# Marine Engineer E-Book and Review Guide

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F.G. MARCOS

BY:

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# CHIEF ENGR. FERDINAND G. MARCOS

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## ACKNOWLEDGEMENT

This book was exclusively prepared to help the Marine Engineers while reviewing the different subjects in preparation for the government licensure examination conducted by the Professional Regulation Commission.

It is a compilation of solutions to the problems encountered during the recent examination. There are also exercise questions including an outline to examinees, to serve as an instant refresher on the most fundamental concept and principles in accordance with the scope of the examination usually given by the Board of Examiners at the PRC.

It is also a complete practical guide to all apprentice cadet, ship personnel and engineers on board, on the latest technology to bring you the most up-to-date coverage possible of high standard on the job aboardship.

The author gratefully acknowledges and appreciates the support of the staff and students of SEALANE CONSULTANCY AND GENERAL SERVICES, INC.

This book is lovingly dedicated to my wife, Terry and my daughters, Sarah Jane, Christine Joy and my sons Ferdinand Jr., Ferdinand Marcos II who have been my constant inspiration in my journey to the port of success.

FERDINAND G. MARCOS Chief Engineer PMMA, Class 1981

Manila, Philippines 11/29/96

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## MATHEMATICS

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In performing our daily duties as ship personnel, engineers, and crew aboard ship we often solve simple problems involving tank calculations, ship speed, horsepower, consumptions and mathematical calculation which need our basic fundamental learning process in solving every day problems:

## **BASIC FUNDAMENTAL OF MATHEMATICS**

**MULTIPLICATION** – is the process in which it is desired to know how much one number is time another.

Examples:

1.1.1.1

2	X	6	=	12
432	x	19	=	8208
0.32	x	0.0046	=	0.001472
3.9472	X	43.16	=	170.36115

**DIVISION** - this is the process in which it is desired to know how many times one number will go into another.

Examples:

6	÷	3	=	2,	6/3	=	2	6	=	2
81	÷	9	=	9				3		
18653	÷	18	=	1036.28						
1121	÷	3 3/4	H	298.93						

**ADDITION** – adding numbers in similar terms and add the numbers in each column separately.

Examples:

	81	+	5	+	12	=	98	
	6.5	+	3	+	.5	=	10	
	2a	+	7b	+	3c			946.75
	5a	-	2b	+	6c			8.42
-	7a	+	5b	+	9c	<b></b>		.00842
			-					955.17842

**SUBTRACTION**—to subtract numbers or algebraic terms, change the sign of the term to be subtracted and then add.

Examples:

92	-	12	=	80
12	-	2.5	=	9.5
8x	-	(-5x)	=	13x
8x		5x	=	Зx

### **OPERATIONS WITH SIGNED NUMBERS**

#### 1. ADDITION

a. For numbers with same signs, add their absolute values and prefix the common sign to the sum.

Examples:

(+8) + (+4) = +12(-8) + (-4) = -12

b. For two numbers with different signs, subtract the lower absolute value from the higher absolute value and prefix the sign of the number with higher absolute value to the difference.

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Examples:

(+8) + (-4) = +4(-8) + (+4) = -4

### 2. SUBTRACTION

a. Any two numbers with same signs, subtract the lower absolute from the higher absolute value and prefix the sign of the number with higher absolute to the difference.

Examples:

(+4) –	(+2)	=	+2
(-4) —	(-2)	=	-2

b. Any two numbers with different signs, add the absolute values and prefix the sign of the number with the higher absolute value to the sum.

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Examples:

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(+4) -	(-2)	=	+6
(-4) -	(+2)	=	-6

## 3. MULTIPLICATION

a. The product of two numbers having the same signs is always positive.

Examples:

(+6)	(+3) =	(+18)
(-6)	(3) =	(+18)

b. The product of two numbers with different signs is always negative.

Examples:

(+6)	(-3)	-	(-18)
(-6)	(+3)	=	(-18)

## 4. **DIVISION**

a. The quotient of two numbers having the same signs is always positive.

Examples:

(+9) /	(+3)	=	(+3)
(-9) /	(-3)	8	(+3)

b. The quotient of two numbers with different signs is always negative.

Examples:

(+9) /	(-3)	=	(-3)
(-9) /	(+3)	=	(-3)

## **TEMPERATURE SCALE CONVERSION**

### To convert 212°F to °C

Subtract 32 from °F and divide remainder by 9 and multiply by 5.

Ex:  $212 - 32 = 180 \div 9 = 20 \times 5 = 100 \degree$ C

## To convert 260 °C to °F

Divide by 5, multiply by 9 and add 32

Ex:  $260 \div 5 = 52 \times 9 = 468 + 32 = 500 \degree F$ 

4

**DECIMALS**— a number less than a whole number may be expressed as a fraction or as a decimal.

one tenth = 1 = 0.1 10 one hundredth = 1 = 0.01 100 one thousandth = 1 = 0.001 1000 one and three tenths = 1 3 = 1.3 10

When decimal number are added together or subtracted, the decimal point must be placed one below the other.

Examples:

a)	Add	4.3785 to 29.46
		4.3785
		_29.46
		33.8385
b)	Subtract	3.8648 from 48.82
		48.8200

<u>3.8648</u> 44.9552

**Conversion of Percent to Decimal** 

Examples:

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88%	=	0.88
0.35	=	35%
1.58	=	158%
99.34%	=	0.9934

$$1/2 = 0.5$$
  
 $5/8 = 0.625$   
 $3/4 = 0.75$ 

**POWER** – an index is a short method of expressing a quantity multiplied by itself a number of times.

Examples:

2³	X	2⁴	=	27	(adding indices)
35	x	3²	=	3³	(a subtracting indices)
(2²)	3		=	2 <sup>6</sup>	(multiplying indices)

**ROOTS** – is the opposite of a power and the root symbol is  $\sqrt{}$ 

Examples:

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the square root of 49 = 
$$\sqrt{49}$$
 = 7  
the cube root of 27 =  $\sqrt[3]{27}$  = 3  
 $\frac{6^2}{2}$  = 3<sup>2</sup> = 9

**RATIO** – is a comparison of the magnitude of one quantity with another quantity of the same kind; it expresses the relationship of one to the other and therefore stated in fractional form. The ratio sign is the colon:

Example:

The lengths of two bars are 250 millimeters and 2 meters respectively, the ratio of one to another expressed.

	250 :	, 2000	note: both quantities must be same units
or	1:	8	

**PROPORTION** – is an equation of ratios, expresses that ratio of one pair of quantities is equal to the ratio of another pair. The proportion sign is the double colon:

Examples:

$$5 : 10 :: 20 : 40$$
  
or 5 : 10 = 20 : 40  
or  $\frac{5}{10} = \frac{20}{40}$ 

Q. A pump takes 55 minutes to deliver 4400 liters of water. How long would it take to deliver 6000 liters?

Let X = time in minutes to deliver 6000 liters. **Batio of times taken** :: Ratio of quantities deliver 55:x :: 4400 : 6000 Xx 4400 55 x 6000 \_\_\_ 6000 55 x x \_ 4400 75 minutes. X =

**METHOD OF UNITY** – deals to proportion problems especially with compound proportion with more than two pair quantities.

Example:

A ship travelling at 12 knots can complete a certain voyage in 16 days. How many days would the ship take to do the same voyage at a speed of 15 knots?

	=	12.	8 da	ys
			15	
At a speed of 15 knots, time	=	16	X	12
At a speed of 1 knot, time	=	16	X	12 days
At a speed of 12 knots, time	=	16 (	days	i

**PERCENTAGE** – is another method of expressing a ratio in fractional form using 100 as the denominator and symbol %.

Ratio of 4 to 25 =  $\frac{4}{25}$  in fractional form =  $\frac{16}{100}$  denominator of 100 = 16% in percentage form.

**FACTORING** – is the reverse of multiplying, it is the process of finding the numbers or quantities which, when multiplied together will constitute the expression given to be factorized.

Example: 2 3 2 2 x .5 X + X 4 \_ 2 (3 + 4 \_ 5) = з<sup>1</sup> 3x + 2xy ΧZ (3 + 2y = X \_ Z) Y<sup>2</sup> – 16 (y + 4) (y -4) =

**EVALUATION** – is the process of substituting the numerical value of the algebraic symbols and working out the value of the whole expression.

. . . .

Examples:

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Evaluate  $3 \times y + X^2 - 4 y$ when x = 2 and y = 3  $= 3 \times y + x^2 - 4y$   $= 3 \times 2 \times 3 + 2^2 - 4 \times 3$  = 18 + 4 - 12= 10

**LOGARITHMS** – purpose is to be reduced the amount of labor and time involved in multiplication and division and the solution of powers and root.

Examples:

1. Find the value of 0.04218 x 4750

Log of 0.	04218	=	1.37489
Log of	4750	=	3.67669 (add)
* .	Sum	=	2.3018
antilog of	2.3018	=	200.4 ans.

1.5

## 2. Divide 240 by 4345

Log of 240	=	2.3802
Log of 4345	=	3.6380
difference	=	-1.2578
antilog of -1.2578	=	0.05524 ans

POWER - Find the value of (4.189)<sup>2</sup>

log of 4.189	=	0.6221
multiply by the power	=	1_
		1.2442
antilog of 1.2442	=	17.55 ans.

ROOT - Find the square root of 7365 log of 7365 = 3.8672 3.8672 divide by 2 = 1.9336 antilog of 1.9336 = 85.82 ans.

EQUATION – is an expression consisting of two sides, one side being equal in value to the other.

4x	+	10 =	18	14x - 2x - 5x = 8 - 15 + 28
<b>4</b> x	=	18 —	10	7x = 21
<b>4</b> x	=	8		x = 3
x	=	2		

Simplify the following equations:

a)  $(a+b)^2$  b)  $(a-b)^2$ 

Ans.	a	+	b			a 🗄	<u> </u>	b	
x	a	+	b		X	່	_	b	
	a²	+	ab			a²	-	ab	
		+	ab +	b²			-	ab +	b²
	a²	+	2ab +	b²	·	a²	-	2ab +	b²

# b) Find the value of x and y in the following equations:

5x		5у	=	50 — 1
7x	+	5у	#	130 2
12x			=	180
		x	=	180
				12
		x	=	15

Substitute:

$$5x - 5y = 50$$
  

$$5 (15) - 5y = 50$$
  

$$75 - 5y = 50$$
  

$$- 5y = 50 - 75$$
  

$$Y = -25$$
  

$$- 5$$
  

$$Y = 5$$

c) Add the following mixed numbers.

5 3/8, 12 1/4, 3 3/4  

$$\frac{43}{8} + \frac{49}{4} + \frac{15}{4}$$
LCD 
$$\frac{43 + 98 + 30}{8}$$

$$= \frac{171}{8}$$
 or 21.375

# **MATHEMATICS (ALGEBRA)**

1. One number is 8 times another number and their sum is 45. Find the unknown?

Let x = smaller number  

$$8x = larger number$$
  
x +  $8x = 45$   
 $9x = 45$   
x =  $\frac{45}{9} = 5$  smaller number

8(5) = 40 bigger number

2. If a rectangle is 4 times as long as its width and its perimeter is 60 ft. Find the length and the width.

Let x = width 2(4x) + (2x) = 60 4x = length 8x + 2x = 60 10x = 60 x = 6 width therefore: 4x = 4(6) = 24 length

3. How long/will it take Oscar and Bong, together to plow a field which Oscar can do alone in 5 days, and Bong do the job in 8 days?

Let x = number of days Oscar & Bong can plow the field together.  $\begin{array}{rcl}
1 & = & \text{work done by Oscar & Bong in one day} \\
\hline
1 & = & \text{work done by Oscar in one day} \\
\hline
5 & & \\
\hline
1 & = & \text{work done by Bong in one day} \\
\hline
8 & & \\
\hline
Equation: \\
\begin{array}{rcl}
1 & + & 1 & = & 1 \\
\hline
5 & & 8 & = & 1 \\
\hline
5 & + & 8 & = & 1 \\
\hline
40 & & x \\
\hline
13 & = & 1 \\
\end{array}$ 

40 x  
13 x = 40 x = 
$$\frac{40}{13}$$
  
x = 3.08 days

4. The sum of two consecutive number is 26. What are the numbers.

Solution: Let x = 1st number  
x + 1 = 2nd number  
x + x + 1 = 26  
2x + 1 = 26  
2x = 26 - 1  
x = 
$$\frac{25}{2}$$
  
x = 12.5

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Q. When you add 5/8; 7/12 and 11/24, what will be the sum?

$$\frac{5}{8} + \frac{7}{12} + \frac{11}{24}$$
Find: LCD = 24  
$$\frac{15 + 14 + 11}{24} = \frac{40}{24} \text{ or } 1\frac{2}{3}$$

0

Q. When you subtract 5/6 from 8/15, what will be the difference?

$$\frac{5}{6} - \frac{8}{15}$$
LCD = 30
$$\frac{25 - 16}{30} = \frac{9}{30} \text{ or } \frac{3}{10}$$

Q. What is the product of 5/8 and 4/7?

$$\frac{5}{8} \times \frac{4}{7} = \frac{5}{2} \times \frac{1}{7} = \frac{5}{14}$$

Q. The quotient of 13 divided by 3/7 is:

$$13 \div \frac{3}{7} = \frac{13}{1} \times \frac{7}{3} = \frac{91}{3}$$
 or  $30 \pm \frac{1}{3}$ 

Q. Solve for x in the equation 12x + 25 - 35 = 14x + 22x - 2

$$12x + 25 - 35 = 14x + 22x - 2$$

$$12x - 14x - 22x = -22 + 35 - 25$$

$$12x - 36x = 35 - 47$$

$$-24x = -12$$

$$x = -12$$

$$-24$$

$$x = 1$$

$$2$$

Q. A wire is to be cut so that one piece is shorten than the other by 8 meters. How long are the pieces if their combined length is 24 meters.

$$x + x - 8 = 24$$

$$2x - 8 = 24$$

$$2x = 24 + 8$$

$$x = \frac{32}{2}$$

$$x = 16 \text{ meters longer wire}$$

$$x - 8 = 16 - 8 = 8 \text{ meters shorter wire}$$

# **CONVERSION FACTORS**

# Temperature Scale:

1. Convert 100°C - °F and 212°F - °C

Ans.	٩	=	9 C	+	32	°C	=	<u>5</u> (°F –	32)
		=	<u>9</u> × 100	) +	32		=	<u>5</u> (212 –	32)
		=	900	+	32		=	<u>5</u> (180)	
		=	5 180	+	32		ш	900	
	٩F	=	212					9	
						٥C	=	100	

2.	Convert	300°C	-	٩F	Answer:	572.ºF
		400°F	-	°C		204.44 °C
		80°C	_	٩F		176ºF

## Measurements:

- 1. Convert the followings:
  - a) 60 mi/hr. Ft/Sec, meter/sec.

•

- b) 6.56 km/hr. Ft/Sec.
- c) 375 hp watts
- d) 700 mm feet

Answer:	a) 60 mi	x 1.6 km x 1000 m x 3.28 ft. x 1 hr. x 1 min.	
	hr	1 mi. 1 km. 1 m 60 min. 60 sec	).
	= .	<u>314880</u> = 87.47 ft/sec. 3600	
· ·	=	87.46 ft/sec = 26.67 m/sec 3.28ft/m	
	b) 6.56 k	rm/hr x <u>1000 m</u> x <u>3.28 ft.</u> x <u>1 hr</u> 1 km 1 m 3600 sec.	
	=	<u>21516.8 ft.</u> 3600 sec = 5.98 ft./sec.	
	c) 375	hp x <u>746 watts</u> 1 hp	
		= 279,750 watts.	
	d) 700 m	nm x <u>1 cm x 1 inch x 1 ft.</u> 10 mm. 2.54 cm. x 12 in.	
	=	2.30 ft.	

Q. A truck's speed increases uniformly from 36 km/hr. to 108 km/hr. In 20 seconds, determine the:

- a) average speed (velocity)
- b) the acceleration in meter/sec.
- c) the distance S in meter covered during this period.

Solution: 
$$36 \text{ km/hr} = 10 \text{ m/sec}$$
;  $108 \text{ km/hr} = 30 \text{ m/sec.}$   
a)  $V = \frac{Vf + Vo}{2}$   
 $= \frac{30 + 10}{2}$   
 $= 20 \text{ m/sec.}$   
 $V = \frac{36 + 108}{2}$   
 $= 72 \text{ km/hr.}$   
 $108 \text{ km/hr} = 30 \text{ m/sec.}$   
b)  $a = \frac{Vf - Vo}{t}$   
 $= \frac{30 - 10}{20}$   
 $= 1 \text{ m/sec.}^2$   
C)  $S = Vt$   
 $= 20 (20)$   
 $S = 400 \text{ m.}$ 

# **PYTHAGOREAN THEOREM or RIGHT ANGLE TRIANGLE**

1. The base of a triangle is 5 ft. and altitude is 8 ft. What is the hypothenuse of the given triangle?



$$C = \frac{8^{2} + 5^{2}}{-64 + 25}$$
  
=  $\sqrt{89}$   
C = 9.43 ft.

2. Find the values of the three trigonometric functions of an angle A if its sine is 3/5.



Phyti	hage	orea	an Ti	heor	em:	1	Note:	SOH	-	CAH	-	TC	)A		
								Sine	=	oppos	<b>site</b>	=	a/c	=	3/5
-	a²	+	b²							hypoth	nenu	ISe			
8	C <sup>2</sup>	-	a²					Cosine	=	adjac	ent	-	b/c	=	4/5
= V	52	-	3²							hypoth	nenu	IS9			
= V	25	-	9					Tan	=	oppo	site	=	a/b	=	3/4
= 🗸	16	_								adjac	ent	•			
=	4														
	= = ∨ = ∨ = ∨ = ∨	Phythage $= a^{2}$ $= C^{2}$ $= \sqrt{5^{2}}$ $= \sqrt{25}$ $= \sqrt{16}$ $= 4$	$= a2 +$ $= C2 -$ $= \sqrt{52} -$ $= \sqrt{25} -$ $= \sqrt{16}$ $= 4$	Phythagorean Ti = $a^{2} + b^{2}$ = $C^{2} - a^{2}$ = $\sqrt{5^{2} - 3^{2}}$ = $\sqrt{25 - 9}$ = $\sqrt{16}$ = 4	Phythagorean Theor = $a^{2} + b^{2}$ = $C^{2} - a^{2}$ = $\sqrt{5^{2} - 3^{2}}$ = $\sqrt{25 - 9}$ = $\sqrt{16}$ = 4	Phythagorean Theorem: = $a^{2} + b^{2}$ = $C^{2} - a^{2}$ = $\sqrt{5^{2} - 3^{2}}$ = $\sqrt{25 - 9}$ = $\sqrt{16}$ = 4	Phythagorean Theorem: = $a^{2} + b^{2}$ = $C^{2} - a^{2}$ = $\sqrt{5^{2} - 3^{2}}$ = $\sqrt{25 - 9}$ = $\sqrt{16}$ = 4	Phythagorean Theorem: Note: = $a^{2} + b^{2}$ = $C^{2} - a^{2}$ = $\sqrt{5^{2} - 3^{2}}$ = $\sqrt{25 - 9}$ = $\sqrt{16}$ = 4	Phythagorean Theorem: Note: SOH $= a^{2} + b^{2}$ $= \frac{C^{2} - a^{2}}{\sqrt{5^{2} - 3^{2}}}$ $= \sqrt{25 - 9}$ $= \sqrt{16}$ $= 4$	Phythagorean Theorem:       Note:       SOH       -         = $a^2 + b^2$ Sine       =         = $\sqrt{5^2 - 3^2}$ Cosine       =         = $\sqrt{25 - 9}$ Tan       =         = $\sqrt{16}$ =       4	Phythagorean Theorem:Note: $SOH - CAH$ $= a^2 + b^2$ Sine = oppositive $= C^2 - a^2$ Cosine = adjace $= \sqrt{5^2 - 3^2}$ Tan = oppositive $= \sqrt{25 - 9}$ Tan = oppositive $= \sqrt{16}$ adjace	Phythagorean Theorem:Note: $SOH - CAH -$ = $a^2 + b^2$ Sine== $\sqrt{2^2 - a^2}$ Cosine== $\sqrt{5^2 - 3^2}$ Tan== $\sqrt{16}$ adjacent= 4	Phythagorean Theorem:Note: $SOH - CAH - TC$ = $a^2 + b^2$ Sine= opposite= $\sqrt{2^2 - a^2}$ Cosine= adjacent= $\sqrt{5^2 - 3^2}$ Tan= opposite= $\sqrt{16}$ adjacent= 4	Phythagorean Theorem:Note: $SOH - CAH - TOA$ $= a^2 + b^2$ $Sine = opposite = a/c$ $= \sqrt{2^2 - a^2}$ $Cosine = adjacent = b/c$ $= \sqrt{2^2 - 3^2}$ $Tan = opposite = a/b$ $= \sqrt{16}$ $adjacent$	Phythagorean Theorem:Note: $SOH - CAH - TOA$ $= a^2 + b^2$ $Sine = opposite = a/c =$ $= \sqrt{2^2 - a^2}$ $Cosine = adjacent = b/c =$ $= \sqrt{2^2 - 3^2}$ $Tan = opposite = a/b =$ $= \sqrt{16}$ $adjacent$

Q. State the Phytagorean Theorem - expressed that the hypothenuse is equal to the sum of the square of the two legs. It is also called right angle whose formula  $C^2 = a^2 + b^2$ ; and the angle sides are opposite, adjacent and base.

