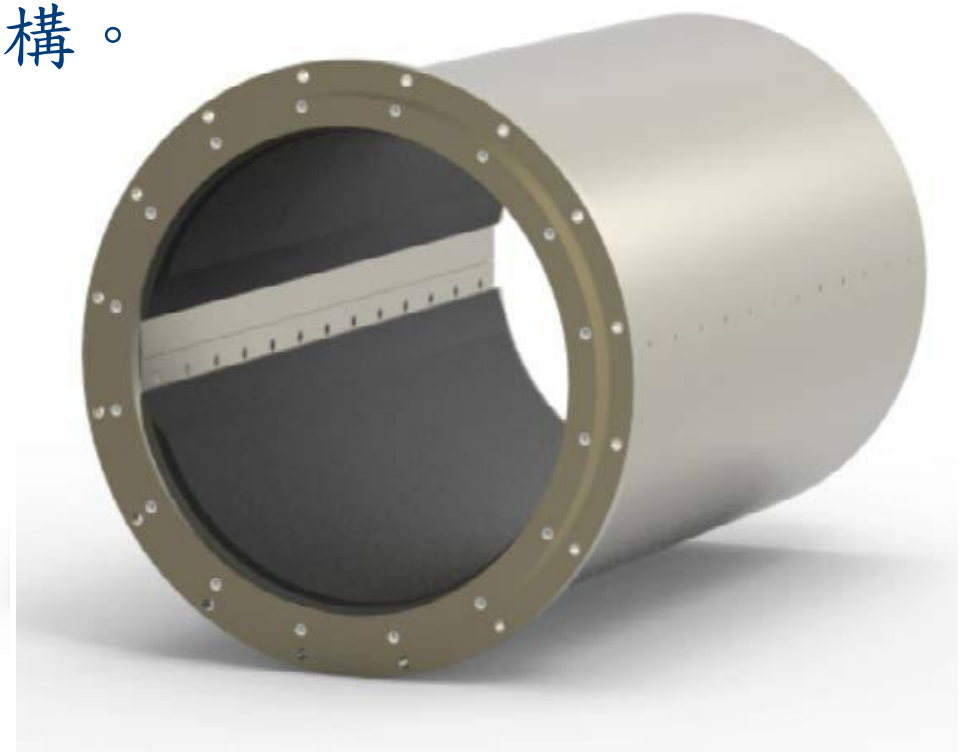


傳統式艉軸承

白合金材質(油潤)

傳統式艉軸承，船廠需於船艉艉軸管結構加工(搪孔)，再依計算將艉軸承壓入結構。

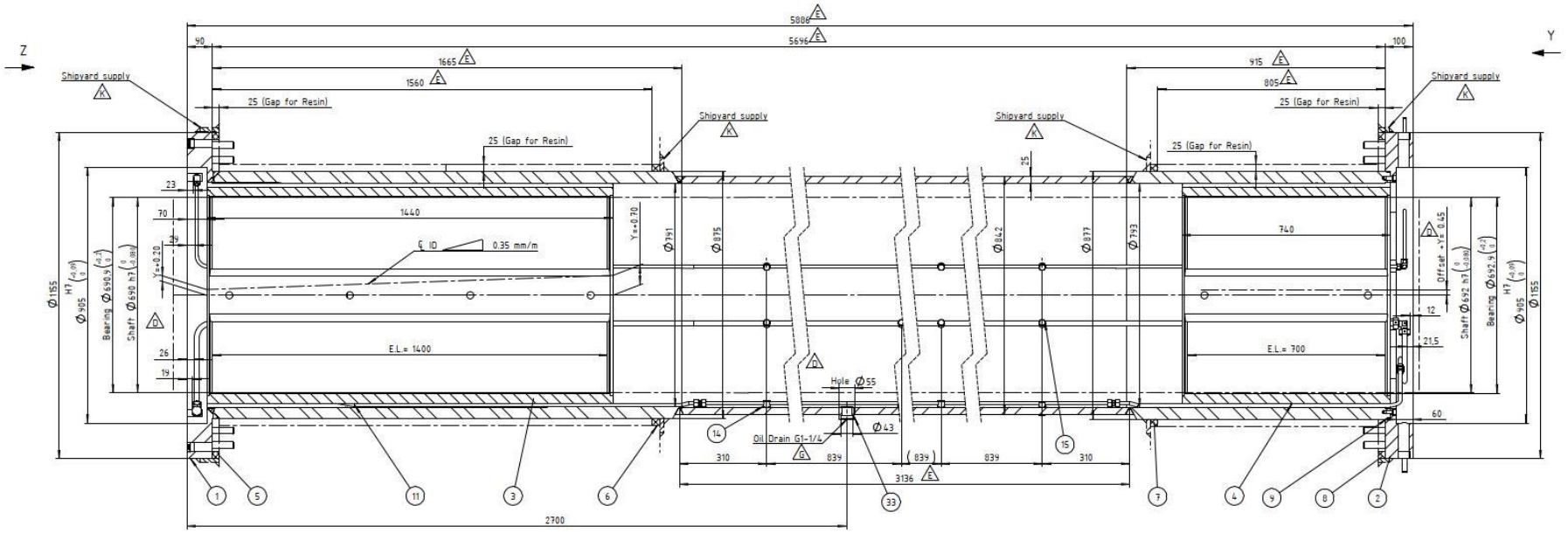




整合式艉軸承

白合金材質(油潤)

整合式艉軸承，就是將軸承與艉軸管整合為一體，船廠可直接安裝，減少艉軸管結構加工時間。



整合式艉軸承

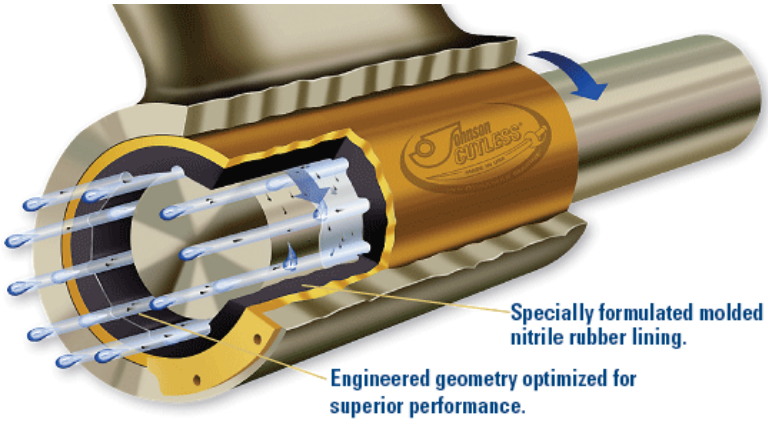
整合式艉軸承安裝

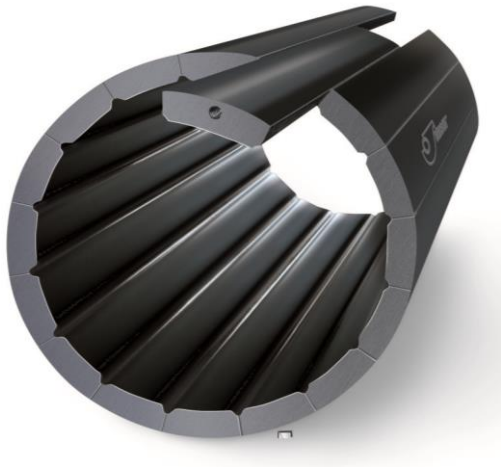
整合式艉軸管安裝是使用環氧樹酯resin chock灌漿方式，利用PUMP將RESIN CHOCK打入，填補結構與軸承間的空間，此環氧樹酯硬化之後強度跟鐵一樣。