3. The diameter of a round steel bar is 50 mm. What is the biggest size of square nut that can be made from the bar.



By: Phythagorean Theorem.

$$a^{2} + a^{2} = d^{2}$$
  
 $2a^{2} = (50)^{2}$   
 $a^{2} = 2500$   
2  
 $a = \sqrt{1250}$   
 $a = 35.3555 \text{ mm.}$ 

size of the square  $a^2 = 1250 \text{ m}^2$ 

# 4. What is the circumference of a circle whose radius is $7 \frac{1}{2}$ meters?

Formula:	Circumference of a circle	=	2 <b>Î</b> r
	where r	=	$7\frac{1}{2} = 7.5$
	С	=	2(3.1416) (7.5)
		=	(6.2834) (7.5)
		=	47.13 meters

5. What is the lateral area of a sphere whose diameter is 10 ft.

Solution:

Area of sphere = 
$$\hat{1}\hat{1}D^2$$
  
=  $3.1416(10)^2$   
=  $3.1416(100)$   
=  $314.16$ 

6. Find the area of a circle whose diameter is 3 ft. What is the area in millimeter?

Ans. A =  $\frac{11}{4}$  d<sup>2</sup> =  $\frac{3.1416}{4}$  (3)<sup>2</sup> = .7854 (914.4 mm)<sup>2</sup> = .7854 (9) = .7854 (9) = 7.068 sq. ft.

7. Find the height of a cylinder tank which hold 250 gallons and dia. 24 inches?

Volume =  $.7854 \text{ D}^2\text{h}$  1 gal. = 231 cu. in. height = volume  $.7854 \text{ D}^2$ =  $\frac{250 (231)}{.7854 (24)^2}$ 

= 127.6' approx. 10  $\frac{1}{2}$  ft.

# 8. A cylindrical tank 12 ft. longholds 2600 gals when full, what is the diameter of the tank?

Volume	_ = .7854 (D)² H	1 gal.	=	231 cu. in.
Diameter	= Volume			
	.7854 (H)			
D²	= <u>2,600 x 231</u>			
	.7854 (12 x 12)			
D²	= 600 600			
	113.09			
D	= √5310.81 inches			
D	= 72.87 inches			

9. A hexagon of equal sides is inscribed in a circle whose circumference is 95 cm. What are the length of the sides of the hexagon?

Area = 
$$2 \hat{I} R^2$$
  
Circumference =  $2 \hat{I} r$   
Radius =  $\frac{C}{2 \hat{I}}$   
=  $\frac{95}{2 (3.1416)}$   
=  $\frac{95}{6.2832}$   
=  $15.12 \text{ cm}$ 

Since hexagon has 6 equal sides therefore length equal is 15.12 cm.

10. The service tank of a container ship is 15 ft. in diameter and 7 meters high. How much fuel oil can it accommodate if the specific gravity of a fuel is 0.95 assuming no volume expansion.

Given:

h = 7 m = 22.96 ft. Sp. gr. = 0.95 dia. = 15 ft. Solution: Volume = area of base x height = .7854 d<sup>2</sup> h = .7854 (15)<sup>2</sup> x (22.96) = .7854 (225) (22.96) (0.95) Volume = 8354.5 ft.<sup>3</sup>

# 11. What is the minimum diameter of a round stock necessary to make a square key 5" on each side?



12. Find the volume of the given cylinder and its content in metric ton of fuel oil whose specific gravity is 0.96 ?

dia = 5 ft. h = 
$$5.25 \text{ m}$$
 where 5 ft. =  $1.52 \text{ m}$   
Volume = Area of base x height  
=  $.7854 (1.52)^2 (5.25)$   
=  $.7854 (2.31) (5.25)$   
=  $9.52 \text{ m}^3 \times .96 \text{ s.g.}$   
Volume =  $9.145 \text{ MT}$   
5 ft.  $5.25 \text{ m.}$ 

## **PUMPS PROBLEMS**

1. A single acting power pump making 200 rpm has dimensions 5" x 6" x 4". Slip is 4.5%. What is its actual discharge in gallons per minute? (G.P.M.)

1 gailon = 231 cu. in.

$$GPM = \frac{\text{vol. of cyl. x no. of strokes x Efficiency}}{231}$$
$$= \frac{.7854 \text{ x } 6^2 \text{ x } 4 \text{ x } 200 \text{ x } 0.955}{231}$$
$$= \frac{21601.64}{231}$$
$$GPM = 93.5$$

2. A double bottom tank holds 6530 gallons. A duplex double-acting pump 8" x 6" x 10" makes 35 double strokes per minute. Leakage 10%. How long will it take to pump out the tank?

$$GPM = \frac{\text{vol. of cyl. x no. of strokes x Efficiency}}{231}$$
$$= \frac{.7854 \text{ x } 6^2 \text{ x } 10x(35 \text{ x } 4) \text{ x } .90}{231}$$
$$= \frac{.35625.74}{231}$$
$$GPM = 154.224$$

therefore 6530 - 154.224 = 42.34 minutes

3. A duplex double acting pump 4" x 6" x 6" makes 25 RPM slip 4%. What is its actual discharge in G.P.M?

$$GPM = \frac{\text{vol. of cyl. x nos. working strokes x Efficiency}}{231}$$
$$= \frac{.7854 \text{ x } (6)^2 \text{ x } 6x(25 \text{ x } 4) \text{ x } .96}{231}$$
$$= \frac{16286}{231}$$
$$GPM = 70.502$$

4. A ship covers 242.6 actual miles in a day. Find the pitch of the propeller if efficiency is 87% and speed is 98 RPM?

Formula:

Pitch = 
$$\frac{6080 \times \text{observed miles}}{N \times 60 \times 24 \times E}$$
  
=  $\frac{6080 \times 242.6}{98 \times 60 \times 24 \times 0.87}$   
=  $\frac{1475008}{122774.4}$   
= 12 ft.

5. A ship travels 5742 miles in 26 days, 16 hour and 8 minutes. Find the average speed in knots for the entire voyage.

No. of min. per voyage =  $[(26 \times 24)] + 16 \times 60 + 8$ =  $640 \times 60 + 8$ = 38400 + 8= 38408 min.Mile per minute = 5742 miles = 0.1495 38408 mins.Mile per hour =  $60 \times 0.1495$ = 8.97 or 9 knots.

6. A ship makes an observed speed of 17 knots per hour. The engine speed is 17.5 knots. What is the propeller slip in % and how many nautical miles the ship makes in 24 hours?

% slip = 
$$\underline{ES} - \underline{OS} \times 100$$
  
 $\overline{ES}$   
=  $\frac{17.5 - 17}{17.5} \times 100$   
= 0.02857 x 100  
= 2.857%  
Nautical miles = observed speed x 24 hours  
= 17 x 24 hours  
= 408 knots or  
= 408 NM

7. A merchant ship navigated a distance of 7,200 nautical miles in 22 days, 12 hours and 30 minutes. Compute the average speed for the whole voyage.

Ans. S = 7200 NM  
t = 22 days x 24 + 12 + .5  
t = 540.5 hours  
Ave. speed = 
$$\frac{distance}{time} = \frac{7,200 \text{ mi.}}{540.5 \text{ hrs.}}$$
  
= 13.32 knots.

8. A ship crane lifts a 1,500 lbs. steel beam to a height of 44 ft. in 10 sec. Find the power developed.

Given: 
$$F = 1500 \text{ lb. } x \underline{1 \text{ kg}} = 681.82 \text{ kg.}$$
  
 $d = 44 \text{ ft.} = 13.415 \text{ M}$   
 $t = 10 \text{ sec.}$   
Power  $= \frac{\text{work done}}{\text{time ellapsed}}$   
 $= \frac{\text{force x distance}}{\text{time}}$   
 $= 681.82 \text{ kg. x } 9.8 \text{ m/sec.}^2 \text{ x } 13.415 \text{ m.}$   
 $10 \text{ sec.}$   
 $= 8963.68 \text{ joule per sec. or watts}$ 

9. A wire 120 inch long with a cross section of 0.125 in<sup>2</sup>hang vertically when a load of 450 lbs. is applied to the wire it streches 0.015 inch. Find Young Modulus of Elasticity.

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{F/A}{\text{AL/L}}$$

$$Y = \frac{450 \text{ lbs. / 0.125 in.}^2}{0.015 \text{ in. / 120 inch.}}$$

$$Y = \frac{3600 \text{ psi}}{0.000125}$$

$$Y = 2.88 \times 107 \text{ psi or } 28,800,000 \text{ psi}$$

10. A ship left port with 12000 barrel of fuel oil on board at 18 knots, the consumption is 400 barrel per day, after the vessel has travelled 2,000 miles, what is the steaming radius?

Speed	= 18 knots x 24
	= 432 miles
Cons. of oil per 1 mile	= 400 - 432
	= .9259 barrel
Fuel cons. at 2000 mile	= 2000 x .9259
	= 1851.8 barrel
Fuel on board	= 12000 — 1851.8
	= 10148.2 barrel
Remaining steaming radius	= <u>10148.2</u>
	.9259
	= 10,960 miles

11. A ships make 320 mi/day at 70 RPM with propeller pitch of 21 ft. What is the propeller efficiency?

Propeller Eff. = 
$$ED \times 6080 \text{ ft.}$$
  
P x RPM x Time  
=  $320 \times 6080$   
 $21 \times 70 \times 1440$   
=  $1945600$   
 $2,116,800$   
=  $.9191 \times 100$   
% =  $91.91$ 

12. Your engine consumes 130 grams of fuel per BHP-HR. How many gallons of fuel will your engine developing 12000 BHP, consume daily with specific gravity of fuel at .92?

<u>.</u>.

cons./day = 
$$130 \text{ gr./BHP-HR} \times 12000 \text{ BHP} \times 24$$
  
.92 x 1000,000 grms.  
=  $37440000$   
920000  
= 40.7 m<sup>3</sup>  
cons/day in gal =  $40.7 \times 1000$  x 0.2642 gal.  
 $1 \text{ m}^3$  1 L  
=  $10.752.94$ 

13. Your daily use fuel tank has or diameter of 7 ft. Every 4 hours watch the height level goes down 15 inches. What is your average hourly consumption in liters?

Given:	
Tank dia.	= 7 ft. = 84 inches
Height diff.	= 15 inches
Consumption Vol.	$=$ $\prod D^2 h$
	4
	= .7854 (84)² (15)
	= 83126.736 in <sup>3</sup> per 4 hrs.
	= 20781.684 in <sup>3</sup> per hr.
Cons. in liters	= 20781.684 <u>x 1 liter</u>
	61.0128 in <sup>3</sup>
	= 340.611 Liters per hour

# **COMPUTATION FOR FUEL CONSUMPTION ON BOARD**

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1. MV Dona Evelyn consumes 20 MT/day sailing whose fuel specific gravity at 15°C = .9730 and correction factor at 85°C heated is .9542. Find the cons. in liters, per watch hour and minutes.

Solution:	1. 20 MT × 1000 L 1 Ton	= 20,000 Liters				
	2. 20000 L 9730 (so) 15%	= 20,554 $=$ 21.541 Liters				
	3. 21,541 L	= 3590 L/watch				
	6 watch/day	= 897 L/Hr. = 15 L/min.				

2. Find the fuel consumption in GRMS-BHP/HR whose cons. per day is 27.10 MT (metric ton) and actual BHP is 7109.52.

Solution:  
= 27.10 MT x 
$$1000 \text{ kg} = 27,100 \text{ kg/day}$$
  
=  $27100 \text{ kg/day}$  = 1,129 kg/hr.  
= 1,129 kg x  $1000 \text{ grms} = 1,129,166 \text{ grms/hr}$   
Hr. 1 Kg  
=  $\frac{\text{fuel cons. in grms}}{\text{actual BHP}} = \frac{1,129.166}{7109.52}$   
=  $158.82 \text{ gms-bhp/hr.}$ 

Q. Find the cylinder oil in grm-bhp/hr. whose consumption 189.36 liters/day, maximum BHP 8200; Specific gravity = .95; ave.rpm = 141.30 and shop trial rpm = 150

Formula:

Cyl. oil cons.	=	Ne x Vd x V <sup>°</sup> x 1000	where Ne= shop rpm			
		N x n <sub>e</sub> x 24	Ν	= actual rpm		
	=	<u>150 x 189.36 x .95 x 1000</u>	n,	= rated output		
		141.30 x 8200 x 24	Vd	= cyl. oil cons.		
	=	26,983,800	۷°	= specific		
		27,807,840		gravity		
Cyl. oil cons.	=	0.970 grms-bhp/hr.				

## TANKS CALCULATIONS WHEN BUNKERING

Q. Your fuel tank on board capacity is 1500 M<sup>3</sup> (cubic meter) at 100% full. How many metric tons are you required of fuel whose specific gravity is .9768 at 15°C if tank to be filled up to 95% full of fuel whose temperature is 45°C, coefficient of expansion is .000720 given data:

Formula:

Net vol. M <sup>3</sup>	=	$(T_2 - T_1 \times \text{coef. of expansion } \times \text{vol. m}^3)$
First	=	1500 m <sup>3</sup> x 95% = 1425 M <sup>3</sup>
Second	=	1425 — (45° — 15° x .000720 x 1425)
	=	1425 — 30.78
	=	1394.22 m³ at 15ºC (0.9768)
To be bunker	=	1361.87 MT

## Q. Fuel Consumption per voyage distance?

How much fuel be consumed to cover the distance of 7,000 miles? Given datas: Bore = 680 mm; stroke = 1250 mm; 6 cylinder mechanical efficiency = 85%, MEP = 8.5 Kg/cm<sup>2</sup>; RPM = 140; Pitch = 3.15 M, F.O. cons. gr-BHP/Hr = 156, F.O. S.G. at 15°C = 0.9700, Heating temp. of F.O. + 85°C, propeller slip = 5%.

Solutions:

1. cylinder constant =  $L \times A = 1.25 \times 3,631.68$ 4500 4500 = 1.0088 2. Prop. dist. 3.15 M x 3.28 Ft. = 10.33 Ft. = .00169736 Mile = 6080 Ft/Mi. 3. BHP = cyl. constant x RPM x P. x ME x no. of cyl. 100  $= 1.0088 \times 140 \times 8.5 \times 85 \times 6$ 100 BHP = 61224. F.O. Cons./Hr.  $= 6122 \times 156 \text{ gms}$ = 955,032 - 1,000,000 = 0.95503 MT Prop. distance/min. = .00169736 x 140 RPM = 0.23762 mi. Prop. distance.hour =  $0.23762 \times 60 = 14.25 \text{ mi}.$ Prop. distance/hr. with 5% slip = 14.25 x .95 = 13.54 mi. = 7000 miles 13.54 mi/hr. = 516.98 Hours. Total consumption = (0.95503 MT/HR) (516.98) = 493.74 MT

# Q. A 1,500 HP turbine operating at full load for an entire day requires the burning of 6.5 tons of fuel oil. Calculate the fuel consumption in pounds per horsepower hour.

Given: Fuel cons. = 
$$6.5 \text{ tons}$$
  
HP of turbine =  $1,500$   
 $6.5 \text{ tons x } 2000 \text{ lbs.} = 13,000 \text{ lbs.}$   
 $1 \text{ ton}$   
Fuel cons. =  $13,000 \text{ lbs.}$   
 $1500 \text{ HP}$   
=  $8.666 \text{ lb. per horsepower-hr.}$ 

Q. A ship travels 5700 miles in 26 days, 16 hours and 8 minutes. Find the average speed in knots for the entire voyage.

Given:

distance =	=	5700 mi.
time =	=	26 days, 16 hr. and 8 mins.
=	=	26 x 24 + 16 + .133
-	2	640.133 hrs.
Ave. speed =	=	distance travelled
		time ellapsed
-	=	5700 miles
		640.133 hrs.
-	=	8.90 knots

Q. A revolution counter reads 69,985 at 8:00 am at 11:00 am the clock was advanced 17 minutes and at noon the counter reads 87, 319. What was the average speed on the 8 to 12 o'clock watch?

Formula:		
Ave. Speed	=	advanced in counter reading
		minutes in watch
	=	87,319 - 69,985
		3 hrs. (60) + 43 mins.
	=	<u>17334</u>
		223
Ave. speed	=	77.73 RPM.

Q. A fuel oil has a specific gravity of 0.948 at 24°C. What is its specific gravity at 15°C? Correction coefficient is .00063 per1°C.

Given: SG = 0.948  $T_{1} = 24.5^{\circ}C$   $T_{2} = 15^{\circ}C$ corr. coeff. = 0.00063 Solution: a.  $T_{1} - T_{2} = 24.5 - 15 = 9.5^{\circ}C$ b.  $9.5^{\circ}C \times .00063 = .005985$ c. 0.948 + .005985 = 0.9539 SG at 15°C Q. Specific gravity of diesel oil is 0.865 at 30°F. What is its gravity at 84°F? S. G. correction is .00037 per 1°F.

Given:

SG = 0.865  $T_{1} = 30^{\circ}F$   $T_{2} = 84^{\circ}F$ corr. coeff. = 0.00037 per 1^{\circ}F
Solution: a.  $T_{2}-T_{1} = 84-30 = 54^{\circ}F$  b.  $54 \times 0.00037 = 0.01998$  c. 0.865 - 0.01998 = 0.8450 at  $84^{\circ}F$ 

Q. During Bunkering, how much shipownner will lose if F.O. supplier supply you F.O. at \$90 per MT. The supplier figures on the delivery receipt are S.G 0.9785 at 15°C; pumping temp. 25°C; total volume 515 m<sup>3</sup>. Your requirement is 500 MT. Before bunkering hydrometer test shows: S.G 0.9525 at 35°C after bunkering sounding was taken and found 511 m<sup>3</sup> at 40°C after applying ship trim correction.

NOTE: Ship owner will lose if you use supplier figure, will not if you use interpolated hydrometer figure:

Solution:

- a. Supplier figure in Metric Tons:
  - $MT = SG .9785 \times 511 M^3 [(40 15 \times .000720 \times 511)]$

= .9785 x (511 - 9.198)

- = .9785 (501.802)
- MT = 491.01
- b. Using Ship Figure by hydrometer test: S.G .9525 at 35 °C

S.G at 15 °C = .9525 + (35 - 15x .000720)

= .9525 + 0.0144

- S.G = 0.9669
- $MT = .9669 \times 511 (40 15 \times .000720 \times 511)$ 
  - = .9669 x 511 9.198
  - = .9669 x 501.802
- MT = -485.19 Ship Figure

Therefore: 491.01 - Supplier figure

485.19

5.82 MT short of delivery

5.82 MT x \$90m = \$523.80 Losses

Using All Suppliers figures:  

$$MT = .9785 \times 515 - (25 - 15 \times .000720 \times 515)$$

$$= .9785 \times 515 - 3.708$$

$$= .9785 \times 511.292 \text{ m}^{3}$$

$$MT = 500.30$$

$$Owner Losses = 500.30 - MT \text{ Supplier}$$

$$- \frac{485.19}{15.11} - \text{ Ship figure}$$

$$15.11 \text{ MT } \times \$90 = \$1,359.90$$

Formula of fuel mixed with specific gravity:

MIXED S.G. = 
$$\frac{(\text{Qty. Before Loading m}^3)(S.G.) + \text{Qty. Received m}^3 \times S.G.}{\text{Qty. Bef. Loading + Qty. Received m}^3}$$
$$= \frac{100 \text{ m}^3 (.950) + 200 \text{ m}^3 (.960)}{100 \text{ m}^3 + 200 \text{ m}^3}$$
$$= \frac{95 + 192}{300}$$
S.G. = 0.956

Q. A hydraulic is fitted with a raised reservoir to prevent cavitation and gives a 6 meter column of oil at specific gravity 910 kg/cm<sup>3</sup>. Determine the pressure worked at the pump intake port.