艉軸承 STERN BUSH(BEARING)

橡膠材質(水潤):

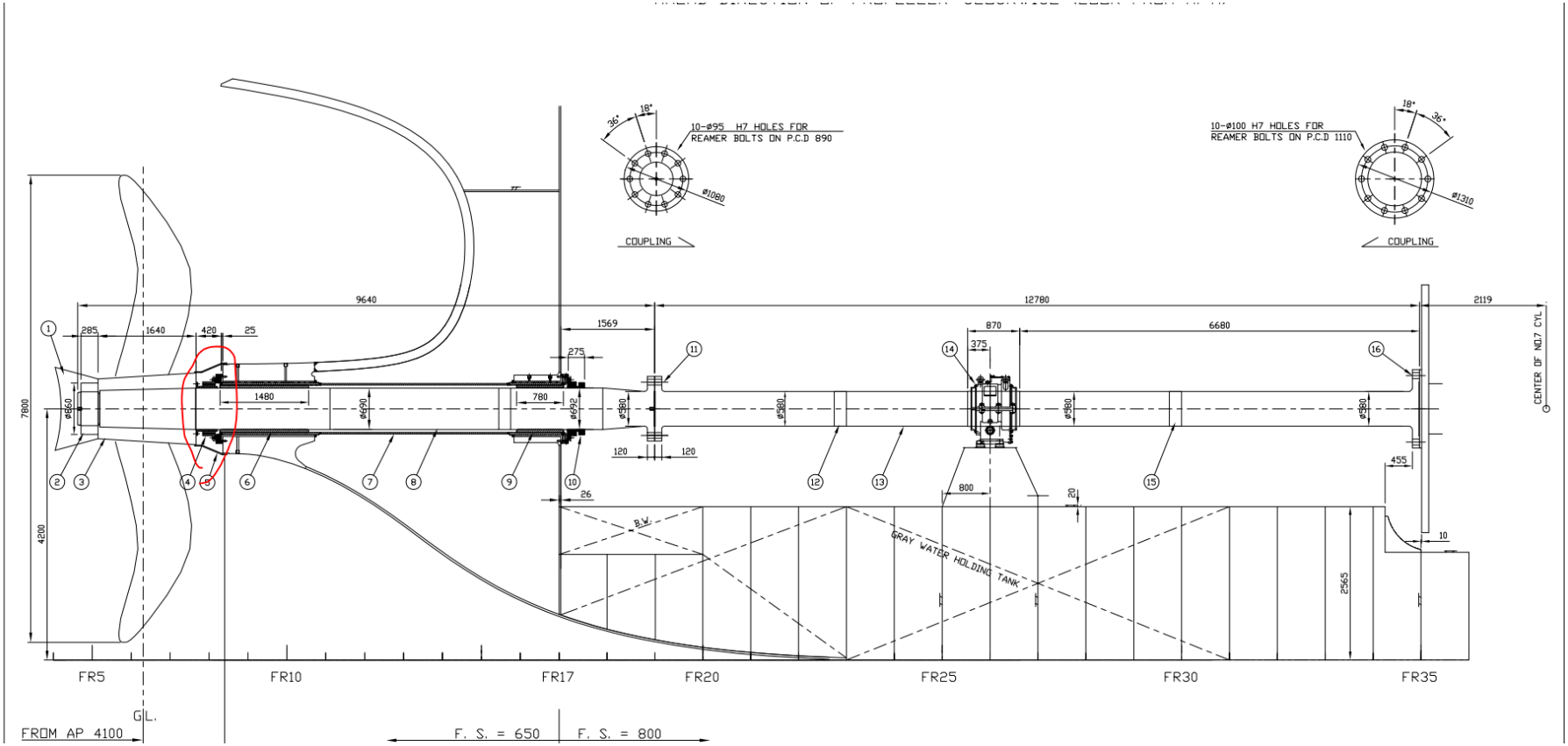
利用海水or淡水冷卻潤滑軸承與軸接觸，裝設在艉軸管結構內之橡膠軸承，無須加裝後seal，利用PUMP從前SEAL由內而外打入冷卻水潤滑。