Solution:

C.

I. Force = 
$$6 \times 910 \times 9.81$$
  
= 53,562 N  
II. Pressure = Force = 53,562  
Area = 53,562 Pa  
= 53,562 Pa  
= 53,566 KPa

Q. In a force multiplication system the area ratio is 100:1. The large piston diameter is 150 mm and it move through a distance of 130 mm. If the small piston stroke 400 times. What distance does it travel per stroke.

Solution:

I. Volume to displace large piston in volume displace by a small piston:

$$A = \frac{1}{4}D^2h$$

0.7854 (0.15)(0.15)(0.13) = .0022972 m<sup>3</sup> = II. Area of Small Piston =  $1 \times 0.15 \times 0.15 \times 0.7854$ 100  $= .0001767 \text{ m}^2$ Total Stroke = Volume =  $2.2972 \times 10^3 \text{ m}^2$ III. Area 0.1767 x 10<sup>-3</sup> m<sup>2</sup> = 13 meter  $13 \text{ m} = 32.5 \times 10^{-3} \text{ m}$ IV. Single Stroke = 400 = 32.5 mm

## **BOYLES LAW:**

1. An accumulator in a hydraulic system is precharged to 900 KPa and is then filled with hydraulic fluid until the gas pressure shows 2,700 KPa. How much oil has been pumped in, if the accumulator volume is 0.4 m<sup>3</sup>.

$$V_1 = 0.4 \text{ m}^3$$
  
 $P_1 = 900 + 101.3 \text{ KPa}$   
 $P_2 = 2,700 + 101.3 \text{ KPa}$   
lla:  
 $V_1 = P_1 \quad V_2 = V_1 \quad P_1$ 

Formula:

$$\frac{V_1}{V_2} = \frac{P_1}{P_2} \qquad V_2 = \frac{V_1 P_1}{P_2}$$
$$= \frac{1001.3 \text{ KPa} \times 0.4 \text{ m}^3}{2801.3 \text{ KPa}}$$
$$= 0.143 \text{ m}^3$$

CHARLES LAW:

2. A rubber gas reservoir has a volume of 0.1 m<sup>3</sup> at -14°C. Its temperature is raised to 90°C. What is it volume increase if the pressure remains the same?

$$V_{2} = V_{1} \times \frac{T_{2}}{T_{1}} = \frac{0.1 \text{ m}^{3} \times (90 + 273)}{-14 + 273}$$
$$= \frac{0.1 \text{ m}^{3} (363)}{259}$$
$$= 0.14 \text{ m}^{3}$$

Q. Two days after a tank was filled with arrival ballast you check the oil content in the tank and found 0.5 cm. of oil on top of the water. Dimension of the tank L = 43 m B = 21 m; d = 22 m. Is it okey to maritime regulation the amount of oil to discharged

£,

# overboard? If no. What shall you do?

NOTE: By Regulation: Required <u>1</u> of total oil volume by parts can be discharged 30,000

# at sea.

4) 4) 4) 4) Solution:

	I.	Total volume of the tank = Length x Breadth x Dep	th
		$= 43 \times 21 \times 22$	
		= 19,866 m <sup>3</sup>	
	11.	Total volume of oil in the tank = $43 \times 21 \times 0.00$	)5 m
		= 4.515 m³	
	111.	By Regulation volume can be	
		discharged = $19,866 \text{ m}^3$	
		30,000	
:		$= 0.6622 \text{ m}^3$	

# FOURTH ENGINEER - January 1989

1. A trapezoidal plane figure with sides in meters measuring 8 3/4, 10 5/8, 5 3/4 and 21 1/4. Find the perimeter. Give your answer in mixed number. What is the area of the above figure? The parallel sides are the 10 5/8 and the 21 1/4.

Solution:





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ы.... ;

$$= \frac{85}{4} + \frac{85}{8} \frac{23}{4}$$
$$= \frac{85}{8} + \frac{85}{16} \frac{23}{4}$$
$$= \frac{170 + 85}{16} \frac{23}{4}$$
$$= \frac{170 + 85}{16} \frac{23}{4}$$
$$= \frac{5865}{64}$$
$$= 91 \frac{41}{64} \text{ m}^2$$

2. At the start of your 4-hour watch, the reading of the revolution counter of the main engine is 996,430. At the end of your watch the reading is 026,430. What is the average rpm. If the time will be advanced 20 minutes, during the watch, What will be the reading at the end of the watch?

Given:	Previous reading	=	996430
	End of watch	=	026430
	Advanced 20 mins.		

Α

Solution:

Revolution before the counter set to 0 is 1,000,000

	1,000,000 - 996,430	= 3570
Total re	evolution after the watch	= 026430 + 3570
		= 30,000 rev.
	= 30,000 rev.	
	240 - 20 mins. adv	vanced
RPM	= 136.36	

3. A look out looking towards the bow of the ship is standing in the bridge with the level of his eyes about 50 meters above the water line. The distance of the bow from the bridge is 160 meters and its height from the lookout be able to see a floating object? What is the distance of the floating object from the bridge?



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3.20
50 30 == 160 + dd 50 d (160 + d) 30= 50 d 4800 + 30 d = 50 d 30 d = 4800 20 d = 4800 d = 4800 20 d = 240 m distance from bow.

The distance of object from bridge:

= 240 + 160 = 400 M

4. A 12-knot ship consumes 125 MT of fuel oil per day. How many days will it take her to navigate a distance of 6,280 nautical miles and how many metric tons of fuel (who) will she consume? If the unpumpable fuel is about 3% and the allowance for delay due to bad weather that may be encountered is 20%. What is the fuel requirement to complete the voyage?

Given:	Ship speed	=	12 knots
	Fuel cons.	=	125 MT/day
	Distance	=	6280 n. miles
	3%	=	allowance for unpumpable
	20%	=	allowance for delay and weather

Solution:

Days to navigate	=	6280 miles	x 1 day
		12 n.m/hr.	24 hrs.
	=	6280 miles	
		288 hrs.	
	=	21.8 days	
Total allowance	=	3 + 20 =	23% <sup>.</sup>
Fuel consumed for the voyage	=	21.8 x 125	<b>x</b> 1.23
	=	3351.75 MT	

Q. What size circular bar is required to make a hexagonal nut of 16 mm sides along the circumferences?  $\checkmark$ 



 a = b = 16 mm  $\sin 30^\circ = \frac{8}{a}$ 
 $d = 2 \times a$  a 

  $= 2 \times 16$   $a = \frac{8}{\sin 30^\circ}$  

 = 32 mm  $\sin 30^\circ$  

 a = 16 mm 

2. The specific fuel consumption of the main engine rated at 12000 metric brake horsepower is 155 g/Bhp – hr. What is the fuel consumption in metric tons to make a voyage of 6,280 nautical miles at the speed of 14 knots? Allow 10% for the unpumpable in the fuel storage tank.

Given:

	Bhp	=	12000
	Sp. fuel cons	=	155 g–bhp/h
	Distance	_=	6,280 nm
	Ship speed	7	14 knots
	10%	, <b>=</b> `	allowance
Solution:			
	Fuel oil cons.	=	155 g-BHP/HR x 12000 bhp x 24 hr/day
			1,000,000 grm/ton
		=	44,640,000
			1,000,000
	· 4	=	44.64 M.T./day
Day the	ships travel	=	6,280 n.m. x 1 day
			14 knots 24 hrs.
		=	18.69 days
Fu	el oil cons.	2	44.64 x 18.69 (1 + 10%)
		=	44.64 x 18.69 x 1.1
		=	917.98 MT.

3. The revolution counter reading at the beginning of a 4 hour watch is 996,430. At the end of the watch the counter reading 026,430. During the watch the time was retarded by 20 minutes. What is the average rpm of the main engine?

Given: previous reading = 996,430 end of watch = 026,430 retarded 20 min.

Solution:

The count	er reset to 0 @	1,0	000,000	
Rev. befor	Rev. before the counter reset to 0 =			
`    1,000,	000 - 996,430	=	3570 rev	
End of wa	tch eng. rev.	=	026430 + 3570	
		≖	30,000	
RPM =	30,000 rev.			
x	240 + 20 min.	reta	ard	
RPM =	115.38			

4. The main engine is an 8 cylinder single acting, 2-stroke cycle diesel with a cylinder of 650 mm bore x 1,350 mm stroke. What is the cylinder constant. What is the indicated horsepower if the indicated pressure is 11 kg/sq. cm. at 110 rpm?

Given:

	No. of cyl.	=	8 cyl. 2 stroke
	Bore	=	650  mm = 65  cm
	Stroke	æ	1350 mm = 1.35 m
	MEP	=	11 kg/sq. cm.
	Rpm	=	110
Solution:			
	cyl. constant	=	Î D <sup>2</sup> x L
			4
			4500
		=	$\widehat{II}$ (65) <sup>2</sup> (1.35)
~			4 4500
		=	.7854 (4225) (1.35)
			4500
	cyl. constant	=	0.9954
	IHP	=	MEP x cyl. constant x Rpm x no. of cyl.
		=	(11 kg/cm²) (.9954) (110) (8)
	IHP	=	9635.47 HP.

5. The pitch of the propeller of an ocean-going ship is 3600 mm. What is the engine mileage in 24 hours if the propeller makes 118 rpm? If the apparent slip is minus 3% What is the observed speed?

Given:	Pitch = 36	00 r	nm =	3.6 m
	RPM = 118	8		•
	Slip = -3%	6		
Solution:				
	Eng. Speed	=	Pitch >	RPM x 60
				1852
		=	3.6 m	x 118 x 60
				1852
		=	13.76	knots
	Slip	=	Eng. S	Speed – O. Speed
			En	g. Speed
	- 0.03	Ħ	13.76	-OS
			13	.76
	- 0.03 (13.76)	=	13.76	– O.S.
	OS	=	13:76	+ (0.03) (13.76)
		=	13.76	+ 0.41
	<b>Observed Speed</b>	=	14.17	knots.

# **SECOND ENGINEER – January 1989**

1. A cylindrical water tank has a diameter of 3 meters at the base and 4 1/2 meters high. How many metric tons of fresh water is to be pumped into the tank in order to have an ullage of 1 meter? If fuel oil of 0.86 specific gravity is to be pumped into the tank, how many metric tons are required to have the same ullage?



Solution:

Î D² h a) Volume of tank For an ullage of 1 m; h = 3 1/2 mVol. of tank @ 3 1/2 m height **1** (3)<sup>2</sup> (3.5 m) = 4 = .7854 (9) (3.5) 24.74 m<sup>3</sup> = For a F.W. Sp. gr. = 1 ton = 1000 kg m³ m³ F.W. to be pumped = 24.74 m<sup>3</sup> x 1 MT/m<sup>3</sup> = 24.74 MT b) Sp. gr. of oil = 0.86 M.T. of fuel oil  $= 24.74 \text{ m}^3 \times 0.86 \text{ (S.G.)}$ = 21.28 MT.

2. A vessel makes an observed speed of 12 knots with an apparent slip of plus 12%. The propeller turns 110 rpm. What is the pitch of the propeller in mm?

Given:			
	Ships speed	=	12 knots
	Slip	=	12%
	RPM	=	110
Solution:			
	Engine Speed	=	<u>P x RPM x 60</u>
			1852
	% Slip	=	ES – SE x 100
			ES
	0.12	=	ES – 12 knots
	· A		ES
	E.S. (0.12)	=	ES – 12
	E.S. (0.12) – E.S.	=	- 12
	- 0.88 E.S.	=	- 12 ·
	E.S.	=	- 12
			- 0.88
	E.S.	=	13.63 knots
	E.S.	=	P x RPM x 60
			1852 m

$$13.63 \text{ knots} = \frac{P \times 110 \times 60}{1852 \text{ m}}$$

$$P = \frac{13.63 (1852)}{110 \times 60}$$

$$P = \frac{25242.76}{6600}$$

$$P = 3.83 \text{ m} = 3.830 \text{ mm}$$

3. A ship's provision is loaded on board from a motor launch by means of a manually operated winch which work on the same principle as the wheel and axle machine. The revolving drum of the winch is 30 cm diameter and the crank attached to the end of the drum is 40 cm. long from the center of the drum. What force is required to lift the provision weighing 300 kg?



Taking moment @ the center of the drum:

$$F x 40 cm = 15 (300 kg)$$

$$F = \frac{15 cm (300 kg)}{40 cm}$$

$$F = 112.5 kg.$$

4. The mean indicated pressure of an 8-cylinder 2-stroke cycle, single-acting engine with a cylinder constant of 0.9954 is 11 kg/sq. cm. What is indicated horsepower at 100 rpm?

Given: No. of cyl. = 8 cyl. 2 cycle, single acting  
Cyl. constant = 
$$0.9954$$
  
MEP =  $11 \text{ Kg/cm}^2$   
RPM =  $100 \text{ rpm}$   
Formula: IHP = MEP x Cyl. constant x RPM x No. of cylinder  
=  $11 \text{ Kg/cm}^2 \times .9954 \times 100 \times 8$   
=  $8759.52 \text{ HP}$ 

5. The specific fuel oil consumption of the main diesel engine at 12,000 metric brake horse power is 155 g/BHP-hr. What is the daily consumption in metric tons? What is the equivalent consumption in gram per kw-hr?

Given: Sp. fuel cons. = 155 gr/BHP-hrBHP = 12,000Solution: a) Daily Cons. =  $\frac{155 \text{ gr. x } 12,000 \text{ BHP x } 24 \text{ hr/day}}{\text{Bhp-hr}}$ =  $\frac{44,640,000 \text{ gr/day}}{1,000,000 \text{ gr/ton}}$ = 44.64 MTb)  $\frac{\text{grams}}{\text{Kw-hr}}$  =  $\frac{155 \text{ gr/Bhp-hr}}{0.746 \text{ Kw/1 HP}}$ = 207.77 gms/Kw-hr.

#### **CHIEF ENGINEER – January 1989**

1. The cross-section of a hollow brass shafting has an outside diameter of 50 mm and an inside diameter 25 mm. Its length is 2 meters. What is the weight of the shafting if its density is 8 grams per cubic cm.

Given:  
Outside dia. = 50 mm = 5 cm  
Inside dia. = 25 mm = 2.5 cm  
Length = 2 m = 200 cm  
Density = 8 gr/cm<sup>3</sup>  
Solution:  

$$D = \frac{Weight}{Volume}$$
Volume =  $\widehat{\prod} D0^2 - \widehat{\prod} D1^2$  (Length)  
=  $\widehat{\prod} (D0^2 - D1^2)$  (L)  
=  $\widehat{\prod} (5^2 - 2.5^2)$  (200)  
= .7854 (18.75) (200)

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= 2,945.24 cm<sup>3</sup>

Weight	=	Density x Volume
	=	8 gr/cm <sup>3</sup> x 2945.24 cm <sup>3</sup>
	=	23,561.9 grams
	=	23,562 kgs.

2. The cylinder block of a diesel engine is held by 4 round mild steel tie rods. If the load on each tie rod is 66 MT, what is the diameter of the tie rods. The yield point of the rod is 47,000 lbs. per sq. inch and the factor of safety is 6.

Given:

	No. of tie rods	=	4
	Load on each tie rod	=	66 MT.
	Yield point of the rod	Ħ	47,000 lbs/in <sup>2</sup>
	Factor of safety	=	6
Solution:			
	Working Stress	=	Yield point
			Factor of safety
		=	47000 psi
			6
		=	7,833.33 psi
	Working Stress	=	Load
			area of rod
	Area	=	Load
			working stress
		=	145,200 lbs.
			7,833.33 psi
		=	18.54 in²
	Area	=	11 D <sup>2</sup>
	0.7854D <sup>2</sup>	=	18.54 in <sup>2</sup>
	$D^2$	=	18.54
		-	0.7854
		=	23.6 in <sup>2</sup>
	D	=	4.85 in

3. A 12-knot ship left Manila on Jan. 19, 1989 at 2:00 a.m. for San Francisco, a distance of 6,280 nautical miles. Find the ETA at San Francisco first by disregarding the difference in time between the two ports and second by taking into account the difference in time. Give the date and time of arrival in both cases.

If the ship consumes 25 MT of fuel per day, what is the quantity required to complete the voyage. Allow 25% for the unpumpable quantity in the storage tank and delays that may be encountered due to bad weather.

Given:

Ship speed = 12 knots Time of dep. = 2:00 pm – Jan. 19, 1989 Distance = 6.280 N. miles Solution: By disregarding time difference Time of voyage = 6,280 N. miles 12 N.M./hr. = 523.33 hrs.  $= 21.8 \, days$ = 21 days and 19.2 hrs. ETA = Feb. 10, 1989 @ 0900 hrs. By taking difference in time --- 16 hrs. behind ETA = Feb. 10, @ 1900 hr. -1600 hrs. ETA by time difference Feb. 09 @ 1700 hr. Ship cons/day = 25 MT/dayVoyage fuel cons = 25 MT (218 days) (1 + 25%) dav = 25 (21.8) (1.25) = 681.25 MT

4. Solve the metric indicated horsepower of an 8-cylinder, single acting, 2-stroke cycle diesel propulsion engine with MEP of 11 kg/cm<sup>2</sup> at 145 rpm. The cylinder is 650 mm bore x 1350 mm stroke.

If the specific fuel oil consumption is 153 grams per indicated horsepower – hr, What is the fuel consumption per day?

Given:	No. of cyl.	Ξ	8; 2 stroke
	MEP	=	11 Kg/cm <sup>2</sup>
	Bore	=	650  mm = 65  cm.
	Stroke	=	1350 mm = 1.35 m.
	Sp. fuel cons.	=	153 gr/IHP - HR.
	RPM	=	145

Solution:

$$IHP = \underline{MEP (L \times A) N \times RPM}_{4500}$$

$$= (11 \text{ Kg/cm}^2) (\underline{11} (65)^2 (1.35) (145) (8) \\ \underline{4} \\ 4500 \\ = \underline{57161292}_{4500} \\ IHP = 12,702.5 \text{ hp.}$$
Fuel consumption:
$$= \underline{153 \text{ gr./IHP-hr. x } 12702.5 \text{ hp x } 24}_{1000000} \\ = \underline{466, 435.80}_{1,000000} \\ = 46.64 \text{ MT/day.}$$

5. The pitch of the propeller of an ocean going vessel is 3,600 mm. The main engine directly driving the propeller makes 145 rpm. What is the observed speed of the vessel if the slip is minus 3%.

How many nautical miles is covered per day?

Given:

Pitch = 3,600 mm. RPM = 145Slip = -3%

Solution:

% Slip =	-	Engine speed – Ship speed
		Engine speed
Engine speed =	=	Pitch x RPM x 60
		1852
=	=	(3,600 mm x 1 m ) (145) (60)
		1000 mm
		1852
=	=	16.91 knots
- 0.03 =	2	16.91 – Ships speed
		16.91
- 0.03(16.91) =	=	16.91 – Ship speed
- 0.5073 =	=	16.91 – Ship speed

Ship speed	=	16.91 + 0.5073
	H	17.42 knots
Distance covered/day	=	17.42 Nm/Hr. x 24 hrs./day
	=	418.08 NM

#### FOURTH ENGINEER – January 1990

1. The density of aluminum is  $2,699 \text{ Kg/m}^3$ . Convert this to grams per cubic centimeter, and to pound mass per cubic foot.

Solution:

 $2,699 \text{ kg x } \frac{1000 \text{ grm x }}{1 \text{ m}^3} = 2,699 \text{ grm/cm}^3$   $2,699 \text{ kg x } \frac{2.2 \text{ lbs. x }}{1 \text{ m}^3} = 168.26 \text{ lb/ft.}^3$ 

# 2. A tank is filled with water to a depth of 42 feet 6 inches. Find the pressure exerted on the tank bottom?

Solution:

Pressure = height x 0.434 = (42 ft. x 0.5 ft.) (0.434) = (42.5 ft.) (0.434) = 18.44 psi

**3.** A 10-knot slip has a 16 feet pitch propeller. If the speed is 70 RPM. Find the slip. Is the slip positive or negative?