防繩罩 ROPE GUARD

用於防止魚網纏繞，防繩罩上方裝有刀片。

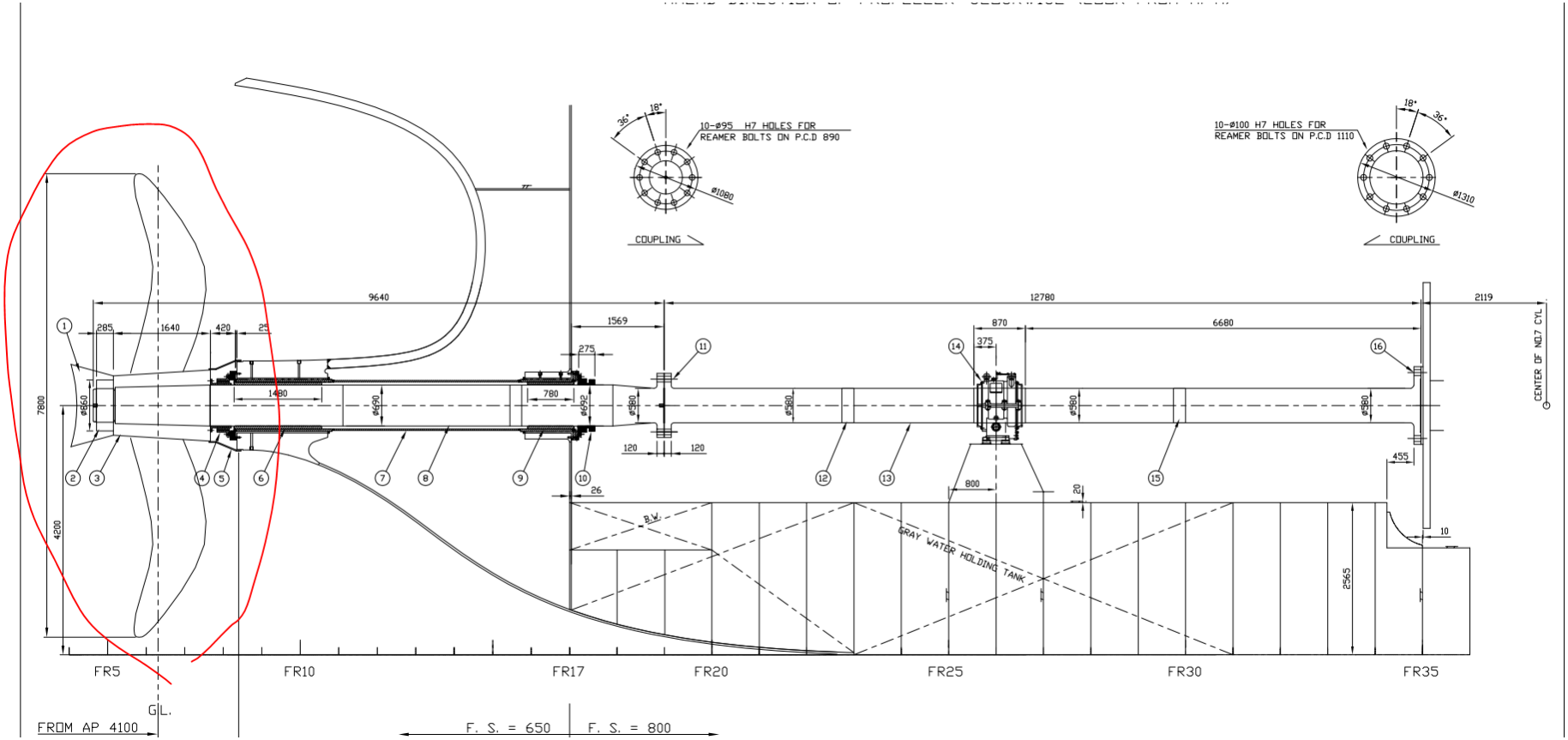


防繩罩 ROPE GUARD

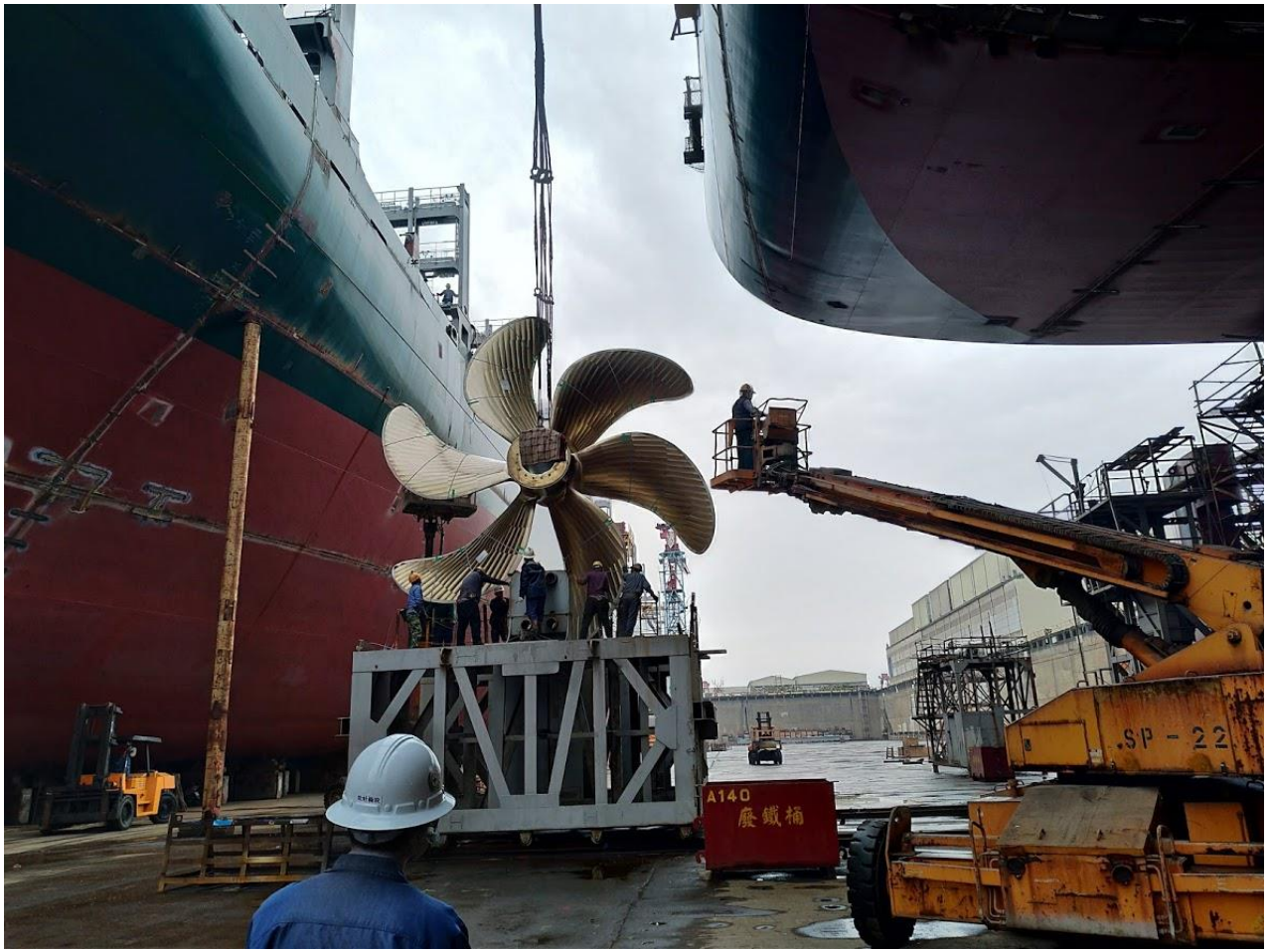
防繩罩 ROPE GUARD

螺槳、液壓NUT、將軍帽

依目前船舶設計，皆為無鍵式螺槳。

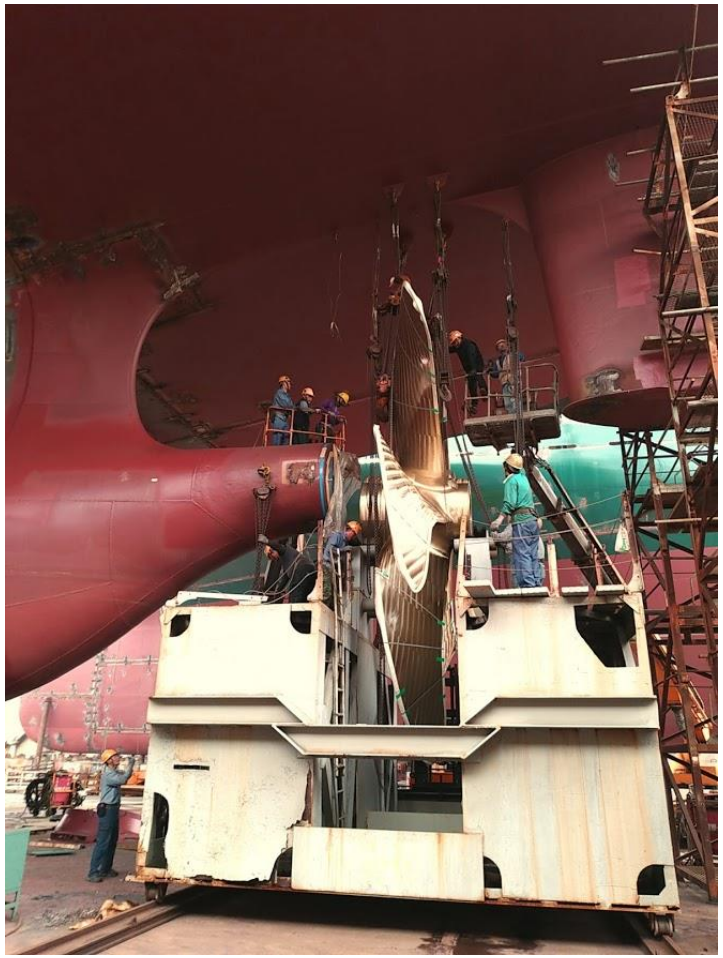


螺槳

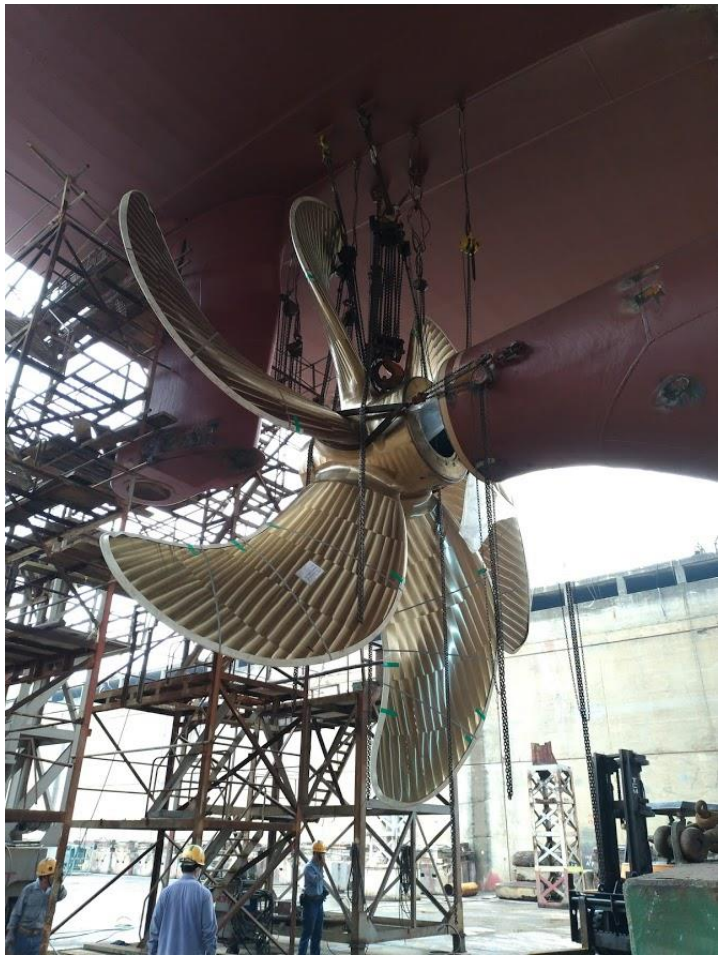


螺槳