Given: Pitch of prop. = 16 ft. RPM = 70 Engine Speed = 10 knots

Formula:

1. Engine Speed =  $\frac{\text{Pitch x Rpm x 60}}{6080 \text{ ft.}}$  $= \frac{16 \text{ ft. x 70 Rpm x 60}}{6080 \text{ ft.}}$ = 11.05 knots

% slip = engine speed – observed speed x 100 engine speed % slip =  $\frac{11.05 \text{ knots} - 10 \text{ knots} \times 100}{11.05}$ =  $\frac{1.05 \text{ knots}}{11.05 \text{ knots}} \times 100$  $\frac{11.05 \text{ knots}}{11.05 \text{ knots}} = +9.52$ 

4. What is the cross sectional area of a rubber o-ring packing whose inside diameter is 49 mm and its outside diameter is 64 mm?

Given datas: inside dia. = 49 mm  
outside dia. = 64 mm  
Find: Cross sectional area = 
$$\frac{11}{4}(d_0^2 - d_1^2)$$
  
= .7854 [ (64)<sup>2</sup> - (49)<sup>2</sup> ]  
= .7854 [ 4096 - 2401 ]  
= .7854 (1695)  
= 1331.25 mm<sup>2</sup>

5. Solve the following equation: 2x + 5y = 20; Given y = 5. Find the value of x?

Solution:  

$$2x + 5y = 20$$
 If  $y = 5$   
 $2x + 5(5) = 20$   $x = ?$   
 $2x + 25 = 20$   
 $2x = 20 - 25$   
 $x = -5$   
 $2x = -5$   
 $x = -2.5$ 

**THIRD MARINE ENGINEER -- January 1990** 

1. At a certain instant, a ship was 4 miles south of a light house. The ship was travelling westward and after 10 minutes its bearing was S 25°15' W from the light house. Find the speed of the ship per hour.

Solution: 
$$\tan 25^{\circ}15' = \frac{b}{a}$$



2. A wire 120 inches long with a cross section of 0.125 inch<sup>2</sup> hangs vertically. When a load of 450 lbs. is applied to the wire, it stretches 0.015 inch. Find the young Modulus of Elasticity.

Given:	initial le	ength	= 1	120 in			
	cross-s	ectional area	a = (	0.125 in <sup>2</sup>			
	force a	pplied	= 4	450 lb.			
	change	in length	= (	).015 ind	ch.		
Find:	Young	s Modulus of	Elasti	city (E)			
Solution: 1.	8	= longitudi	nal stre	ess			
		longitudi	nal stra	ain			
	ε	= fo	rce/are	a			
		change i	n lengt	th/initial	length	•	
2.	stress	= Force =	450	lb=	3600	) psi	
		area	0.12	25 in <sup>2</sup>			
	strain	= \$L =	0.01	5 in =	0.00	0125	
		L	120	in			
	3	= stress =	3600	0 psi =	28,8	00,000 psi	
		strain	0.00	0125			

3. A force of 10 lbs. is used to move a box across a horizontal deck, a distance of 5 ft. If the force makes an angle of 30 degrees with the floor, how much work is done?



4. A house 15 meters high stands on one side of a street. What is the angle of elevation of the top of the house from the other side of the street, if the street is 20 meters wide?



Formula:

$$= \underbrace{\text{given side}}_{\text{given side}} = \operatorname{trigo function of}_{\text{unknown angle}}$$
$$= \underbrace{15 \text{ m}}_{20 \text{ m}} = \underbrace{\text{opposite}}_{\text{adjacent}} = \operatorname{tan} \theta$$
$$\tan \theta = \underbrace{15 \text{ m}}_{20 \text{ m}}$$
$$\tan \theta = 0.75$$
$$\theta = 36^{\circ}52'$$

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1. The gauge pressure of water in the water mains is 35 lbs./inch<sup>2</sup>. How much work is required to pump 500,000 ft.<sup>3</sup> of water, at atmospheric pressure, into the mains?

Given: Pressure =  $35 \text{ lb./in.}^2$ Volume =  $500,000 \text{ ft.}^3$ Convert 500,000 ft.<sup>3</sup> to in<sup>3</sup> =  $500,000 \text{ ft.}^3 \times \frac{1728 \text{ in.}^3}{1 \text{ ft.}^3} = 8.64 \times 10^8 \text{ in.}^3$ Find: Work Req =  $(35 \text{ lb/in.}^2) (8.64 \times 10^8 \text{ in.}^3)$ =  $302.4 \times 10^8 \text{ lb-in.}$ Convert lb-in. to ft-lb. =  $302.4 \times 10^8 \text{ lb-in.} \times 1 \text{ ft.} = 25.2 \times 10^8 \text{ ft.-lb.}$ 12 in.

2. The hatch of a submarine is 100 ft. under the surface of the ocean. If the weight density of sea water 64 lbs./ft.<sup>3</sup>, Find the pressure at the hatch due to the water, and the net force on the hatch if it is rectangle 2 ft. wide and 3 ft. long. The pressure inside the submarine is the same as that at the surface.

Given: height = 100 ft. wt. of density = 64 lbs./ft.<sup>3</sup> dimension of rectangle = 2 ft. x 3 ft. = 6 ft.<sup>2</sup> Solution: a) Pressure = density x height = 64 x 100 = 6,400 lb/ft.<sup>2</sup> b) Force = pressure x area = (6,400 lb./ft.<sup>2</sup>) (6 ft.<sup>2</sup>) = 38,400 lb.

3. A diesel engine consumes 1/2 ton of fuel oil per day, when it is operating at full load. When the unit is operating at half load, the consumption per BHP increases by 21%. Determine the full consumption rate per hour at one-half load, allowing 2,240 lbs./ton in this case.

Given:	Cons. = $1/2$ ton/day at full load
	Cons. increase by 21% at half load
Find:	Consumption rate per hour at half load

Solution:

 $\frac{1/2 \text{ ton } x}{\text{day}} \frac{1 \text{ day } x}{24 \text{ hrs.}} \frac{2240 \text{ lb.}}{1 \text{ ton}} = 46.67 \text{ lb./hr.}$ at one-half load : 46.67 lb/hr x 0.21 = 9.8 lb/hr. Total consumption at 1/2 load = 46.67 + 9.8 = 56.47 lb./hr.

4. The tension on outside of a belt is 350 lbs. and that on the other side is 150 lbs. The belt is moving at 300 ft./min. Find the horse power delivered to the pulley.

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Given: Total Force Acting = 350 + 150 lbs. = 500 lbs. = 300 ft./min. Speed Find: HP delivered Power = (500 lbs.) (300 ft./min) = 150,000 ft. lb min Convert: Ft. lb to HP min. = 150,000 ft.-lb x 1 HP min. 33000 ft.-lb = 150,000 33,000 = 4.5 HP

**CHIEF MARINE ENGINEER – January, 1990** 

1. The cross section of the tube at point A 10 inch<sup>2</sup>, and at point B is 2 inch<sup>2</sup>. If the velocity of the steam and point A is 12 ft./sec., What is it at point B?

Given: area at pt. A = 10 in.<sup>2</sup> area at pt. B = 2 in.<sup>2</sup> velocity at pt. A = 12 ft./sec. velocity at pt. B = ? By ratio and proportion area at A = velocity at A area at B velocity at B velocity at B = (area at B) (vel. at A) area at A

$$= (2 \text{ in.}^{2}) (12 \text{ ft./sec.})$$
10 in.<sup>2</sup>
velocity at B = 2.4 ft./sec.

2. A refrigerated container ship's main engine is consuming 74 tons of fuel per day at 21 knots; the ref. plant, aux. machinery and hotel load are consuming 10 tons per day. What is the nautical mile radius of travel? The ship has to travel 1,875 miles to reach port, and only 275 tons of available fuel remain. Assuming that the consumption varies as the cube of the speed, can the ship make port with the fuel on board if the speed is reduced to 19 knots?

cons. A = 74 + 10 tons/day Given: Speed A = 21 knots ? cons. B = Speed B = 19 knots distance = 1875 mi. = 275 tons fuel left Find: Consumption B.  $\frac{C_A}{C_B} = \frac{Speed_A}{Speed_B}$ 1,875 mi. x 1 hr. = 98.68 hr. voyage left 19 mi. 98.68 = 4.11 days of voyage left  $84 \text{ tons} = (21 \text{ knots})^3$ (19 knots)<sup>3</sup> C<sub>R</sub> 24 hr/day  $C_{B} = (84 \text{ tons}) (19 \text{ knots})^{3} 62.21 \text{ tons } x 4.11 \text{ days} = 255 \text{ tons req.}$ (21 knots)<sup>3</sup> dav to reach port.  $C_{B} = (84) (6859)$ Therefore since fuel left is 275 tons, the ship 9261 can reach port with still enough fuel.  $C_{p} = 62.21 \text{ tons/day}$ 

**3.** A barge is 30 ft. long and 16 ft. wide, and has vertical sides. When two automobiles are driven on board, the barge sinks 2 inches further into the water. How much do the automobiles weight?

where 2 inch = 0.167 ft.

Solution:

Weight of automobile	=	wt. of displace water
	=	(density of water) (volume of water)
	=	(62.4 lb./ft³) (80.16 ft³)
	=	5001.984 lbs.

# 4. Find the specific gravity of API 18.5 at 60°F

Formula: 141.5 API = S.G. at 60°C - 131.5 18.5 141.5 = S.G. at 60°C - 131.5 131.5 + 18.5 = <u>141.5</u> S.G. S.G. <u>141.5</u> = 150 S.G. 0.9433 =

### FOURTH AND THIRD ENGINEER May 1991

Q. What is the volume of a spherical tank whose diameter is 10 feet.

Given:	diameter	-	10 ft.
Formula:	Volume	=	
	·	=	6 <u>3.1416 (10)³</u>
			6
		=	3.1416 (1000)
			6
		=	<u>3140</u>
			6
	Volume	=	523.33 ft <sup>3</sup>

# Q. A 11 knots ship has a 17 feet pitch propeller. If the speed is 75 RPM. Find the slip. Is the slip negative or positive?

Given:	Pitci Rpn Eng	h of propeller n gine Speed	= =	16 70 10	ft. knots				
Find: a) Engine Spee		d	=	Pitch	x	<u></u>	x	60	
				=	17 ft.	x	75 RP	<u>M</u>	60
						6	080 ft.		

.

$$= \frac{17 \text{ ft. x 75 Rpm x 60}}{6080 \text{ ft.}}$$

$$= \frac{76500}{6080}$$

$$= 12.58 \text{ knots}$$
b) % slip = Eng. Speed - Obs. Speed x 100  
Eng. Speed  
$$= \frac{12.58 - 11}{12.58} \times 100$$

$$= \frac{1.58}{12.58} \times 100$$
Slip % = 12.55 (positive)

Q. The indicated horsepower of an engine is 15.448 and the brake horsepower is 12. What is the mechanical efficiency of the engine and what is the MEP. If the cylinder is 9 by 12 in and speed is 240 Rpm?

Given Datas:	IHP	=	15.448	•					
	BHP	=	12						
	RPM	=	240 Rp	m					
Formula:	Mecha	anic	al Efficie	ency	=	BHP IHP	x	10	0
					=	12 15.44	B	X	100
					=	0.776	(10	D) <sup>^</sup>	
				%	=.	77.68			
Find:	Area	=	$\frac{\hat{\mathbf{I}}}{4} \mathbf{D}^2$						
			4 705 <i>1</i>	(0)2					
		=	7954	(9)- (91)					
			62 62	(01) in 2					
IHP	= <u>PL</u>	<u>.AN</u>	-						
. <b>P</b>	= 33	,000	0 x IHP			•			
		ĿA	N						
	= <u>33</u>	,00	0 (15.44	8)		,			
	(1	FT.	) (63.62	) (240)					
Р	= 33	.38	kg/cm <sup>2</sup>						

### Q. A cylindrical tank is 8' 4" high 3' 7" in diameter. How many gailons will it hold?

Given: diameter = 3' 7" = 43 inches height = 8' 4" = 100 inches

Formula: volume of cylinder 
$$= \frac{\hat{II}}{4} D^2 h$$
  
= .7854 (43)<sup>2</sup> (100)  
= .7854 (1849) (100)  
= 145,220.46 cu. in.  
231 in<sup>3</sup>/gal.  
= 628.66 gallons

**Q.** If the average RPM for 24 hrs. and 18 mins. is 102, pitch of propeller is 16.2 ft. **Distance** by observation is 360 miles, What is the slip in percent.

Given:	Pitch	=	16.2 ft.
	Obs. Dist.	=	360 miles
	Rpm		102
	Time	=	24 hrs. + 18 mins.

Formula:

Engine Distance = Pitch x Ave. Rpm x Time 6080 ft. 16.2 x 102 x 1458 = 6080 ft. = 396.25 miles = Engine Distance – Observe Distance x 100 Slip % Engine Distance = 396.25 - 360 x 100 396.25 36.2 x 100 = 396.25 = 0.0913(100)= 9.1%

Q. I. What are the four fundamentals of Mathematics

II. State the Phythagorean Theorem

III. Formulas of volume cylinder rectangular, temperature scales and absolute temperature. See notes.

# SECOND/CHIEF ENGINEER - May 1991

Q. Find the circumference of a circle whose diameter is 19 inches?

Given data: diameter = 19 inches Formula: circumference =  $\widehat{11}$  D = 3.1416 (19) = 59.69 inches

Q. Find the area of a 13 inches diameter circle to one decimal place.

Formula: Area of a circle 
$$= \frac{\hat{II}}{4} D^2$$
  
 $= \frac{3.1416}{4} (13)^2$   
 $= .7854 (169)$   
A  $= 132.7 \text{ in.}^2$ 

Q. A cylindrical tank 18 inches in diameter, is 4 ft. in height.a. What is the volume in cubic inches?b. What is the capacity in gallons?

Given: diameter = 18 inches height = 4 ft. = 48 inches 1 gal. = 231 cu. in. Formula: a. Volume = .7854 D<sup>2</sup> height = .7854 (18) (18) (48) = 12,214.54 in.<sup>3</sup> b. Volume in gallons:  $= \frac{12,214.54}{231}$ = 52.87 gallons

Q. The stroke and bore of an 8 cylinder, 2 stroke diesel engine are 1350 mm and 650 mm respectively from the engine indicator cards the IHP is 13,900 at 154 RPM. What is the indicated mean effective pressure?

Datas:	Length	of strol	<b>ke</b>	=	13	50 mm	=	1.35 m
	Cylinde	r bore		=	65	0 mm	=	65 cm
	-	IHI	Ρ	8	13	,900		
		RF	M	=	15	4		
Solution	:: a)	Find th	ne A	rea	=	Î D²		
						4		
					=	3.1416	6 (6	5)²
						4	-	
					=	.7854	(422	25)
			Α			3318.3	32 c	m²
	b)	IHP	=	PL	AN			
				45	00			
		Ρ	=	45	00	<u>x IHP</u>		
				-	LA	N		
			=	-	45	00 x 13	3,90	0
				_1.3	85 >	< 3318.	32 :	x 154
			=	62	550	000		
				68	987	8.72		
		Р	=	90.	.66	kg/cm <sup>2</sup>		

Q. A tank is filled with water to depth of 40 ft. 6 inches. Find the pressure exerted on the tank bottom?

Given data: Depth of tank = 40 ft., 6 inches = 0.5 ft. Formula: Pressure = height x 0.434 = (40 ft. + 0.5 ft.) (0.434)= (40.5 ft.) (0.434)= 17.57 psi

Q. What is the volume of a sphere whose diameter is 70 inches?

Given data: Diameter = 70 inches Formula: Volume of sphere =  $\frac{\hat{\Pi} d^3}{6}$ 

$$= \frac{3.1416 (70)^3}{6}$$
$$= \frac{3.1416 (343,000)}{6}$$
Volume = 179,594.8 cu, in,

#### Q. What is the lateral surface of a sphere 10 inches in diameter?

Formula: Area =  $\widehat{\Pi} D^2$ = 3.1416 (10)<sup>2</sup> = 3.1416 (100) = 314.16 in.<sup>2</sup>

Q. A revolution counter read 69895 at 8:00 AM, at 11:00 AM the clock was advance 17 mins. and at noon the counter reads 87,319. What was the average speed on the 8-12 clock watch?

Solution:

Average RPM =  $\frac{\text{Present} - \text{Previous reading}}{\text{Time in watch-advanced}}$  $= \frac{87319 - 69895}{240 - 17}$  $= \frac{17424}{223}$ Ave. RPM = 78.13

Q. A ship leaves port with 7200 barrel of fuel oil on board. At 15 knots, the fuel consumption is 360 barrels/day. After the vessel has travelled 1642 miles, what is the remaining steaming radius?

Solution:

1.	Total speed/day	=	15 knots, x 24 hrs.
		=	360 miles 🛹
2.	Cons. of oil/ 1 mile	=	360 + 360
		=	1.0 barrel
3.	F.O. cons at 1642 mi	les	= 1642 x 1.0
			= 1642 barrels
4.	Fuel on board	=	7200 - 1642
		=	5558 barrels

# **BOARD QUESTIONS**

# FOURTH, THIRD, SECOND, CHIEF ENGINEER

# MATHEMATICS

1.	When you add 5/8; 7/12 and 11/24, what will the sum be?			
	A. 1 and 2/3	B. 1 and 3/2	C. 1 and 1/3	D. 1/3
2.	When you subtra	act 5/6 from 8/15, wha	t will the sum be the d	ifference?
	A. 1/5	<b>B.</b> 3/10	C. 2/6	D. 2/4
3.	What is the prod	luct of 5/8 and 4/7?		
	A. 4/7	<b>B</b> . 5/14	C. 10/14	D. 4/6
4.	The quotient of	13 divided by 3/7 is:		
	A. 15 and 2/1	B. 30 and 3/6	C. 30 and 1/3	D. 2/30
5.	The quotient of (	36.744 divided by 24 is	S:	
	A. 1531	B. 15.31	<b>C</b> . 1.531	D. 153.1

55

6. Multiply .397 by 41 the product is:

	<b>A</b> . 16.277	B. 162.77	C16277	D. 1627.7
7.	From 128 subtra	act 96.307, the differen	ce is:	
	<b>A</b> . 31.693	B. 316.93	C31693	D. 3169.3
8.	Solve for x in the	equation 12x + 25 - 3	35 = 14x + 22x - 22	
	A. x = 11	B. x = 12	<b>C</b> . $x = 1/2$	D. x = 6
9.	The quotient of 2	2.5 divided by .05 is:		
	A50	<b>B</b> . 50	C05	D. 5.0
10.	-180 degrees far	renheit in centigrade is	:	
	A. 117.77 d. C	<b>B</b> 177.77 d. C	C, 68 d. C	D68 d. C
11.	Solve for x in the	equation $8x - 22 = 1$	2x - 18.	
	A. x = -1	<b>B</b> . x = 1	C. x = 4	D. x = -4
12.	The height of an are as follows: 2 mean height of t	indicator diagram me 27, 39, 47, 51, 48, 32, the diagram in millimet	asured at regular inter 20, 11, 8, 5, mm. resp rers.	vals along its height bectively. Find the
	A. 288 mm.	B. 2.88 mm.	<b>C</b> . 28.8 mm.	D0288 mm.
13.	A pump can emp hours, and anoth ing together on t	pty a tank in 12 hours, her can empty this tan this tank, how long woo	another pump can em k in 9 hours. If all three uld it take to empty it?	pty the same tank in 4 pumps are set work-
	A. 4/9 hours	B. 2 and 1/4 hours	C. 2 hours	D. 3 hours
14.	-243 degrees fa	hrenheit in absolute is	:	
	<b>A</b> . 217 d. A	B217 d. A	C. 217.29 d. A	D217.29 d. A
15.	-65 degrees cen	tigrade in fahrenheit is	:	
	A60 d. F	B. 85 d. F	<b>C.</b> -85 d. F	D. 60 d. F
16.	Given 7.5 cm. ra	adius Pi is 3.1416. Find	d the circumference.	
	A. 47.1238 cm.	. B. 23.562 cm.	<b>C</b> . 47.124 cm.	D. 12 cm.