螺槳



螺槳



螺槳

根據船東航速需求設計出螺槳葉片數量、線型、螺距等。

螺獎穀部(boss)依照軸徑與軸長設計。

必須依class需求帶入螺槳資訊進行壓入計算。

螺槳

在螺槳和軸製作完畢後需要做matching test。

因螺槳為無鍵式螺槳需靠摩擦力咬住，避免軸轉動時螺槳滑掉。

於艉軸螺槳段塗藍丹再以軸的重量放入螺槳中，看接觸面積是否有達70%以上。

螺漿壓入計算

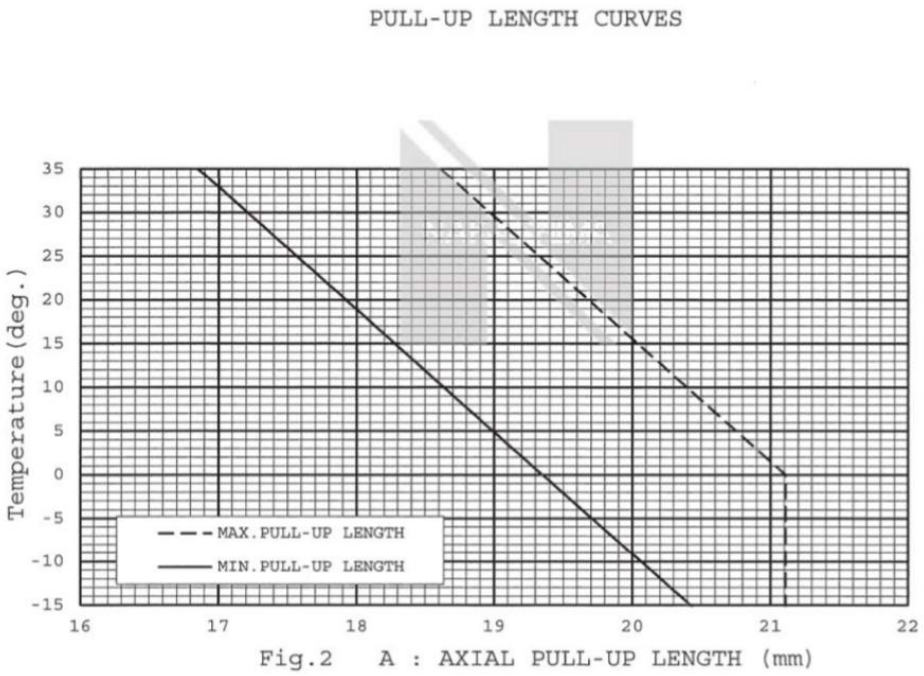


Fig.2 A : AXIAL PULL-UP LENGTH (mm)

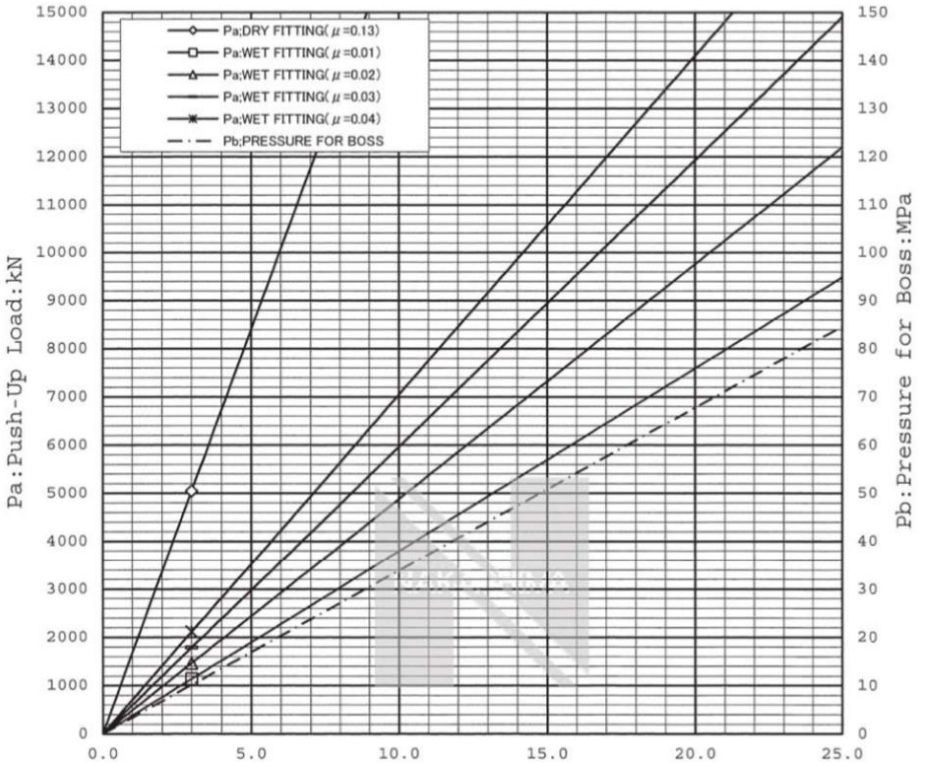
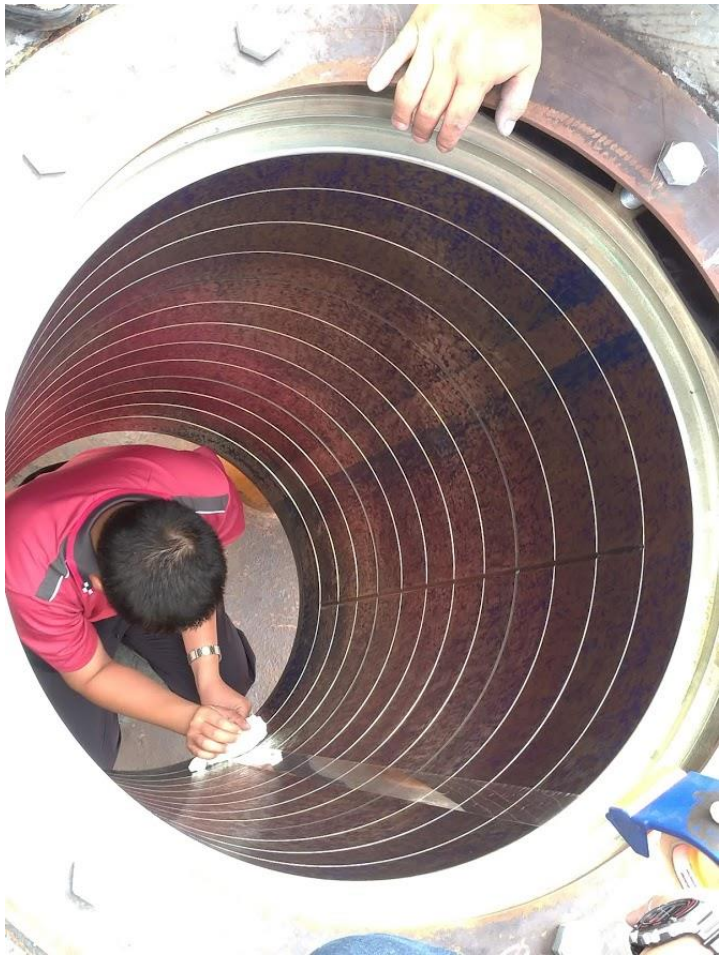