17. Given 8 cm. diameter. Find the circumference.

	<b>A.</b> 25.1328 cm. B. 12.5662 cm.	C50.2656 cm. D. 50 cm.
18.	Negative Forty million eleven minus Six	thousand one is:
	A40,006012 B39,994,010	C. 39,993,010 D. 40,006012
1 <del>9</del> .	Solve for x in the equation -14x - 15x +	29 = 2x - 31 - 11
	A. x=-1 and 4/27 B. x=2 and 9/	'31 C. x = 27/31 D. x = 7
20.	Negative Sixteen million one minus nega	ative Nine hundred ninety-nine equals:
	A15,999,002 B. 15,999,002	C. 16,000,901 D16,009
21.	The distance covered by a ship on four a 330 nautical miles respectively. Find the	successive days were 320, 300, 310 and average days run.
	A. 5040 naut. miles B. 2520 naut. mile	es C. 1260 naut. miles <b>D.</b> 315 naut. miles
22.	An automobile battery supplies a curren of 0.84 ohms. Find the voltage delivered	t of 7.5 amps to a headlamp with resistance I by the battery.
	A. 7.93 volts B. 6.3 volts	c. 8.93 volts D. 6.395 volts
23.	A wire is to be cut in such a way that one How long are the pieces, if their combine	e piece is shorter than the other by 8 meters. ed lenght is 24 meters.
	A. 16 m shorter piece; 8 m longer piece	B. 14 m shorter piece; 12 m shorter piece
	C. 12 m longer piece; 12 m shorter piece l	D. 16 m longer piece; 8 m shorter piece
24.	A revolution counter reads 69,985 at 8 a min. and at noon counter reads 87,316. watch?	a.m. at 11a.m. the clock was advanced 17 what was the average on the 8-12 o'clock
	A. 135.6 rpm B. 77.71 rpm	C. 78,1210 rpm C. 156.2 rpm
25.	Find the value of a in equation: $2(a+3)$	+ 3(2a-4) = 4(11-3a)
	A. a = -2 1/2 B. a = 7	<b>C.</b> $a = 2 \frac{1}{2}$ D. $a = 4$
26.	A ship makes an observed speed of 17 knots. What is the propeller slip in perce	knots per hour. The engine speed is 17.5 ent?

A. 28.5 % B. 285% C. .0285% D. 2.85%

27. 200 tonne of oil were bought at one port at \$60 per tonne and 600 tonne of oil at another port at \$70 per tonne. What was the average cost of oil per tonne?

A. \$ 67.50 B. \$ 67.85 C. \$ 67.60 D. \$ 68

28. A motor boat travels up-river against the current from one point to another at a speed of 6 knots, and then down the river with the current back to the original point at a speed of 9 knots, taking a total time of 2 and 1/2 hours. Assuming the speed of the current remains unchanged, find the distance between points.

A. 9 naut. miles B. 10 naut. miles C. 8 naut. miles D. 13 naut. miles

29. How much water must be added to 400 liters of mixture that is 80% alcohol to reduce it to a 60% mixture?

A. 80 liters B. 70 liters C. 20 liters D. 50 liters

- 30. A ship's hold, A, contains 250 tonne of cargo, another hold B, contains 620 tonne. How much cargo must be taken from B and put into A so that A will contain five times as much as B?
  - A. 275 tonne B. 475 tonne C. 570 tonne D. 300 tonne
- 31. A ship covers the measured mile (one nautical mile) against the current, in a 3 minutes 20 seconds, and then in the opposite direction over the same distance with the current in 3 minutes exactly. Find in knots:
  - A. The speed gainst the current
  - B. The speed with the current
  - C. The average speed
  - A. 1) 18.95 knots 2) 20 knots 3) 18 knots
  - B. 1) 20 knots 2) 18 knots 3) 18.95 knots
  - C. 1) 18 knots 2) 20 knots 3) 18.95 knots
  - D. 1) 2 knots 2) 13 knots 3) 18 knots
- 32. A rectangular is to cut so that the lenght is four times the breadth and having an area of one square meter. Find the length and breadth.

A. 3 and 4 meters B. 2 and 2 meters C. 1 and 5 meters D. 2 and 0.5 meters

33. The actual horsepower delivered by an engine was found to be approximately 12.5 the indicated horsepower from diagram was 15.36. Find the mechanical efficiency.

A. 19.2 % B. 50 % C. 81.3% D. 1.23%

34. A 56 in. diameter tank is 14 ft, 4 in. high and is filled to within 16 in. of the top with water. How many cubic inches of water are in the tank?

A. 285,340,3673 **B.** 384,230.2464 C. 495,341.3575 D. 162,018,0242

35. A tank can be filled by two pipes in 4 and 6 hours respectively. It can be emptied by a third pipe in 5 hours. In what time can an empty tank be filled in the three pipes are open?

A. 4 2/7 hours **B.** 4 8/13 hours C. 4 4/7 D. 4.0 hours

36. There are two intake pipes to a large storage tank. Using the smaller pipe alone, it takes twice as long to fill the tank as it does using the large pipe alone. The tank can be filled in 12 minutes if both pipes are used. How long would it take using only the smaller pipe?

A. 24 minutes B. 36 minutes C. 18 minutes D. 20 minutes

37. In 5 hours less time that it takes a certain ship to travel 330 nautical miles, another ship which is 3 1/2 knot faster can travel 4 nautical miles further. What are the speed of the two ships?

Α.	1) 13.5 knots 2) 16.2 knots	C. 1) 14.1 knots 2) 15.9 knots
в.	1) 13.9 knots 2) 16.1 knots	D. 1) 13.2 knots 2) 16.7 knots

38. A ship travelling at 17.5 knots leaves one port bound for another 4 1/2 hours after another ship whose speed is 16 knots leaves the same port set on the same course. After how many hours and at what distance from port will the fast ship overtake the slower one?

<b>A.</b> 1) 48 hours	C. 1) 16 hours
2) 840 n.m.	2) 12 n.m.
B 1) 24 hours	D. 1) 12 hours
2) 16. n.m.	2) 10 n.m.

39. An engine develops 2500 IHP and the BHP is 2000. What is the mechanical efficiency?

A) 12.5 or 12% B. 1.25 or 1% C. .8 or 80% D. .08 or 8%

40. A ship travel 9 miles in 45 mins. What is its speed in miles per hour?

A. 3 miles B. 6 miles C. 12 miles D. 2 miles

# FORMULAS

Area of rectangle A	=	length x width L x W
Area of circle	=	Î R <sup>2</sup> Î D <sup>2</sup> 4
Circumference of circle	=	2ÎÎr ÎÎ D
Area of square	=	side x side s x s
Area of triangle	=	<u>1</u> ab 2
Area of Ellipse	=	ÎÎ ab ÎÎ Dd 4
Area of Trapezoid A	= .	$\frac{1}{2}$ (b <sub>1</sub> + b <sub>2</sub> ) h
Area of Sector A	= .	1 radius x arc
A	= .	$\frac{1}{2} r^2 \theta$
Area of Parallelogram	=	base x perpendicular height
Area of Parabola	=	base x <u>2</u> height 3
Area of cylinder	=	circumference x height + area both ends
Area of sphere	=	d² x Îl where Îl = 3.1416
Volume of rectangular solid	=	Length x width x height

Volume of cylindrical = area of base x height vessel  $V = .7854 D^2 h$  $V = \widehat{\Pi} R^2 h$ 

 $V = L \times W \times H$ 

Volume of coal bunker (trapezoidal end)  

$$V = \frac{Wr + Wb \times H \times L}{2}$$
Volume of Spherical tank =  $\frac{\widehat{\Pi} d^3}{6}$ 

#### **TEMPERATURE SCALES**

°F =	<u>9</u> C + 32 5
= C°	<u>5</u> (°F – 32) 9
Deg. absolute =	°C + 273
Deg. absolute =	°F + 460

Phythagorean Theorem / Right Angles:

 $= a^2 + b^2$ 

Trigonometric Functions:

C²

sine <del>o</del>	= 0	Cosec 🕈	=	1	H	<u>h</u>
	h			sin e		0
cos 🖶	= <u>a</u>	sec 😝	=	1	=	<u>h</u>
	h			COS O		а
tan <del>o</del>	= _0	cot <del>o</del>	=			a
	а			tan <del>o</del>		h

.

where O = opposite h = hypotenus a = adjacent

Physics, Strength of Materials formulas:

Torque = Force x Distance

Average Speed	= Distance travelled Time ellapsed
Velocity	= <u>Distance</u> <u>s</u> = m/sec, Ft./sec, mi/hr. time t
Force	= Mass x Acceleration
Work	= Force x Distance
Power	= <u>Worked done</u> time
Acceleration	= <u>Velocity</u> Time
Efficiency	= <u>Output</u> input
KE energy	$= \frac{1}{2} MV^2$
Stress in Tube	$= \frac{P_1 \times P_2 \times P}{D^2 \times .7854}$
Volume	= <u>Weight</u> Volûme
Density	= <u>Mass</u> Volume
Specific gravity	$=$ $\frac{mg}{V}$
<b>Ideal Gas eq</b> uat pV	ion: = mRT
<b>Avogadro's Lav</b> VaMa	$V = V_{b} M_{b}$

Enthalphy h = u + pVPotential Energy: Ep = mgzInternal Energy: du = CvdT Boyle Law =  $V_1 \times P_1 = V_2 \times P_2$ Charles Law:  $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ Gay-Lussac Law:  $P_1 = \frac{T_1}{P_2} = \frac{T_2}{T_2}$ Pressure = Force (N) Area (m<sup>2</sup>)  $= \frac{\text{Pressure}}{\text{Area}} = \frac{\text{P}}{\text{A}}$ Compressive Tensile Stress=Tensile=TAreaA= <u>Yield pt.</u> = <u>Y</u> Strain Elastic limit

### ENGINE/LOG-BOOK REPORT FORMULAS:

**Indicated horsepower:** 

$$IHP = \frac{PLAN}{33,000}$$
where: P =  $\frac{33,000 \times IHP}{LAN}$ 

$$A = \frac{33,000 \times IHP}{PLN}$$

where: P L A N		mean effective press length of stroke Area $\frac{\widehat{\Pi}}{4}$ D <sup>2</sup> Rpm	≈ट∯ <u>'</u>		
IHP/cylinder 4 stroke	-	MEP x cylinder constant x RPM 2			
IHP/cylinder 2 stroke	=	MEP x cylinder constant x RPM			
Cylinder constant (Metric)	8	<u>length of stroke x area</u> 4500 A =	Meter Cm <sup>2</sup>		
Cylinder constant (English)	=	length of stroke x areawhere: L33,000A	Ft. in.²		
MEP = Average heig Where: Avera	ht o Ige l	f the card x Spring constant height = <u>(area) in.²</u> (length) in.			
Slip = Eng. distance Engine	Slip = <u>Eng. distance – Observed distance</u> = <u>ED–OD</u> Engine distance ED				
Slip % = Engine distance – Observed dist. x 100 Engine distance					
Actual Slip=Engine speed - Actual speedActual BHP=Total IHP x Mechanical efficiency% Mech. Efficiency=BHPxIHP					
Output Ratio = <u>Actual BHP</u> constant (BHP max. shop trial)					
Average RPM = <u>Ac</u>	lvan M	nced in counter reading linutes in watch			
Average Speed = Di	stan	nce travelled in miles Time in hr.			
Engine Distance = (P	itch 60	of the propeller) (Ave. RPM) (Time) 80 ft. or 1852 m/miles			

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Propeller Constant	۳	<u>(Pitch) (60)</u> 6080 ft.			
Propeller Speed	-	Propeller constant x RPM			
Propeller Slip %	8	Prop. speed – ship speed prop. speed	x	100	

## **PUMPS FORMULAS:**

G.P.H.	= <u>MÁNS</u>	M =	min. in 1 hr.
	231	A =	area liquid cylinder
G.P.M.	= <u>ALNE</u>	N =	no. of stroke
	231	S =	length of stroke
G.P.H.	= ALNE x 60	E =	efficiency
	231		

### **Taper formula for Lathe Work:**

Taper per inch	= <u>D-d</u>		where:		
·	Ŀ		D	H	diameter at large end
·			d	=	diameter at small end
Taper per foot	$= \frac{D-d}{L} \times$	12	L	8	length in inches

# **CONVERSION TABLE**

The Principal units of the metric System are:

- 1. The metric for lengths
- 2. The square meter for surface
- 3. The cubic meter for large volumes
- 4. The liter for small volume
- 5. The gram for weights

1 millimeter	=	0.03937 inch
1 centimeter	=	0.3937 inch

- 1 centimeter
- 1 meter
- = 39.37 inches or 1.0936 yards = 0.6214 mile
- 1 kilometer
- 1 inch 1 foot
- = 2.54 centimeters
- = 304.8 millimeters; 0.3048 meter
- 1 yard = 0.9144 meter

1 mile	=	1.609 kilometers
10 millimeters (mm)	=	1 centimeters (cm)
10 centimeters	=	1 decimeter (dm)
10 decimeters	=	1 meter (m)
10 meters	=	1 decameter (dm)
10 decameters		1 hectometer (hm)
10 hectometers	=	1 kilometer (km)
10 kilometers	=	1 myriameter
1 square millimeter	=	0.00155 square inch
1 square centimeter	=	0.155 square inch
1 square meter	=	10.764 square feet
1 hectare	=	107.640 square feet
1 square kilometer	=	0.3861 square mile
1 square inch	=	6.452 square centimeters
1 square foot	=	929 square centimeters
1 square yard	=	0.836 square meter
1 square mile	=	2.5899 square kilometers
1 liter	=	61.023 cubic inches
	=	1.0567 U.S. quarts
	<u></u>	0.2642 U.S. gallons
1 cubic inch	=	16.383 cubic centimeters
1 cubic foot	=	0.02832 cubic meters
	=	28.317 liters
1 cubic yard	=	07645 cubic meter
1 gallon U.S.	=	3.785 liters
1 gallon British	=	4.543 liters
1 gram	H	0.03216 ounce troy
	=	0.03527 ounce Avoirdupois
	=	15.432 grains
1 kilogram	=	2.2045 pounds avoirdupois
1 metric ton	=	2204.6 pounds
1 grain	=	0.0648 gram
1 ounce troy	=	31.103 grams
1 pound	=	453.6 grams
1 U.S. ton of 2000 lb	S=	907.2 kilograms
1 barrel oil	=	158.9828 liters
1 cubic meter	I	1000 liters
1 cubic meter	=	6.2899 barrels
1 Iona ton	=	1.016 MT

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#### **COMPUTATIONS in VOLUME:**

To get: BARRELS =  $m^3 \times 6.2899$ Metric Ton =  $m^3 \times S.G. \times C.F.$ Long Ton = MT  $\stackrel{\bullet}{\rightarrow} 1.016$ Cubic Meter = MT  $\stackrel{\bullet}{\rightarrow} S.G.$ 

#### **WEIGHTS & MEASURES**

#### **METRIC SYSTEM**

#### LENGTH

kilometer = 1,000 meters = 3,280 feet, 10 inches
 hectometer = 100 meters = 328 feet, 1 inch
 meter = 100 cm. = 39.37 inches
 centimeter = .01 meter = .3937 inch
 millimeter = .01 meter = .0394 inch
 micron = .000001 meter = .00039 inch
 millimicron = .00000001 meter = .00000039 inch

#### SURFACE

1 sq. kilometer = 1,000,000 sq. meters = .3861 sq. mile 1 hectare = 10,000 sq. meters = 2.47 acres 1 are = 100 sq. meters = 119.6 sq. yards 1 centare = 1 sq. meters = 1,550 sq. inches 1 sq. centimeter = .0001 sq. meter = 156 sq. inch 1 sq. millimeter = .000001 sq. meter = .00155 sq. inch

#### VOLUME

1 kiloliter = 1,000 liters = 1,308 cu. yards or 264.18 gallons 1 hectoliter = 100 liters = 2.838 bushels or 26.418 gallons 1 liter = 1 liter = .908 quart or 1.057 quarts 1 centiliter = .01 liter = .061 cu. inch or .338 ft. ounce 1 milliliter = .001 liter = .061 cu. inch or .271 ft. dram

#### WEIGHT

1 kilogram = 1,000 grams = 2.205 pounds 1 hectogram = 100 grams = 3.527 ounces 1 gram = 1 gram = .035 ounce 1 centigram = .01 gram = .154 grain (Troy) 1 miligram = .001 gram = .015 grain (Troy)
#### VOLUME

1 gal (U.S.)	=	128 ft. oz (U.S.)
	=	231 cu. in.
	=	0.833 gal. (Brit.)
1 cu. ft.	=	7.48 gal. (U.S.)

#### WEIGHT OF WATER

cu. ft. at 50°F weighs 62.41 lb.
 gal. at 50°F weighs 8.34 lb.
 cu. ft. of ice weights 57.2 lb.
 Water is at its greatest density at 39.2°F
 cu. ft. at 39.2°F
 cu. ft. at 39.2°F weighs 62.43 lb.

#### WEIGHT OF LIQUID

1 gal. (U.S.)	=	834 lb. x sp. gr.
1 cu. ft.	=	62.4 lb. x sp. gr.
1 lb.	=	0.12 U.S. gal. + sp. gr.
	=	0.016 cu. ft. + sp. gr.

#### FLOW

1 gpm ·	-	0.134 cu. ft. per min.
:	=	500 lb. per hr. x sp. gr.
500 lb. per hr. :	=	1 gpm + sp. gr.
1 cu. ft. per mir	1.	(cm) = 448.8  gal. hr. (gph)

#### WORK

1 BTU (mean) =	778 ft. lb.
=	0.293 watt hr.
.,	1/180 of heat required to change
	temp. of 1 lb. water from 32°F
	to 212°F
1 hp. hr. =	2545 BTU (mean)
=	0.746 kwhr.
1 kwhr =	3413 BTU (mean)

#### POWER

1 BTU per hr. = 0.293 watt

- = 12.96 ft. lb. per min.
- = 0.00039 hp.

1 ton refrigeration (U.S.) = 288,000 BTU per 24 hr.

- = 12,000 BTU per hr.
- = 200 BTU per min.
- = 8333 lb. ice melted per ltr. from and at 32°F

1 hp = 550 ft. lb. per sec.

- = 746 watt
- = 2545 BTU per hr.
- = 33,480 BTU per hr.
- 1 boiler hp = 34.5 lb. water evap. per hr. from and at 212°F
  - = 9.8 kw.
- 1 kw = 3413 BTU per hr.
  - = 1000 watt

#### MASS

1 lb. (Avoir)	=	16 oz. (Avoir)
	=	7000 grain
1 ton (short)	÷	2000 lb.
1 ton (long)	=	2240 lb.

#### OTHER USEFUL MEASUREMENTS (Metric System)

#### LONG MEASURE

=	1 foot (ft.)
=	1 yard (yd.)
=	1 fathom
=	1 pole
=	1 furlong
=	1 mile
æ	1 league
=	1 degree

#### **CUBIC MEASURE**

728 cubic inches	=	1 cubic foot
27 cubic feet	=	1 cubic yard
128 cubic feet	=	1 core of wd.
24 1/4 cubic feet	=	1 ph. of stone

#### SQUARE MEASURE

144 sq. inches	=	1 sq. feet
9 sq. feet	=	1 sq. yard
30 1/4 sq. yards	=	1 sq. pole

#### TIME MEASURE

60 seconds
60 minutes
24 hours
7 days
30 days
12 months
365 days
366 days
10 years
20 years
100 years

- = 1 minute
- = 1 hour
- = 1 day
- = 1 week
- = 1 calendar month
- = 1 year
- = 1 common year
- = 1 leap year
- = 1 decade
- = 1 score
- = 1 century

GENERAL	CONVERSION	FACTORS
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Unit	Conversion to	Multiply by	Reciprocal
Linear Measure			
mil (0,001 inch)	millimetre	0,0254	39,37
inch	millimetre	25,4	0,03937
foot	metre	0,3048	3,281
yard	metre	0.9144	1.0936
mile	kilometre	1,6093	0.6214
nautical mile	kilometre	1,8532	0,5396
Square Measure		<u></u>	
square inch	square millimetre	645,2	0,00155
square inch	square centimetre	6,452	0,155
square foot	square metre	0,0929	10,764
square yard	square metre	0,8361	1,196
acre	square metre	4047,	0,0002471
acre	square foot	43560,	0,00002296
square mile	acre	640,	0,001562
square mile	square kilometre	2,590	0,3863
Volume			
cubic inch	cubic centimetre	16,387	0,06102
cubic foot	cubic metre	0,02832	35,31
cubic foot	gallon (U.S.)	7,48	0,1337
cubic foot	litre	28,32	0,03531
cubic yard	cubic metre	0,7646	1,3079
ounce (U.S., liq.)	cubic centimetre	29,57	0,03382
quart (U.S., liq.)	litre	0,9464	1,0566
gallon (U.S.)	gallon (Imperial)	0,8327	1,2009
gallon (U.S.)	litre	3,785	0,2642
barrel (U.S. Petroleum)	gallon (U.S.)	42,	0,0238
barrel (U.S. Petroleum)	litre	158,98	0,00629
Mass		······································	
grain	milligram	64,8	0,01543
ounce (oz)	gram	28,35	0,03527
pound (lbs)	kilogram	0,4536	2,205
short ton	metric ton	0,9072	1,1023
long ton	metric ton	1,0161	0,9842
Work, Heat and Energy			
British thermal unit (Btu)	joule	1055,	0,0009479
foot pound-force	joule	1,356	0,7375
calorie	joule	4,187	0,2389
Btu	foot pound-force	778,	0,001285
kilocalorie	Btu	3,968	0,252
Btu	kilogram metre	107,56	0,009297
Biu per hour	watt	0,2929	3,414
watthour	joule	3600,	0,0002778
horse power	kilowatt	0,7457	1,341
Miscellaneous			
pound per gallon (U.S.)	gram per litre	119,8	0,00835
pound mole (gas)	cubic foot (STP)	359,	0,00279
gram mole (gas)	litre (STP)	22,4	0,0446
board foot	cubic metre	0,00236	423,7
milliampere per foot <sup>2</sup>	milliampere per metre <sup>2</sup>	10,76	0,0929
gallons (U.S.) per minute	metre" per day	5,451	0,1835
pound-force	newton	4,448	0,2248
kilopond (Kp)	newton (N)	9,81	0,102



**ELECTRICITY** – the effect of electrons in moving from point to point or the excess or lack of electron in a material. It may be produced thermally, mechanically or by chemical action. On board as engineer simply can be defined by its effects. Electricity consist of a flow of energy in a wire that cause the wire to become hot, which produced magnetic field around the wire and can be put to works like driving, pumps, auxialliaries equipments etc.