Fig.3 A : AXIAL PULL-UP LENGTH : mm

螺槳 matching test

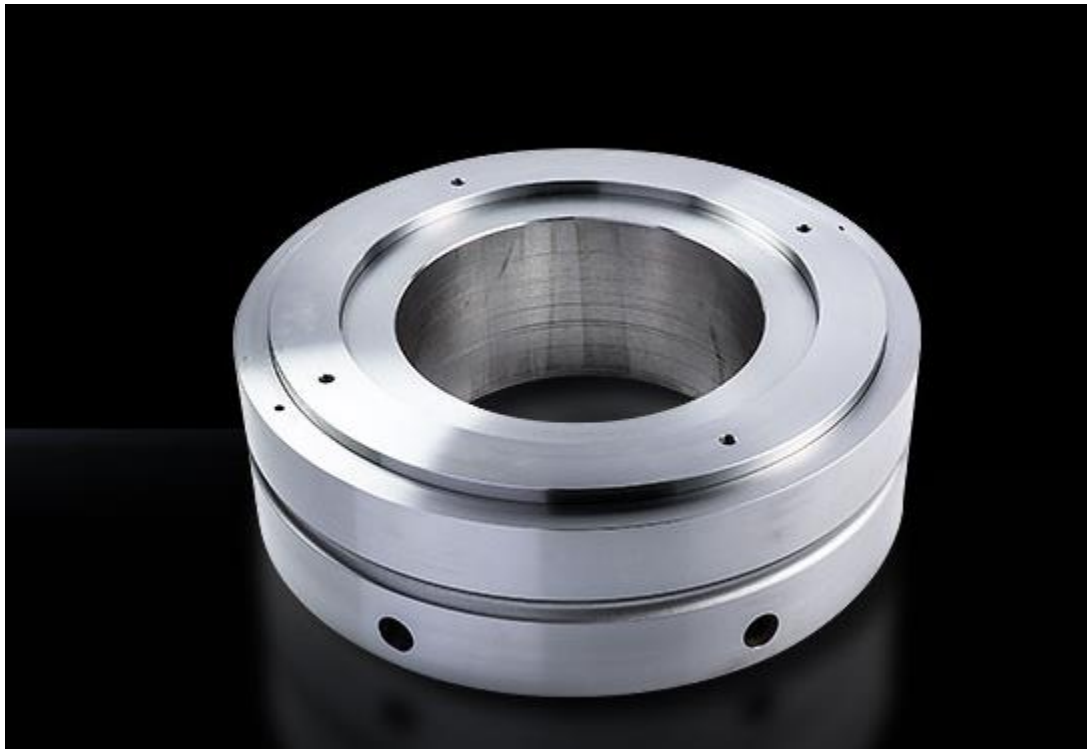
螺槳 matching test

螺槳 matching test



液壓NUT

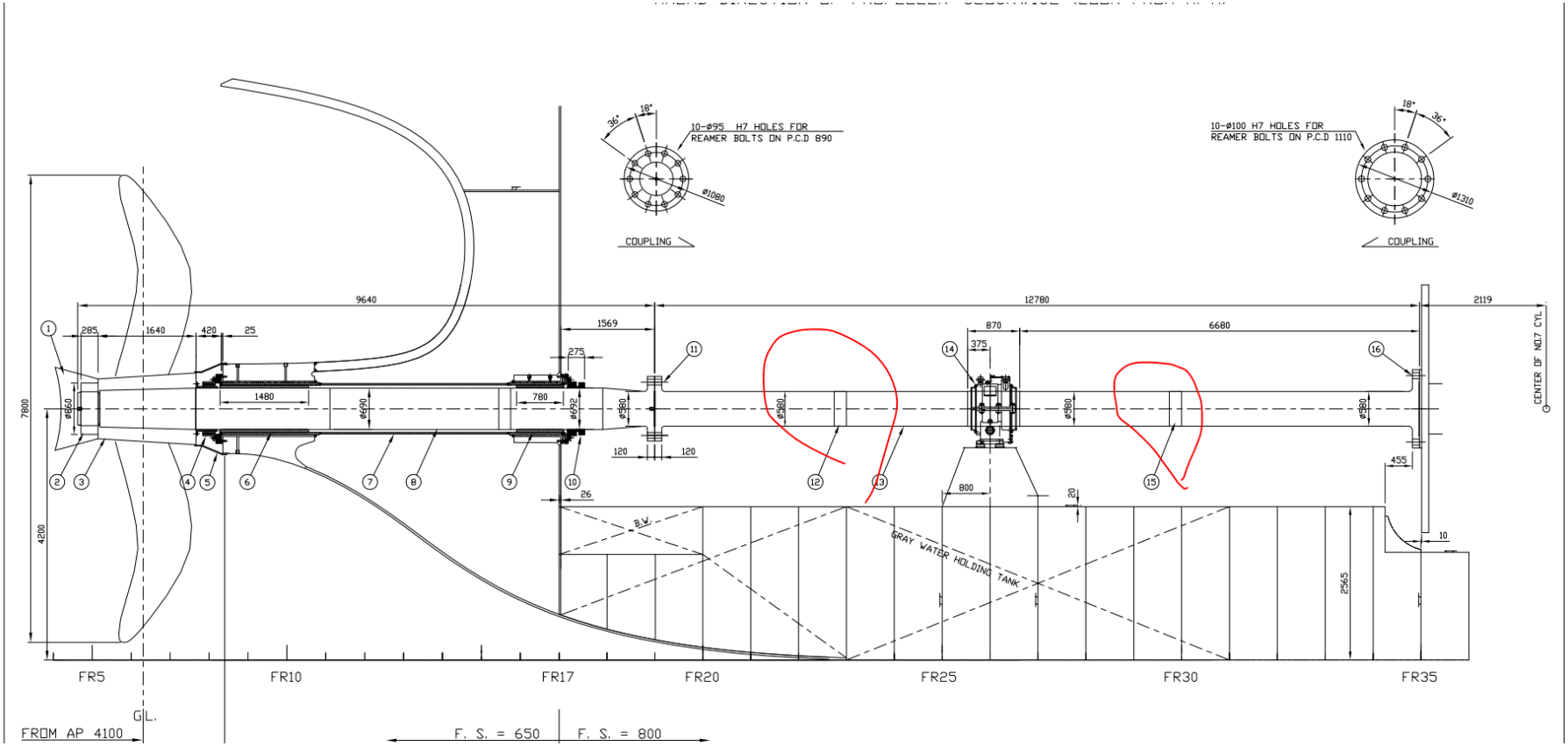
用於壓入螺漿、固定螺漿避免鬆脫。



將軍帽

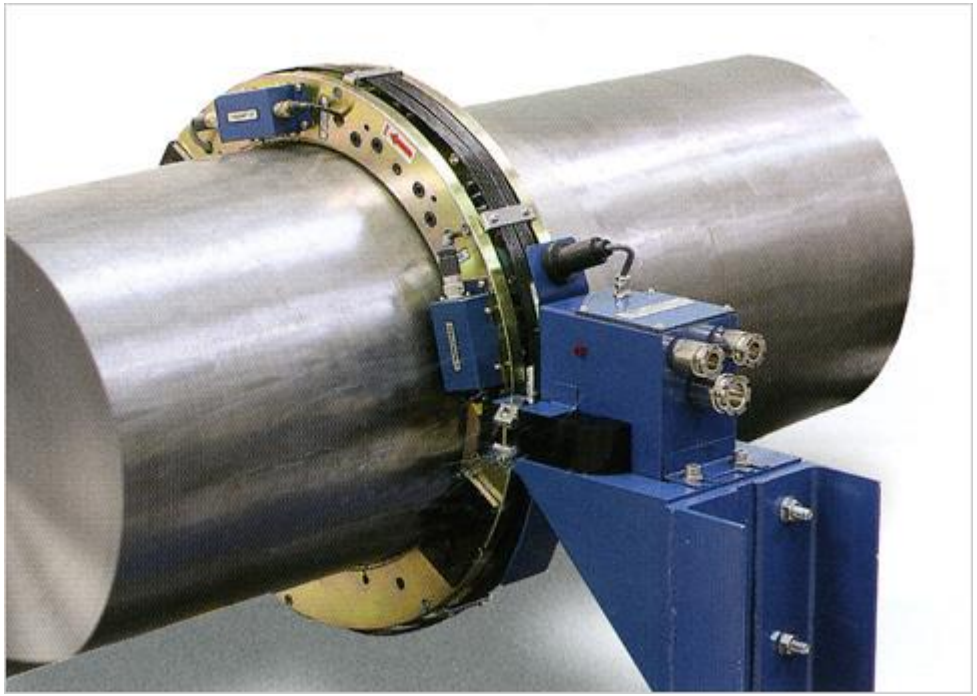
當液壓NUT安裝完後，會在將軍帽內部塗滿牛油，安裝在艉軸末端，鎖上螺絲並用水泥加固避免螺絲鬆脫。

馬力計及軸接地裝置


10-ø95 H7 HOLES FOR
REAMER BOLTS ON P.C.D 890
COUPLING
10-ø100 H7 HOLES FOR
REAMER BOLTS ON P.C.D 1110
COUPLING
9640
12780
2119
1569
870
6680
1480
780
120
120
800
455
26
20
10
GRAY WATER HOLDING TANK
B.W.L.
CENTER OF NO.7 CYL.
FR5
FR10
FR17
FR20
FR25
FR30
FR35
GL.
FROM AP 4100
F. S. = 650
F. S. = 800