#### 6 SOURCES OF ENERGY THAT ELECTRICITY CAN BE PRODUCED

- 1. Friction charged caused by rubbing one material against another. Example: wood/stone
- 2. Pressure produced electricity by applying to a crystal of a certain, or by speaks in telephone.
- 3. Heat electricity produced by heating the junction of a thermo-couple.
- 4. Light electricity produced by striking photosensitive material. Example: iron, selenium alloy.
- 5. Magnetism produced by relative movement of a magnet and wire that result in the cutting of line of force.
- 6. Chemical action electricity produced by chemical reaction in an electric cell. Example: Battery

#### DEFINITIONS AND FUNCTIONS OF ELECTRICAL TERMS GIVEN TO ALL RANKS PREVIOUS EXAMINATIONS

ALTERNATING CURRENT – is a current that changes its direction rising from zero to a maximum intensity and back to zero and cycle repeats.

AMMETER - instrument used to measure amperes/rate of flow.

AMPERE - unit of electrical current.

AMPERE TURNS – the strength of an electromagnet can be determined either by the number of turns of wire or by the strength of the current.

APPARENT POWER - the power indicated by an ammeter and voltmeter readings.

**ARMATURE WINDING** – is to cut lines of forces passing between field magnets and transmit the developed eletromotive force to the commutator.

ATOM - the smallest physical particle into which element can be divided.

**AUTOMATIC CONTROL** – a system in which the value of a process if compared against a desired value and corrective action taken to correct the deviation without the use of human help.

BALANCER SET – it is a motor generator, both units are alike, used in some wire, W-voltage system to help the load balanced between the two side of the circuit.

**BATTERY** – a series of two or more cell that are capable of producing electricity by electrochemical means. It is charged by reversing the current through the battery by using DC to restore the material deposited in the electrolyte back on the plate in position. Type of Battery: Primary - cannot be recharge. Secondary - can be recharged.

**CAPACITANCE** – when voltage across an electric current changes, the circuit opposes this change called and measured in Farads.

**CAPACITOR** – is a device for storing an electrostatic charge.

**CIRCUIT BREAKER** – a mechanical safety device that open a circuit when the current in the circuit exceeds a pre-determined amount.

**CONDUCTOR** – it is a substance that offers a low resistance to the flow of current. Example: Aluminum, Copper, Silver, Steel.

**COMMUTATOR** – is to convert the AC from the armature winding into direct current and transmit it through the brushes to the external circuit.

**CONVERTER** – an electrical device used for converting alternating current to direct current.

**CONDENSER** – a combination of conducting plate separated by an insulator.

**CONTACTORS** – consist of two broad flat copper surfaces that are pressed tightly together to close the circuit.

**COUNTER EMF** – is counter voltage induced in a conductor or which opposes a change in flow of the current in the conductor. In electrical motor, CEMF is the voltage generated in the armature which opposes the supply voltage.

**DC GENERATOR** – is a mechanical power turn the armature and the moving armature generates electrical power.

**DC MOTOR** – electrical power forces the armature to turn through mechanical system, belts, gears which produced mechanical load,

**DEAD BAND** – a zone within a change of value of an input signal does not cause a change in the controller. If the dead band is too small, the steam value may hunt. If the dead band is too large, speed regulation will be poor.

**DEAD SHORT** – is a short circuit that has such low resistance that the circuit is made inoperative.

DIRECT CURRENT - the current that flow only in one or constant direction.

**EDDY CURRENT** – induced circulating current in a conducting materials caused by a varying magnetic field, Eddy currents are reduced by laminating the armature core.

ELECTRON - small negative charged particle of a nucleus (-).

**ELECTROLYSIS** – is the chemical action related to the conduction of electricity through acid or salt solution.

**ELECTRO MAGNET** – a piece of soft steel or iron that is magnetized by having a coil of current carrying wire wrapped around it, when current is shut off, the iron or steel becomes demagnetized.

**ELECTROMAGNETISM** – magnetism produced when electric current is passed through a coil or wire.

**EQUALIZER** – a connection between two generators of different capacities running in parallel so that the running load is divided proportionally between the two.

**EXCITATION** – the process of exiting current to the rotor of an A.C. generator, or the supply of electrical current for the purposed of producing a magnetic field.

**EXCITER** – a small D.C. generator which supplies the exciting current to the A.C. generator.

**EXTERNAL CIRCUIT** – it is the part of the electrical circuit leading from the source of supply back to the source of supply.

**FARADAY LAW** – states that if a magnet is moved past a wire, electrical current will start through the wire. If the magnet is stopped near the wire, the current will stop. Electricity will flow only when the magnetic field or magnetic lines of force are being cut by the wire.

FREQUENCY – means the number of times per unit of time the cycle is repeated.

60 CYCLE - means the number of times which is 60 time per second a cycle is repeated.

**FUSE** – electrical safety device to break off the circuit in case of overload of current, consit of low-melting metal in series with the line at predetermined temperature caused it to melt thus breaking the circuit and stopping the flow of current.

**GALVANOMETER** – instrument to measure or detect small electric current by moving magnetic coil in a magnetic field.

GENERATOR -- it is a machine which converts mechanical energy into electrical energy.

**GROUNDED CIRCUIT** – a circuit that has come in contact with the earth either by coming in contact somewhere itself or leak off to the ship hull directly. Typical signs of a ground are abnormal amperage, voltage, resistance readings, also shock and abnormal circuit performance.

**GROUND LIGHTS** – set of two lights which are used for checking grounds or low insulation of electrical circuits.

**GROWLER** – an electro magnetic device with two adjustable pole pieces for finding - short circuited coils and for magnetizing and demagnetizing.

**HORSEPOWER** – unit of mechanical energy equivalent to 1 horsepower equal to 33,000 ft. lbs. per minute.

**HYDROMETER** – instrument use for checking the charged capacity of a battery with full charged approximately 1,300 S.G. and low 1,000 Specific Gravity.

**INDUCED CURRENT** – consist of magnetic lines of force that cut a wire, electric current is induced to flow in the wire.

**INDUCTION COIL** – operates on DC current and gives an instantaneous voltage when the primary circuit is made or broken.

**INDUCTION MOTOR** – is an AC motor whose speed is not proportional to the frequency of the system; Mostly squirrel-cage type consist of stator which is cuter, hollow, stationary laminated steel, slotted for armature winding and having an inner cylindrical motor. It is usually found on board where sources is alternating current.

**IMPEDANCE** – in an AC circuit with combined effects of resistance XI and Xc and measured by ohms.

**INTERLOCKS** – operating levers are interlocked mechanically to prevent incorrect operation like reverses, astern or ahead.

**INTERPOLES** – used on DC motor in order to offset armature reaction and give better commutation.

**INSULATOR** it is a substance that offers a high resistance to the flow of current. Examples: rubber, cork, porcelain.

**INVERTER** – is a piece of electrical equipment for converting DC to AC.

JAMMING RELAY – fitted on motor serve as device that inserts resistance in series with a motor armature in case of excessive overloads and overheating, thus motor armature current is cut down to a safe value.

**K.W. METER** – electrical meter that shows the operator the amount of electrical power in Kw.

**LENZ LAW** – an induce current sets up a magnetic field which opposes the motion that causes the current.

**MEGGER** – instrument used to measure the effectiveness of an insulation resistance of electrical equipment.

**MEGOHM** – equivalent to one million ohms.

MILLIOHM – equivalent to thousand ohms.

**MOLECULE** – combination of two or more atoms.

**MOTOR** – a machine device which converts electrical energy into mechanical energy.

**NEUTRON** – neutral particle in the nucleus consist of electron and proton.

OHM - unit of electrical resistance.

**OHMETER** – instrument used to measure consumption of electrical energy.

**OHMS LAW** – states that the current flowing in a electrical circuit is directly proportional to the impressed voltage and inversely proportion to the resistance.

**OVERLOAD RELEASE** – device automatically breaks the current if an excessive current is drown by the motor.

**PARALLEL CIRCUIT** – is an electrical connection in which the various parts are so connected together that there is more than one path for the flow of current or when the apparatus are connected side by side.

**PERMANENT MAGNET** – a piece of steel that has been hardened and placed under the influence of a magnetic field. When removed, it retains its magnetism of the field through its life.

**PHASE BALANCE RELAY** – It act to trip out the circuit breaker on the transformer and open the generator and motor field contactor, if unbalance excess of 25 percent it shows short circuit if phase unbalance or ground in one phase.

**POWER FACTOR** – ratio between true power and apparent power. It is expressed as a percentage of the apparent power.

**PROTON** - positive charged particle of a nucleus (+).

**RECTIFIER** – an electrical device used to change alternating current to undirectional current.

**RIGHT HAND RULE** – in every case where an EMF is induced by a conductor moving through stationary lines of force, the direction of this EMF can be found as follows: Place the right hand with the thumb. forefinger and middle finger all at right angles to one another; point the forefinger along the lines of force and thumb along the direction in which the conductor is moved, the middle finger will then show the direction the EMF induced in the conductor.

**RELAY** – is a device that is operative by a variation in the condition of one electric circuit to control the operation of other devices in the same or another electric circuit.

**RHEOSTAT** – an instrument composed by a combination of resistance used for regulating the strength of an electric current through the field windings of a generator.

**RESIDUAL MAGNETISM** – is the magnetism remaining in the field after all exciting current is shut off. It is important because the D.C. generator could not built up a voltage without it.

**RESISTOR** – a device in which the flow of electric current always produces heat.

**REVERSE POWER RELAY** – protects the generator from a power reversal.

**ROTARY CONVERTER** – used to convert AC to DC.

**SERIES CIRCUIT** – is one which all parts of the circuit are connected together so that there is only one path for the flow of current.

SERIES-PARALLEL CIRCUIT – is one in which the parts are connected both in series and parallel combination.

SHORT CIRCUIT – is a circuit with too low resistance to the system caused by insulation being damaged of two adjacent electric wires permit the current to pass from positive

to the negative wire without passing the usual resistance. Typical signs of short circuit are blown fuses, increase heat, low voltage, high amperage and smoke or burn.

SLIP RING - purpose is to supply D.C. current to the field winding of the motor.

SOLENOID - an electro magnetic coil that contains a movable plunger.

**STATOR** – stationary part of an electric motor which produces the rotating magnetic field.

**SYNCHROSCOPE** – an electrical apparatus used in synchronizing two or more D.C. generator.

SYNCHRONOUS MOTOR – the average speed of normal operation is exactly proportional to the frequency of the system which connected, and their main application in marine work as main propulsion motor. Its construction is similar as AC generator parts.

**THERMOCOUPLE** – two dissimilar metals are joined together; when heated, a voltage is produced.

**TRANSFORMER** – it is an electrical device used for increased or decreased voltage of alternating current.

**STEP DOWN TRANSFORMER** – is one that lowers the AC voltage and increase the ampere. The change in amperes is inversely proportional as the turns in the primary are to the turns in the secondary.

**STEP UP TRANSFORMER** – is one that raises the AC voltage and decreases the amperes. The change in volts is directly proportional, as turns in the primary are to the turns in the secondary.

**TRANSDUCERS** – a device capable of converting pressure, temperature or level into an electrical equivalent.

TRUE POWER - actual power as measured by watt-hourmeter.

WATT - unit of electrical power.

WATT HOUR METER - instrument used to measure consumption of electrical energy.

**VOLT** – unit of electrical pressure.

**VOLTMETER** – instrument used to measure volt/electrical pressure.

**VOLTAGE REGULATOR** – used to maintain the generator voltage within specified limits at constant with different load.

#### (1987-1991) QUESTIONS AND ANSWERS

#### FOURTH, THIRD, SECOND AND CHIEF ENGINEERS.

#### Q. Enumerate 10 causes which may result to a poor commutation of DC generator.

- 1. Overload
- 2. Hard or high resistance brushes
- 3. Rough commutators bars
- 4. High mica on the commutator grounds
- 5. Short circuit in the armature
- 6. Open circuit in the armature
- 7. Poor brush contact
- 8. Uneven air gap
- 9. Weak magnetic field
- 10. Inaccurate brush spring

#### Q. What are the causes of failures of a DC generator to build up?

- 1. Field connection reversed
- 2. Brushes are not in proper position
- 3. Wrong direction of rotation
- 4. Speed too low
- 5. Field circuit open
- 6. Not enough residual magnetism
- 7. Machine short circuit

#### Q. Name the causes of low voltages in generator.

- 1. Overload
- 2. Low speed
- 3. Improper setting of brushes

#### Q. What are the causes of too high voltage?

- 1. Field too strong
- 2. Speed too high (generator)

#### Q. What are the causes of hot commutators?

- 1. Sparking under brushes
- 2. Poor contact of brush
- 3. Near some hotter part of machine.

#### Q. Causes of sparking at the brushes?

- 1. Overload
- 2. Brushes setting is wrong
- 3. Poor brush contact
- 4. Rough commutator
- 5. Weak field
- 6. Armature winding broken or short circuited.

#### Q. Causes of too low generator speed?

- 1. Overload
- 2. Brushes setting wrong
- 3. Excessive friction
- 4. Short or ground in armature
- 5. Too little field resistance

#### Q. Causes of too hot field?

- 1. Overload
- 2. Damp windings
- 3. Too large field current
- 4. Short circuited coil.

#### Q. What general care should a generator receive while in operation?

- 1. It should be kept clean and dry.
- 2. The bearing should be kept well oiled.
- 3. The governor should be kept in good condition.

#### Q. Causes of too high generator speed?

- 1. Brushes setting too forward.
- 2. Open field circuit.
- 3. Wrong connection
- 4. Too much field rheostat resistance.

#### Q. What are the results of shorts in DC armature colls?

- 1. Overheating
- 2. Sparking at brushes.
- 3. Burning
- 4. Discoloration.

#### Q. What are some causes of failure of a generator to build up?

- 1. Field connection reversed
- 2. Brushes not in proper position
- 3. Wrong direction of rotation
- 4. Speed too low
- 5. Field circuit open
- 6. Not enough residual magnetism
- 7. Machine short circuited.

#### Q. Reasons why a self-excited DC generator might fail to come up to its rated voltage when starting up?

- 4. Speed too low.

- Brushes not in proper position.
  Field connection reversed.
  Wrong direction of rotation.
  Field circuit open.
  Not enough residual magnetism.
  Machine short circuited.

Q. A generator is vibrating, what check ups should be made before changing any balance weights.

- 1. Misalignment
- 2. Spring shafting
- 3. Somethings changing the rotating element
- 4. Foreign matter shaft.
- 5. Loose bolts, foundation
- 6. Faulty speed governor.

Q. What are the advantages gained by rotating the field in an AC generator rather than the armature?

- 1. The load current from the stator is connected directly to the external circuit without using slip ring.
- 2. Only two slip rings are necessary to supply excitation to the revolving field.
- 3. The stator winding is not subjected to mechanical stresses that are due to centrifugal force.

#### Q. What four things determine the amount of induced voltages and amperes?

- 1. The strength of the field
- 2. The number of conductor
- 3. The speed of cutting the fields
- 4. The angle which the conductors have to the field.

#### Q. Name some generator check-ups which should be made at least once a month.

- 1. Check load condition
- 2. Lubrication system operation
- 3. Governor action of prime mover
- 4. Bearing temperature and vibration

#### Q. Give the method of synchronizing by the use of bright lamp method.

In synchronizing by the use of the bright lamp method, the paralleling connection should be completed at the instant that the lamp shines at their maximum brilliancy.

#### Q. Give the method of synchronizing by the use of dark lamp method.

In synchronizing the use of the dark lamp method, the paralleling connection should be completed at the middle of the interval between the disapperance of the last glow and the time the same amount of glow reappear.

#### Q. Name the major parts of an AC and DC generator.

#### A. AC generator

- 1. The stator which contains the armature windings.
- 2. The rotor which contains the field windings.

#### B. DC generator.

- 1. The stator which contains the field windings.
- 2. The rotor which contains the armature windings.

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#### Q. Name the kinds of AC and DC motors.

#### AC motors

- 1. Wound rotor motor
- 2. Universal series motor
- 3. Repulsion motor
- 4. Synchronous motor

#### **DC motors**

- 1. Series motor
- 2. Shunt motor

3. Compound wound motor

- 4. Universal series motor
- Q. What are the types of transformer according to the method of winding the coll?
  - 1. Core type
  - 2. Shell type
  - 3. H-type

#### Q. Upon what factors does generated voltage depends?

- 1. Speed that the magnetic lines of force are cut.
- 2. Strength of the magnetic field.
- 3. Number of turns of wire.

#### Q. What protective device are installed in an electric drive system?

Fuses, circuit breakers, phase balance relays, reverse power relays, ground relays, interlock alarms such as klaxons and bells.

#### Q. What are the instruments used in synchronizing two or more AC generator?

- 1. Voltmeter
- 2. Synchronoscope
- Q. Name the instruments found in DC and AC switchboard panel.

Circuit breaker, voltmeter, ammeter, rheostat ground light, synchroscope, voltage regulator, P.F. meter, Kw meter.

### Q. What condition must exist in order that two AC generator will operate in parallel? They must have:

- 1. Same voltage
- 2. Same frequency
- 3. Same phase rotation.

#### Q. What are the factors that effect resistance on a wire?

- 1. Length of wire. 3. Type of material
- 2. Cross sectional area of wire. 4. Temperature of wire.
- Q. What are the conditions which would cause an AC generator to overheat?
  - 1. Overload

- 4. Dirty windings
- 2. Short circuit in coils
- 5. Fan or air cooler defective
- 6. Low power factor load

3. Damp coils

## Q. A generator is vibrating. What check-up should be made before changing any balance weights.

Misalignment, sprung shafting, something chafing the rotating element, foreign matter on shaft, overloading, loose bolts, faulty speed governor.

#### Q. Name some generator check-ups which should be made at least once a day.

Check load condition, commutator condition, lubrication system operation, governor action of prime mover, bearing temperature and vibration.

#### Q. What means are employed to prevent the outer circuit from overheating?

- 1. It must have a proper size of wire to the proper amount of current to be supplied.
- 2. Overload
- 3. Short circuited connection

### Q. What are the factors to be considered when synchronizing two or more generators?

#### They must have the following:

- 1. Same voltage
- 2. Same frequency
- 3. Same phase rotation and be in phase

#### Q. What happens when a 60 Hz motor load is connected to a 50 Hz generator?

The motor rated capacity to drive will be underated or less to its rotational capacity because of the generator frequency is low.

### Q. Which motor (AC or DC) can be smoothly controlled in terms of speed and why?

AC motor can be smoothly controlled in terms of speed. Unlike DC motors; AC motors does not use commutators therefore most occured troubles encountered in the operation of DC motors are eliminated.

# Q. As a marine engine officer, you are duty bound to maintain and preserve the electrical power system on board your vessel. State briefly what you know about electricity?

As a marine engineer officer my duties in regards to electrical equipment on board ship are as follows:

By definition basically Electricity may be defined as the effect of electron moving from one point to point and exist in static form which may be produced thermally, mechanically and through chemical actions.