馬力計

用於量測，軸馬力、轉速



軸接地裝置

軸系材料為鋼材，螺槳為銅。

兩個不同材質接觸會產生電位差，且軸在轉動時會產生電流。這些因素都會導致軸、軸承的腐蝕。

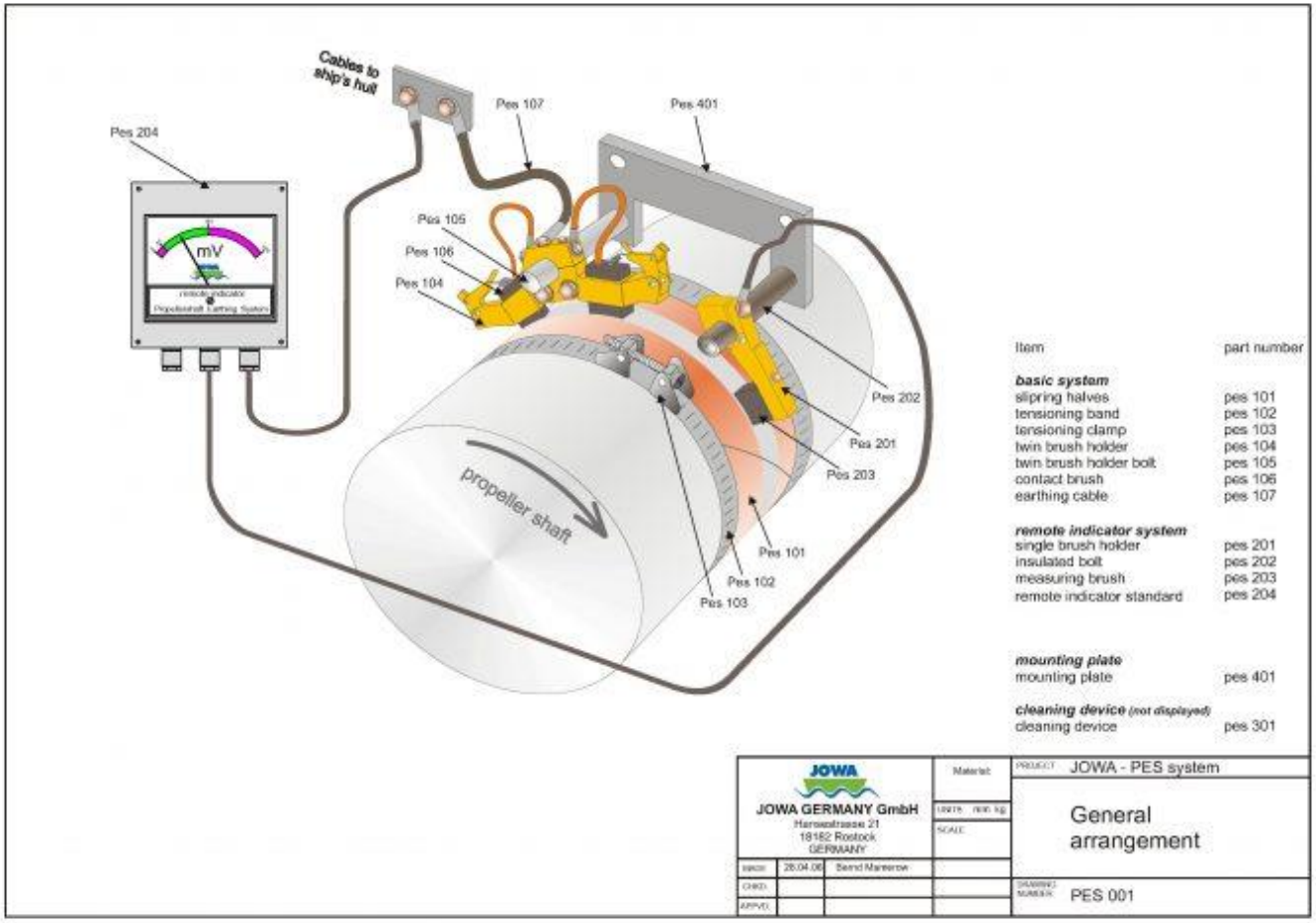
相對應比起來鋼活性較銅高，所以腐蝕將從鋼材開始。

電腐蝕也會造成軸承燒損。

電腐蝕也會造成曲軸箱有電火花有爆炸風險。

所以軸接地裝置目的就是將電流導向船體，保護軸系。

軸接地裝置


Cables to ship's hull
Pes 107
Pes 401
Pes 204
Pes 105
Pes 106
Pes 104
mV
Pes 202
Pes 201
Pes 203
propeller shaft
Pes 101
Pes 102
Pes 103
Item
part number
basic system
slipring halves
pes 101
tensioning band
pes 102
tensioning clamp
pes 103
twin brush holder
pes 104
twin brush holder bolt
pes 105
contact brush
pes 106
earthing cable
pes 107
remote indicator system
single brush holder
pes 201
insulated bolt
pes 202
measuring brush
pes 203
remote indicator standard
pes 204
mounting plate
mounting plate
pes 401
cleaning device (not displayed)
cleaning device
pes 301
JOWA
JOWA GERMANY GmbH
Hansastrasse 21
18182 Rostock
GERMANY
Material
PROJECT
JOWA - PES system
General arrangement
PES 001

看中

從船艉 AP點往船艏對準中心點

從M/E第一缸軸線高度往船艏對準中心點

看中

在軸承各點架設針孔，確認光線有穿透並保持一直線。

定位螺栓孔位

排軸規畫

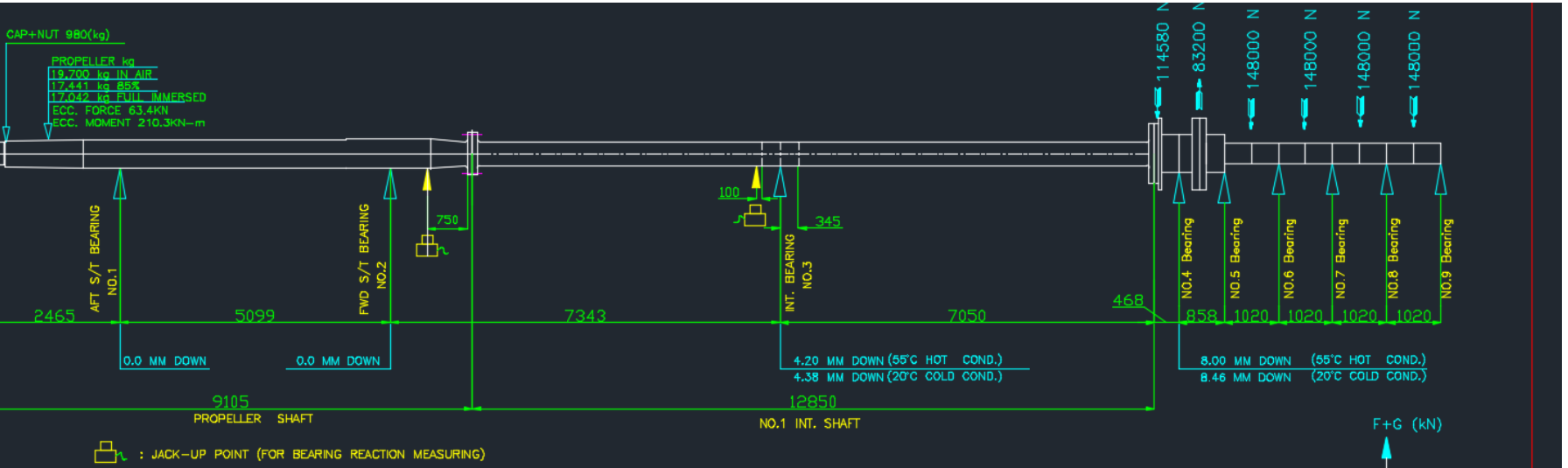
以軟體設計、計算出各軸承位移、附載及大軸安裝條件，並確認是否附載是否符合CLASS需求。