Proper electrical maintenance methods of all generators, motors, and auxilliary machineries such as checking for short and grounded circuit, overloading, megger test for insulation resistances battery, wiring system for lighting and starting motor etc.

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Checklist maintenance test and records should be done on board regarding safety alarm test, insulation records, overhauling and repairs. Instrumentation like pressure and temperature gauges, alarms must be in good order.

#### Q. Advantages of turbo-electric drive ships.

- 1. Allows high speed prime mover and low-speed propeller at highest efficiency.
- 2. Allows full power of turbine when astern.
- Less noise and vibration. 3.
- 4. Does away with line shafting from turbine to propeller.
- 5. The electric instruments indicate the power output and can be used to improve operation.

#### Q. What is meant by power factor? Express it mathematically.

Power factor - is the ratio of true power to apparent power. It is expressed as a percentage of the apparent power.

P.F.	=	true power	=	Kw	=	Watt
		apparent power		KVA		Volt-Ampere

#### Q. How does the size of wire affects its resistance?

The resistance of a wire is inversely proportional to the square of the diameter. the length remaining the same.

#### Q. Give 4 factors that affect resistance in a wire.

- 1. Lenath of wire
- 2. Cross sectional area of wire
- 3. Type of material
- 4. Temperature of wire.

#### Q. As the length of a wire increases, what happens to its resistance? If the cross sectional area increases, what happens to the resistance?

As the length of a wire increases, the resistance remain the same. As the cross sectional area increases, the resistance decreases.

#### Q. What kind of metal is used for pole pieces of generator field.

Metal consist of round square and rectangular copper wire wrapped about a soft iron core.

#### Q. Describe a series electrical circuit when resistance are connected in series. What might be said about:

1. Current Flow

- 2. Voltage across each
- 3. Total voltage drop 4. Total resistance
- The current in every circuit is the same. 1.
- 2. The voltage across the circuit equal to the sum of the voltage across each separate resistance.

- 3. Total voltage drop is equal to the total line current multiplied by total resistance.
- 4. Total resistance is equal to the sum of the individual resistance.
- Q. Describe when resistance in parallel. What can be said about (1) the voltage drop across the entire parallel circuit; (2) voltage drop across each branch;
  (3) amount of current flow through each branch.
  - 1. The voltage drop across the entire parallel circuit is the same as the voltage across each branch.
  - 2. The voltage drop across each branch is the same.
  - 3. The total current through the combination is the sum of the current through each branch.

#### Q. What are the three things necessary to induce a voltage in a wire?

- a) Magnetic field
- b) A conductor in a closed circuit
- c) Relative motion between the two

#### Q. Give some characteristics and applications of types of DC motor.

**SERIES WOUND MOTOR** - speed varies with the load, at no load it overspeeds, at full load it decreases speed. This motor has a very high starting torque. Used for street cars, cranes, elevators, locomotives.

SHUNT WOUND MOTOR - constant speed over load range, constant load over speed range, has a good control and used mainly on machine tools where variable speed is desired.

**COMPOUND WOUND MOTOR** - has desirable features of both above types. Good starting torque, flexibility of speed control, constant load speed application. Used for centrifugal pumps, cargo winches, boat hoist, air compressor drive.

#### Q. Give some characteristics and applications of DC generator.

SERIES WOUNDED GENERATOR - which has its field coils wounded in series with the armature. The field coils has a few turns of large wire. The voltage will rise with an increase in load. They are not in general use, but may be used for boosting voltage in transmission of D.C.

SHUNT WOUND GENERATOR - it is a generator which has its field coil wounded in parallel with the armature. The field coil wounded in parallel with the armature consist of large number of turns of small wires. The voltage drops off with an increase in load. Used for battery charging and A.C. generator excitation.

**COMPOUND WOUND GENERATOR** - has two fields on each pole piece. One of the coils is made up of a few turns or heavy wire and wounded in series with armature. The other coils is composed of a great armature. This kind of generator is used for almost general purposes where DC current is required and also voltage <sup>+</sup> is fairly constant from no-load to the full-load.

### Q. What are the two general types of AC motors? Describe their characteristics and their uses?

1. Synchronous motor - has a rotating field with salient poles which are excited

by direct current speed is constant and torque is moderate. It is suited best for ship propulsion.

2. Induction motor - has a stator, the stationary part and the rotor as the rotating part. The speed is nearly constant, low starting torque and high starting current. It is used for general purposes.

#### Q. What are the two different types of induction motors, and its applications?

1. SQUIRREL CAGE TYPE - has no winding but rather has bars and end rings in the core of the rotor.

Uses - blower, machine shop motors, steering gear, motor generator and fans.

2. WOUND ROTOR TYPE - has windings on the wire of the rotor and slip rings on the shaft which are used for inserting resistances to vary its speed and for starting.

Uses - Boat hoist, capstans, cargo winches and elevators.

#### Q. What is the meaning of alternating current?

It is the current that between any two consecutive instants of time is either increasing in strength, decreasing in strength, or reversing in direction.

#### Q. Describe one cycle of A.C.

Start at zero strength and increases in strength to maximum in one direction, decreases in strength in the same direction to zero, reverses direction, increases in strength to maximum in the new direction, decreases in strength to zero, where it reverses again to the original direction.

#### Q. What is meant by frequency of A.C.? What is 60 cycle A.C.?

Frequency means the number of times per unit of time the cycle is repeated. 60 Cycle A.C. means that the cycle is repeated 60 times per second.

#### Q. What is meant by "staggering the brushes" of a generator?

It means placing them on the commutator so that they are not in line, so as to prevent them from grooving the commutator.

#### Q. What is the effect of brushes ahead or behind neutral in a DC generator?

The voltage will not be its highest, more field current must be used to get the required voltage thus heating up the field poles. Sparking at the brushes will cause the commutator to run hot.

#### Q. Why do most DC motors designed to operate at various speeds have compensating colls and interpoles?

These poles are placed midway between the main poles to induce the voltage in the coil being commutated. This helps in a quick reversal of current in that coil which reduces sparking.

#### Q. How does a DC generator differ from an AC generator?

The DC generator has a commutator, the AC generator has a slip ring.

Q. Explain why compound wound DC generators are most commonly used on ships and how is the voltage controlled?

This type of generator develops a constant voltage at all loads. Voltage is controlled by means of rheostat.

Q. State two ways to reverse the polarity and two ways to vary the strength of an electromagnet.

To reverse the polarity, either reverse the winding of the coil or reverse the direction of the flow of current in the coil.

To change the strength, either change the number of turns of wire or change the amount of current flowing through the wire.

#### Q. How would you reverse the polarity of a 4-pole compound wound DC generator?

Lift the brushes and places of cardboard under each brush. Connect an outside electrical supply either another generator or a battery, and throw in the switch for a few seconds. Pull out the switch, remove the cardboard and start the machine.

### Q. How is speed control obtained for direct current motors? Speed control for DC motors obtained by:

- 1. Varying the strength of the field.
- 2. Varying the voltage in the armature.
- 3. The shunt field has a rheostat connected in series.

#### Q. Give some general rules to follow in the operation of a DC motor?

- 1. Keep the motor clean and the commutator smooth
- 2. Keep the brushes in good condition, properly space and on the neutral point.
- 3. Do not overload the motor.
- 4. Use the proper voltage.
- 5. Use the motor only in the temperature which it is designed.

### Q. How would you temporarily repair an open coll in an armature to prevent sparking and flashing until the ship reaches port?

Isolate the coil completely by cutting both ends of the coil and tape thoroughly.

### Q. If you found a generator had been wet and had heavy moisture grounds, what would you do to get the machine ready for service?

If heating grids are installed in the unit, use them. If not, run a low voltage through the windings.

### Q. How would you proceed to locate a ground shown by ground lamps on a 240 volt DC auxilliary power bus?

Cut out different line switches on the switch board until the ground disappears. To locate the grounded circuit, go to that circuit box and cut out each individual switch until the ground disappears. Work along this final circuit until the ground is located.

#### Q. In general, how is the speed of DC motors controlled?

In general, speed of DC motors are controlled by a varying the strength of the field or by varying the voltage in the armature. Usually, the shunt field has a rheostat connected in series with it.

#### Q. What is meant by overload and no-load protection of a DC motor?

Overload protection means that the current is automatically shut off if the load becomes greater that which the motor is built.

No-load protection means that if the load falls off, the current is shut off to prevent the motor from running away and damaging itself.

#### Q. Suppose your motor failed to start, explain the sequence to correct the trouble.

- 1. Look for broken leads to the motor, for the connection may be hooked up wrong.
- 2. Field may be weak.
- 3. Motor maybe too overloaded
- 4. There maybe excessive friction in the bearings.

#### Q. What four things determine the amount of induced voits and amperes?

- 1. The strength of field
- 2. Number of conductors
- 3. Speed of conductors through the field
- 4. Angle of conductor have to the field

#### Q. What care and maintenance would you give a lead acid battery?

- 1. Avoid high rates of discharge
- 2. Never discharge a bettery to a specific gravity less than 1.150
- 3. Never allow a battery idle in discharge condition
- 4. Use distilled water
- 5. Never add acid to electrolyte
- 6. Avoid charging cell rapidly at high rate
- 7. While charging never exceed temperature of 110°F

#### Q. Describe an alkaline type storage battery?

One of the type of storage battery usually consist of nickel plates, caustic soda, water electrolyte and rubber case. It has a longer life but a lower voltage and cannot stand high current discharge rate.

#### Q. Describe a lead acid storage battery?

A type of storage battery where positive plates are lead peroxide, negative plate are pure lead. The electrolyte are mixture of sulfuric and water and active material are porous and have absorptive qualities similar to a sponge. The pores are filled with electrolyte as the battery discharge acid contact, form chemica combination change into lead sulfate. Thus result specific gravity decreases when fully charge material of positive plates gain lead and negative plate pure lead.

#### Q. What causes short circuit in storage batteries and how are they detected?

Causes – by faulty separators, lead particles and metallic particles, forming contact between positive and negative plates, buckling of plates, excessive sediment, crack in partition, and use of impure water.

Short are detected by overheating, voltage drop, and low specific gravity of electrolyte.

### Q. What are the five reasons why a lead acid battery will not develop its rated capacity?

- 1. Continuous discharging at high rates
- 2. Longer age of service time
- 3. Sulfation will form lead sulfate

- 4. Internal short circuit caused by impurities in electrolytes
- 5. Mechanical faults cause by poor connection, crack and bucked plates.

#### Q. What general care does a storage battery in operation required?

- 1. Keep cool and well ventilated
- 2. Maintain proper level of electrolyte at least 1/2 inch cover the plates.
- 3. Maintain proper specific gravity of electrolyte
- 4. Keep terminals clean.

#### TROUBLE SHOOTING OF ELECTRICAL COMPONENTS

#### Q. What are the causes for electrical equipment to breakdown?

- 1. Heat increases the resistance of the circuit thus increases the current which cause the material to expand, dryout, crack, and wear down much quicker and sooner or later the device will breakdown.
- 2. **Moisture** cause also circuit to draw more current and eventually breakdown. Moisture like water and liquids cause expansion, warping and abnormal current flow or short circuit.
- 3. Dirt and other contaminants such as fumes, vapors, grease, oils etc that cause electrical device to clog or gum up and operate abnormally until break-down.
- 4. Vibration and physical abuse can cause also these types of breakdown.
- 5. **Poor installation** which often work of unqualified personnel who is careless or in a hurry can cause also breakdown soon.

#### Q. What are the effects of breakdown causes and their characteristics?

- a. **Open circuit** is the result of an incomplete circuit, which prevents the current from flowing in a complete path. It has a infinite resistance reading and zero current since its path has been broken when checking to instrument like multimeter.
- b. Short circuit often result when the current takes a direct path across its source. It draws more current because the resistance in the circuit decreases and as a result the voltage decreases. Typical signs of short circuits are: blown fuses, increased heat, low voltage, high amperage and smoke.
- c. Grounded Circuit result of a defect in the insulation or placement of a wire or equipment component causes the current to take an incorrect or abnormal route in the circuit. It result also when part of the windings make electrical contact in the frame of the motor or other equipment body. When grounded in a circuit it shows the following signs. Abnormal amperage, voltage and resistance readings, shock.
- d. Mechanical breakdown are often result of too much friction, wear or vibration which moving parts like broken belts, worn contacts, worn bearing, loose belts damage electrical controls are some examples of mechanical problems, which you can determine by means of noise, abnormal, circuit failure and visual inspection during operations through our senses.



- Q. What are the basic methods in troubleshooting an electrical or electronic devices?
  - 1. Voltage measurement of a circuit is usually taken by using a voltmeter, which zero voltage reading indicate an open circuit, while a low-voltage reading may indicate a shorted component. Remember, always connect a voltmeter in parallel with the circuit when measuring voltage.
  - 2. Amperage measurement of a circuit is usually taken by an ammeter or a "clam on" ammeter which indicate and locates common circuit faults, such as short, open and grounds. Always remember, connect the ammeter in series with the circuit when measuring current.
  - 3. **Resistance measurement** an ohmeter is used to measure the continuity resistance of a circuit or a component. It is used for locating shorts, grounds, and open circuits. Remember, always shut off the power before measuring resistance.
  - 4. Substitution is a technique of replacing a suspected faulty components with a good spare component to save time and effort in locating faults.
  - 5. Bridging when electrician suspects a component like a capacitor, to be faulty, he "jumps" or places a known good component across suspected faulty component from the circuit, thus save time by bridging.
  - 6. **Heat** by means of applying heat, to a suspected thermal intermittent component will break and mostly using hot blower as device in order not to damage component especially plastic type.

- 7. Other methods of trouble shooting like freezing, signal tracing, using testers, test lamp, resoldering, adjusting and by-passing method in locating faults of every components in a circuit.
- Note: One approach to troubleshooting is: define the problem investigate the problem (voltage, amperage, resistance readings), analyze the information and determine the cause of the problem, and question that should be asked like when, what, which and where. Remember, step by step procedure is important when approaching a problem, with the aid of service diagrams available. See figure below.



Always connect a voltmeter in parallel with the circuit.



Always connect the ammeter in series circuit.

Always turn off the power in the circuit before measuring the resistance.







Checking a switch for continuity using an ohmmeter



Reversing the rotation of a three-phase induction motor by switching the outer two leads while dc motor simply reverse the polarity either the field or brushes.



#### TROUBLESHOOTING AND REPAIR OF DC MOTORS

#### The symptoms encountered in defective dc motors are given below.

- 1. If the motor fails to run when the switch is turned on, the trouble may be a. Open fuse or protective device d. Open field circuit a. Worn bearings b. Dirty or cloaged brushes e. Shorted or arounded field h. Grounded brushholder c. Open armature circuit f. Shorted armature i. Defective controller
- If the motor runs slowly, the trouble may be 2. a. Shorted armature or commutator c. Open armature coils e. Overload b. Worn bearings d. Brushes set off-neutral
- 3. If the motor runs faster than nameplate speed, the trouble may be
  - a. Open shunt-field circuit

  - b. Series motor running without a load
- If the motor sparks, the trouble may be 4.
  - a. Poor brush contact e. Shorted or grounded field i. Open field circuit
  - b. Dirty commutator f. Reversed armature leads j. High or low bars
  - c. Open circuit in the armature g. Wrong lead swing k. High mica
  - d. Wrong interpole polarity h. Brushes set off-neutral I. Unbalanced armature
- 5. If the motor is noisy in operation, the trouble may be a. Worn bearings b. High or low bars c. Rough commutator d. Unbalanced armature
- 6. If the motor runs hot, the trouble may be
  - a. Overload b. Sparking c. Tight bearings d. Shorted coils e. Too much brush pressure

#### The typical troubles occur in manual DC Controller are:

- If the motor does not start when the handle is moved several points, the trouble may be; 1.
  - a. Open fuse, breaker, or relay,
  - b. Open resistance unit: test by placing a 115-volt test lamp across adjacent contact points; the lamp should light: if not, the resistance between the two points is open.
  - Poor contact between the arm and the contact points; arcing may occur. C.
  - Wrong connection starter. d.
  - Broken wires may cause open circuits in the armature or field circuits. **e**.
  - Low voltage or excessive load. f.
  - Loose or dirty terminal connections. a.
  - An open holding coil in a three-point box: this will cause an open field circuit. h.
- 2. If the handle does not hold when it is brought to the last point, the trouble may be:
  - An open holding coil, due to burn-out, broken leads, or poor contacts. а.
  - b. Low voltage d. Wrong connection.
  - e. Overload contacts open C. Shorted coil
- If the fuse blows when the handle is moved up, the trouble may be: 3.
  - Grounded resistance units. contacts or wires. a.
  - Handle brought up too quickly. b.
  - Open shunt-field circuit on starting box; C.
  - d. Resistance shorted out.
- 4. If the starting box overheats, the trouble may be:
  - a. Overload motor.
  - b. Handle brought up too slowly.
  - Shorted resistance units or contacts. C.

- f. Wrong voltage
- c. Shorted or grounded field
- d. Differential connection in a compound motor

#### Procedure for using multimeters:

1. Zero Correction of Indicator

Place the pointer on "0" on the left hand side of scale by turning the zero corrector.

2. Red lead plug into positive (+) jack

Black lead plug into negative (-) jack connection.

3. Selection of Function and Range. Note: Put your selection first on high range.

DC volt (DCV) a) 0.1 V •) 0.5) 2.5 V ) 10 V Figures show maximum volt reading for that range. ) 50 V ) 250 V ) 1000 V ) b) AC volt (AVC) 10 V ) 50 V ) figures show maximum volt reading for that range. 250 V ) 1000 V ) c) DC current (DCA) 50uA ) 2.5 mA figures show maximum current reading for that range. ) 25 mA ) 0.25 A )

d) Resistance

X 1	)		1			
X 10	)	indicates	multiplication	of reading	for that	range.
X 1K	)		-	-		
X 10 K	ý					

4. Measurement

For voltage and current measurement, care must be taken to ensure that the range switch is first of all set to the highest range. It is then to be switch down to lower ranges until optimum deflection is obtained.

- a) Ammeter
- 1. Current must flow through ammeter.
- To measure current break the circuit and insert the ammeter in the break. 2.

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Note:

The multi-meter must never be connected in the current ranges to a voltage source that can supply a higher current than allowable maximum. If current range is connected for example, directly to 220 V mains, the apparatus would be immediately destroyed. The operator would be in extreme danger.

B) Voltmeter

A voltmeter is used to measure emf across 2 points in a circuit. Simply prod the voltmeter across the voltage to be measured.

- c) Resistance an  $O\Omega$  adjustment
- 1. Resistance measurement is powered by internal batteries. For correct reading of resistance, the sensitivity of the indicator must be adjusted according to the voltage supplied by batteries.

To measure **resistance** the power supply to the circuit must be switched off first before applying the multimeter. Make zero adjustment with multimeter probes shorted.

2. The range selector is placed at the range being used. With the + and -com terminal shorted together, the pointer moving towards O  $\Omega$  is adjusted by turning O  $\Omega$  ADJ to the right or left in order to place it exactly on O  $\Omega$  of the scale right. The pointer must be adjusted each time the range is moved.



MULTIMETER

Enumerate some test equipments and used in troubleshooting electrical circuit and components.

- 1. Digital multimeter usually used for electronic technician who need extreme accuracy in work and digital equipment testing and servicing. It measure correct value of voltage, resistance and current.
- 2. Oscilloscope used for measuring a visible display of waveform, peak to peak voltage, frequency, time periods, phase angles and frequency response.
- 3. Tube tester is a fairly accurate way of testing electron tubes.
- 4. **Transistor tester** used to check in accurate such as diodes and transistors with their performance, and also measure transistor leakage, collector leads, base and identify emitter.
- 5. Capacitor tester check the quality of the capacitor but also determine the value of unknown capacitor. It also identify power factor values, leakage, open. Remember remove to the circuit to check the correct value and don't touch the terminal of capacitor tester when the voltage is turned up. Severe shock can result.
- 6. Frequency counters are used to measure the frequency in hertz of an electronic components. Usually used to adjust the frequency of radio receivers and transmitters.
- 7. **Megohmmeter** is an insulation-resistance meter, used to check the electrical resistance of an insulator by indicating the resistance on a scale as it supplies a voltage. It is a self-contained hand operated generator. or power supply source.
- 8. Voltage testers commonly used by electricians in measuring ac voltage. These testers are portable, easy to use.
- 9. Growler consist of two kinds: internal and external, are used to test armatures and stators of electric motors, generators and other equipment.
- 10. Test lamp is a simple test device used to check continuity of a circuit or component which easily shows illuminance of the bulbs.
- 11. Clam-on ammeter used to measure the current on a circuit, conductor without interrupting the circuit.
- 12. Neon voltage tester is used to check the presence of voltage in a circuit which often used in troubleshooting housewiring.