在排軸完成後即可安裝、固定主機及中間軸承。

開始排軸前會將主機定位螺栓孔鑽好，待排軸軸承附載無誤之後固定主機、中間軸承底座，

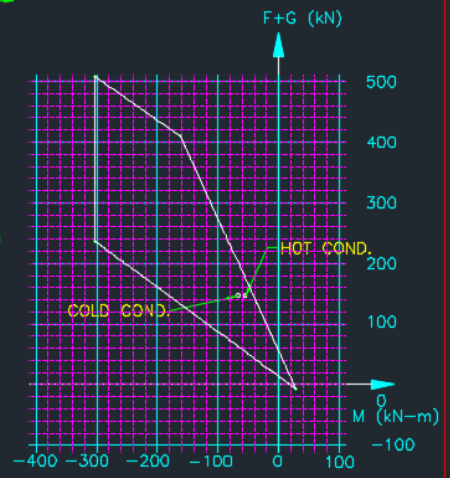
完成軸系的安裝。

Shafting alignment



PREDICTED BEARING REACTION (Kg) / PRESSURE (bar)
(THE COLD(20 DEG C),HOT ,RUNNING CONDITIONS ARE CALCULATED AT PROPELLER FULL IMMERSED CONDITION RESPECTIVELY,)

BEARINGS	AFT BUSH (kg)	AFT BUSH (bar)	FWD BUSH (kg)	FWD BUSH (bar)	INT. BEARING (kg)	INT. BEARING (bar)	MAIN BEARING (No.1)	MAIN BEARING (No.2)	MAIN BEARING (No.3)	F + G (kN)	M (kN-m)
STRAIGHT LINE	31,991	4.55	3,072	1.07	10,339	6.52	26,678	-7,381	16,003		
COLD CONDITION	30,131	4.29	5,973	2.08	10,638	6.71	12,572	8,088	15,553	148.1	-66.5
HOT CONDITION	30,186	4.29	5,920	2.06	10,468	6.61	13,895	6,906	15,588	149.7	-57.8
DRY DOCKING	30,787	4.38	5,537	1.93	10,959	6.92	10,434	7,488	15,562	146.7	-70.6
RUNNING COND.	20,551	2.92	9,964	3.47	9,834	6.21	14,589	6,358	15,604	151.3	-54.1
PERMITTED LOAD	56,168	8.00	22,925	8.00	19,000	12.00	Note*1				



Note*1
1. MB1 (aftermost): Min. 0kN ~ Max. 420kN (about 0 ~ 42 ton).
2. MB2,3: 21 ~ 420kN (about 2.1 ~ 42 ton).

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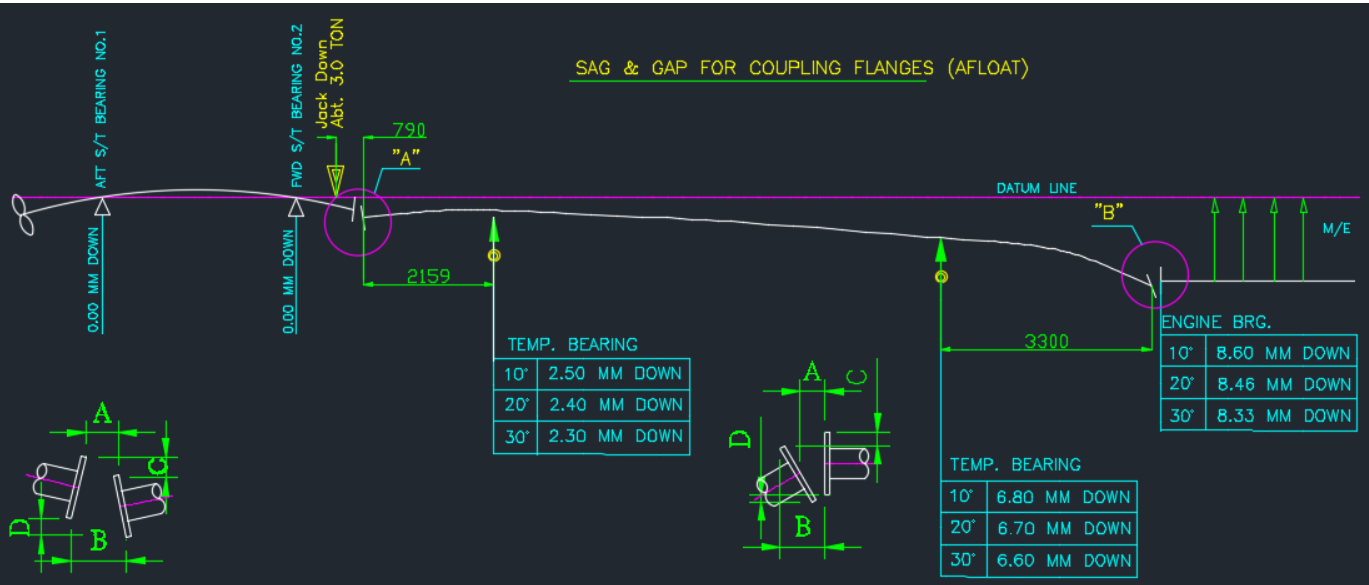
SAG & GAP



PROPELLER CONDITION	TEMP.	SAG (C+D)/2 (mm)	GAP B−A (mm)
85% (VOLUME) IMMERSED	10°C	0.53 ±0.1	0.11 ±0.1
	20°C	0.48 ±0.1	0.11 ±0.1
	30°C	0.43 ±0.1	0.11 ±0.1
DRY DOCK	10°C	0.51 ±0.1	0.09 ±0.1
	20°C	0.46 ±0.1	0.09 ±0.1
	30°C	0.41 ±0.1	0.09 ±0.1

DETAIL "A"

PROPELLER CONDITION	TEMP.	SAG (C+D)/2 (mm)	GAP B−A (mm)
85% (VOLUME) IMMERSED	10°C	0.74 ±0.1	0.11 ±0.1
	20°C	0.76 ±0.1	0.11 ±0.1
	30°C	0.78 ±0.1	0.11 ±0.1
DRY DOCK	10°C	0.74 ±0.1	0.12 ±0.1
	20°C	0.76 ±0.1	0.12 ±0.1
	30°C	0.78 ±0.1	0.12 ±0.1

DETAIL "B"

◎ : TEMP. BEARING (FOR SAG & GAP METHOD)

▽ : JACK DOWN (FOR SAG & GAP METHOD)

NOTE: 1. 3 TONS JACK DOWN FORCE IS REQUIRED WHILE SAG & GAP METHOD CARRY OUT.
2. SAG & GAP CALCULATION, THAT ARE ACCORDING TO THE VOLUME OF PROPELLER AT 85% IMMERSED CONDITION IN SEA WATER OR AT DRY DOCK CONDITION
3. MAIN ENGINE TO BE HOLD STRAIGHT WHILE SAG & GAP CARRIED OUT.
4. THE SAG & GAP METHOD IS PROVIDED FOR YARD MECHANIC TO SET SHAFTING ONLY. IT IS NO NEED TO BE WITNESSED BY CLASS SURVEYOR & OWNER REPRESENTATIVE, BUT THE DATA SHOULD BE RECORDED.

注意: 1. 拆軸時請確認Jack Down力道為3噸.
2. 卓葉體積淡水率分別以85%及乾塢計算.
3. 當執行SAG & GAP 時主機需保持直線.
4. SAG & GAP值供船廠於施工過程中確認記錄用,不需交驗船級和船東.相關量測數據資料做成紀錄後,提交船東參考。

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Q & A