#### ELECTRICAL SAFETY

Electricity can be dangerous and even fatal to those who do not understand and practice the simple rules of SAFETY. There are many fatal accidents involving electricity by well-trained personnel who either thorough over-confidence or carelessness, violate the basic rules of personal SAFETY.

Current that does the damage. Currents above 100 milliamperes or only one tenth of an ampere are fatal. A workman who has contacted currents above 200 milliamperes may live to see another day if given rapid treatment. Currents below 100 milliamperes can be serius and painful. A safe rule: Do not place yourself in a position to get any kind of a shock

#### Nine rules for safe practice and to avoid electric shocks:

- 1. Be sure of the conditions of the equipment and the dangers present BEFORE working on a piece of equipment. Many sportsmen are killed by supposedly unloaded guns; many technicians are killed by supposed "dead" circuits.
- 2. **NEVER** rely on safety devices such as fuses, relays and interlock systems to protect you. They may not be working and may fail to protect when most needed.
- 3. **NEVER** remove the grounding prong of a three wire input plug. This eliminates the grounding feature of the equipment making it a potential shock hazard.
- 4. DO NOT WORK ON A CLUTTERED BENCH. A disorganized mess of connecting leads, components and tools only leads to careless thinking, short circuits, shocks and accidents. Develop habits of systemized and organized procedures of work.
- 5. **DO NOT WORK ON WET FLOORS.** Your contact resistance to ground is substantially reduced. Work on a rubber mat or an insulated floor.
- 6. **DON'T WORK ALONE.** It's just good sense to have someone around to shut off the power, to give artificial respiration and to call a doctor.
- 7. WORK WITH ONE HAND BEHIND YOU OR ON YOUR POCKET. A current between two members crosses your heart and can be lethal. A wise technician always works with one hand.
- 8. **NEVER TALK TO ANYONE WHILE WORKING.** Don't let yourself be distracted. Also, don't you talk to anyone, if he is working on dangerous equipment. Don't be the cause of an accident.
- 9. ALWAYS MOVE SLOWLY when working around electrical circuits. Violent and rapid movements lead to accidental shocks and short circuits.

#### <u>Burns</u>

Accidents caused by burns, although usually not fatal, can be painfully serious. The dissipation of electrical energy produces heat.

Four rules for safe practice and to avoid burns:

- 1. *Resistors get very hot*, especially those that carry high currents. Watch those five and ten watt resistors. They will burn the skin off your fingers. Stay away from them until they cool off.
- 2. Be on guard for all capacitors which may still retain a charge. Not only can you get a dangerous and sometimes fatal shock, you may also get a burn from an electrical discharge. If the rated voltage of electrolytic capacitors is exceeded or their polarities reversed they may get very hot and may actually burst.
- 3. Watch that hot soldering iron or gun. Don't place it on the bench where your arm might accidentally hit it. Never store it away while still hot. Some innocent unsuspecting student may pick it up.
- 4. HOT SOLDER can be particularly uncomfortable in contact with your skin. Wait for soldered joints to cool. When de-soldering joints, don't shake hot solder off so that you or your neighbour might get hit in the eyes or on his clothes or body.



SECTIONAL DIAGRAM OF INDUCTION MOTOR

#### PART LIST AND MATERIALS

1	TERMINAL BOX	CAST IRON	10	FRAME	CAST IRON
2	LOCKNUT & WASHER	MILD STEEL	11	STATOR CRAMPER	MILD STEEL
3	FAN BOSS	CAST IRON	12	ROTOR BAR	COPPER
4	FAN	MILD STEEL	13	END RING	COPPER
5	COVER FOR COOLING FAN	MILD STEEL	14	STATOR COIL	INSULATION WIRE
6	END BRACKET	CAST IRON	15	END BRACKET	CAST IRON
7	ROTOR CRAMPER	CAST IRON	16	BEARING COVER	CAST IRON
8	ROTOR CORE	SILICON STEEL	17	BALL BEARING	CARBON CHROMIUM BEARING STEEL
9	STATOR CORE	SILICON STEEL	18	SHAFT	CARBON FORGED

#### **Disassembly and Assembly**

#### **General Cautions**

Below are the general procedures and items of caution for disassembly and assembly of motor. Be sure to read them thoroughly before starting the disassembly/assembly.

- 1. Disassembly or assembly by one person is not only inefficient but is likely to cause fatal damage to the machine. Hence, see to it that the job is carried out by two or more people.
- 2. Keep the place of disassembly in good order and well arranged to prevent mixing up of other parts and to improve the work efficiency.
- 3. Cover the disassembled parts, particularly the important rotating parts such as bearing, etc., with vinyl or cloth to protect from dust.
- 4. Before pulling out or inserting the rotor from or into the stator, fit their shaft centers so that the two may not come in contact. Take particular care not to scratch the stator winding coil, rotor bar, shortcircuit ring, core, etc.
- 5. Lay the rotor on a stand, and be sure to cover with vinyl or cloth, and wrap the bearing part of shaft with cloth for storage.
- 6. When separating the fan and fan boss, be sure to put fitting marks, and use these marks at the time of reassembly.
- 7. See the sectional drawings of the motor carefully to get the outline of the construction before starting disassembly.

#### Disassembly

- 1. Remove all external cables connected to the motor.
- 2. Remove the direct coupling.
- 3. Remove the bolts connecting the motor with auxiliary machine stand.
- 4. Suspend the whole motor unit, and carry to the place of disassembly.
- 5. In the case of vertical type motor, lay the motor down horizontally.
- 6. Pull out the coupling.
- 7. In the case of motor with open type bearing, remove the grease nipple and grease injecting pipe.
- 8. In the case of motor with external fan, remove the external fan cover, and unscrew the lock nut tightening the fan boss before removing the external fan.
- 9. Remove the bearing covers on both the coupling side and the opposite side. (Motor with small capacity may not have these covers.)
- 10. Remove the end brackets on the coupling side and the opposite side. When these brackets are removed, the spigot joint detached and, at the same time, the rotor drops down to the level equivalent to the air gap, causing the rotor and stator to collide violently, and this may damage the core and winding coils. Hence, support both ends of the shaft with a crane or jack, or with hand (in case of motor with small capacity before removing the end brackets.
- 11. Pull out the rotor from the stator.

#### Assembly (Reassembly)

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- 1. Carry out reassembly normally in the reverse order of disassembly. Before reassembly, thoroughly wipe off the dust oil etc., from the disassembly parts.
- 2. Do not forget to replenish grease after installing the bearing.

3. Remove the protectors in a section before installing the parts, and after carrying out corre of direct coupling, make connection of electric circuits. This ends the constant of the section before installing the parts and of direct coupling, make connection of electric circuits.

#### Troubleshooting

Trouble	Cause	Countermeasure
Fails to start.	Disconnection or shortcuircuit of winding coil and lead wire	Rewind or repair
	Slackening of connecting term- inals, etc.	Carry out additional tightening of the slackened portions.
	Disconnection or misconnection of starter	n Repair the disconected part or make change according to the con nection diagram
	inadequacy or unbalance of supply voltage	Measure terminal volt age and adjust it to the specified voltage
	Single-phase operation	If the motor snarls, after the power is turned on, but fails to rotate, check for dis- connection and repair.
	Excessive over-load	Check the auxiliary machinery side.
The rotation against specified rpm is abnormal	Inadequate supply voltage	Measure the terminal and adjust to the normal voltage
	Variation in power frequency	Measure the frequency and adjust to the normal frequency
	Excessive slipping	Check the rotor bar for breakage on check the joint of shortcircuit ring.
Motor gets excessively heated	Inadequacy or unbalance of supply voltage	Measure the terminal voltage, and adjust to the normal voltage.
	Excessive over-load	Check the auxiliary machinery side.
	Shortcircuit between phases	Rewind
	Defective ventilation	Remove the obstruc- tion preventing the ventilation, and clean

#### **Three-Phase Induction Motor**

The 3-phase, cage-rotor, induction motor is the most commonly used motor onboard ships. It is popular because it is simple, tough and required very little attention. It is also readily controlled by simple, reliable direct-on-line contactor starters, and AC sources available.

#### Construction

The induction motor has two main components, the stator and the rotor. The Stator carries the 3-phase winding in slots cut into a laminated steel magnetic core. The ends of the stator windings are terminated in the stator terminal box where they are connected to the incoming 3-phase supply cables. The stator windings are wound for specific numbers of pole-pairs and can be connected in either star or delta connection.

Stator slots to take the windings are cut around the inner surface. The slots are semi-enclosed as shown, so as to distribute the magnetic flux as uniformly as possible in the airgap, thereby minimizing the ripple that would appear in the emf waveform if open slots were used.

The rotor of the cage induction motor has a core which is built up of iron laminations. The conductors consisting of copper or aluminum bars is inserted, without insulation, into slots spaced evenly round the circumference of the rotor. The bars are short-circuited at each end by rings or plates to which the bars are blazed or welded. The air gap between the rotor and the stator is uniform and made as small as it is mechanically possible. The reliability of the induction motor comes from having this type of simple, tough rotor which has no insulation and does not troublesome bruches, commutator or slip-rings.



#### STAR-DELTA STARTER DIAGRAM

#### **Operation of Star-Delta Motor Starter Control Circuit-Schematic Diagram**

Circuit breaker 52 is closed.

When BS 1 start push button is pressed relay coil 6 is energised.

Contact 6a closes and 6b opens.

Main contact 6 on motor supply line also closes.

Timer delay coil 19 and main contactor coil 88 get energised.

Main contactor 88 on the motor supply circuit closes and motor runs starconnected.

Auxiliary contact 88a also closes.

Instantaneous contact of timer relay 19 a closes. It is a holding contact when BSI is released.

After a predetermined time delay of 25/60 sec., delay contact 19b opens and 19a closes.

Relay coil 6 gets energised and its contact 42 b opens and contacts 42a closes.

The main contactor 42 on the motor supply line closes.

Motor is now running delta-connected.

With 42b open, timer delay coil 19 gets de-energised and all its contacts return to its original position.

Contact 42a now functions as a holding contact.

indicating lamp L is now on.

To stop the motor press BS2.

### Comparison of star delta and direct-on-line starting methods: Advantages:

#### **Direct On Line**

#### Star Delta

1.	starter at full phase voltage.	starter at reduced phase voltage V3.
2.	starting current 6 to 8 times full load current.	starting current 2 to 2.5 times full load current.
3.	starting torque about 1.5 times full load torque.	starting torque less than half full load torque.
4.	motor can be started on full load if required.	motor can be started only on no load or light load.
5.	high acceleration torque so has low starting time.	low acceleration torque so has long start- ing time.

### COMMON TROUBLES AND REPAIRS THREE PHASE MOTORS

The symptoms encountered in defective three-phase motors are given below. Under each symptom are listed the possible troubles and remedies.

- 1. If a three-phase motor fails to start, the trouble may be
  - Burned-out fuse (1). a.
  - Worn bearings (2). b.
  - Overload (3). C.
  - Open phase (4). d.
  - Shorted coil or group (5). e.
- f. Open rotor bars (6). Wrong internal connections (8). g.
- Frozen bearing (9). h.
- **i**. Defective controller (10).
- j. Grounded winding (11).

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g.

h.

d.

- 2. If a three-phase motor does not run properly, the trouble may be:
  - Burned-out fuse (1). a.
  - Worn bearings (2). b.
  - Shorted coil (5). C.
  - Reversed phase (12). d.
  - Open phase (4). e.

Overload (3)

C.

a.

- 3. If the motor runs slowly, the trouble may be:
  - Shorted coil or group (5) **a**.
  - Reversed coils or groups (8) b.
    - Worn bearings (2)
- e. Wrong connection (reversed phase) (12).
  - f. Loose rotor bars (6)

Overload (3)

- 4. If the motor becomes excessively hot, the trouble may be
  - d. Motor running on single phase (4)
  - b. Worn bearings (2) or tight bearing (9). e. Loose rotor bars (6)
  - Shorted coil or group (5) **C**.
- 1. Burned-out Fuse. Remove fuses and test with test lamp, if the lamp lights, the fuse is good. A burned-out fuse is indicated when the test lamp does not light. To test fuses without removing them from the holder, a voltmeter must be used. If a test light designed for 230 volts is mistakenly used on 460 volts, it will blow out and may trigger a severe electrical explosion. If the fuse is open, there will be a line voltage read across it.
- 2. Worn Bearings. If a bearing is worn, the rotor will ride on the stator and cause noisy operation. When the bearings are so worn that the rotor rests firmly on the core of the stator, rotation is impossible. To check a small motor for this condition, try moving the shaft up and down. Motion in this manner indicates a worn bearing. Remove and inspect the rotor for smooth, worn spots. These indicate that the rotor has been rubbing on the stator. The only remedy is to replace the bearings.
- Overload. To determine whether a three-phase motor is overloaded, remove the 3. belt or load from the motor and turn the shaft of the load by hand a broken part or dirty mechanism will prevent the shaft from moving freely. Another method is to use an ammeter on each line wire. A higher current reading than on the nameplate ay indicate an overload.

Incorrect voltage (7). i.

Open rotor bars (6).

Grounded winding (11).

Open parallel connections (13).

- 4. **Open Phase.** If an open occurs while the motor is running, it will continue to run but will have less power. An open circuit may occur in a coil or group connection. The motor will continue to run if a phase opens while the motor is in operation but will not start if at a standstill. The conditions are similar to those of a blown fuse.
- 5. Shorted Coll of Group. Shorted coils will cause noisy operation and also smoke. After locating such defective coils by means of the eye or balance test, the motor should then be rewound.

When the insulation on the wire fails, the individual turns become shorted and cause the coil to become extremely hot and burn out. Other coils may then burn out, with the result that an entire group or phase will become defective.

- 6. Open Rotor bars. Open rotor bars will cause a motor to lose power. One sign of open bars is when a motor is connected to the right voltage at no load, it has a very low amp reading. A light load will pull down the speed, and at full load the motor will run below the nameplate speed.
- 7. *Incorrect Voltage.* Some T-frame motors are designed for a definite voltage. Thus a motor designed for 208 volts will overheat when operated on 250 volts, and a motor designed for 250 volts will not have enough power if operated on 208 volts. If the motor is rate 208-220-440 volts on the nameplate, it will operate well on a range of voltages.
- 8. Wrong Internal Connections. A good method of determining whether or not a polyphase motor is connected properly is to remove the rotor and place a large ball bearing in the stator. The switch is then closed to supply current to the winding. If the internal connections are correct, the ball bearing will rotate around the core of the stator, if the connections are incorrect, the ball bearing will remain stationary.
- **9.** *Frozen Bearing.* If oil is not supplied to the part of the shaft that rotates in the bearing, the shaft will become so hot that it will expand sufficiently to prevent movement in the bearing. This is called a *frozen* bearing.
- **10.** *Defective Controller*. If the contacts on the controller do not make good contact, the motor will fail to start.
- **11.** *Grounded Winding.* This will produce a shock when the motor is touched. If the winding is grounded in more than one place, a short circuit will occur which will burn out the winding and perhaps blow a fuse. Test for a grounded winding with test lamp and repair by rewinding or by replacing the defective coil.
- **12.** *Reversed Phase.* This will cause a motor to run more slowly than the rated speed and produce an electrical hum indicative of wrong connections. Check the connections and reconnect them according to plan.
- **13.** Open Parallel Connection. This fault will produce a noisy hum and will prevent the motor from pulling full load. Check for complete parallel circuits.
# TROUBLESHOOTING AND REPAIR AC CONTROLLERS

Assumed that the motor and fuse are in good condition. To make certain that the motor is not at fault, connect a voltmeter at the motor terminals and determine whether voltage is available when the contacts of the controller are closed. If there is no voltage. the trouble probably lies in the controller, like push button switch starters, drum, wyedelta, braking controllers.

Because there are many different kinds and makes of controllers, a general procedure for locating the source of trouble is given.

- 1. If the motor does not start when the main contacts close, the trouble may be
  - Open overload heater coil or poor connection. а.
  - Main contacts not making the contacts become dirty, gritty or burned. b.
  - Broken, loose, or dirty terminal connection. С.
  - Loose or broken pigtail connection. d.
  - Open resistance units or open autotransformer. е.
  - Obstruction on the magnet core, preventing the contacts from closing. f.
  - Mechanical trouble, such as mechanical interlocks, gummy pivots, and poor g. spring tension.
- If the contacts do not close when the START button is pressed, the trouble maybe 2.
  - **a**. Open holding coil (This can be tested by connecting a voltmeter across the coil terminals when the START button is pressed. If there is voltage when the START button is pressed, but the coil does not become energized, the coil is defective.)
  - Dirty START-button contacts or poor contact. b.
  - Open or dirty STOP-button contacts. C. Loose or open terminal connections.
- f. Low voltage. Shorted coil. g.
- Mechanical trouble. h.

- Open overload-relay contacts. **e**.
- 3. If the contacts open when the START button is released, the trouble may be
  - a. Maintaining contacts that do not close completely or are dirty, pitted, or loose. b. Wrong connection of station to the controller.
- If a fuse blows when the START button is pressed, the trouble may be 4.
  - a. Grounded contacts. b. Shorted coil. c. Shorted contacts.
- If the magnet is noisy in operation, the trouble may be: 5.
  - Broken shaded pole causing chattering a.
  - b. Dirty core face
- 6. If the magnet coil is burned or shorted, the trouble may be:
  - a. Overvoltage.

d.

- Excessive current due to a large magnetic gap caused by dirt, grit, or mechanical b. trouble.
- Too-frequent operation. C.

# PROCEDURE OF SAFETY Grand ATIONS

### SINGLE GENERATOR RUNNING

Before starting the engine for driving the required generator, confirm that the circuit breakers for loads, air circuit breaker, etc., are "OFF". Then start the engine.

By virtue of the under-voltage tripping device (UVC), the air circuit breaker (ACB) has been put to its OPEN (tripped) state.

As the engine speed rises,

RUN pilot lamp "GL" (green) will light. Then, adjust the voltage to the rated on the voltmeter by means of the voltmeter transfer switch (VS) and the frequence to the rated value by means of the frequency meter transfer switch (FMS). The rated values are indicated by red marks on the corresponding meters.

After the rated frequency and voltage have been reached, close the air circuit breaker (ACB), and the pilot lamp "GL" (green) will light. Then, close the objective MCB to feed power

When the ACB is closed, it the breaker (MCB) of the feeder circuit is closed, the generator will immediately be loaded. This instant, a small voltage drop will be found. However, there will occur a quick voltage recovery. So, there is no need to worry about it.

## STOPPING OF GENERATOR

In order to stop the generator in operation, first unload it and then push the ACB OPEN push button switch, for manual opening. Thereafter, stop the engine, in doing so, it the ACB should be opened while the generator is loaded, there would occur such adverse effects as an instantaneous rise in the engine speed. So, it is advisable to lessen the load to a lower value (the lower the better) before tripping the ACB, because the engine, the generator and the ACB will then be less affected and will be capable of stable operation for a long time.

#### PARALLEL RUNNING

Start the second generator by following the same procedure as for starting the first generator. After confirmation of the voltage of the second generator, align the voltages of both generators by means of the voltmeter transfer switch (VS). Simultaneously match the frequencies by means of the frequency transfer switch (FMS). Once the voltage and frequency of both generators are identical, change over the synchroscope (SYS) to the second generator and check the synchronous state by means of the synchroscope (SY).

In accordance with the lighting and going off of the synchronizing lamp the pointer needle will revolve. See the direction of the revolution, and if it is revolving to the "FAST" side, inch the governor switch (GS) of the second generator to the "LOWER" side. If the opposite is true, then inch it to the "RAISE" side.

By means of this manipulation the lighting and going off of the lamp as well as the revolution of the pointer will become slower, until the top lamp goes off and the pointer comes to the top, showing the state of synchronization. The energize the air circuit breaker (ACB) of the second generator immediately. If the synchronous state is not maintained, since the air circuit breaker (ACB) will trip by means of the reverse power relay (RPR), repeat the above.

In energizing the generator, it is ideal to close the air circuit breaker (ACB) when the index of the synchroscope turn toward the "FAST" mark side and closes on to the black mark at the center, "SLOW" side turning may undesirably cause operation of the reverse power relay (RPR). If the frequency difference between the two generators in parallel operation exceeds 3Hz, the lamp alone will be going on and off, and the pointer will not revolve. With this in mind, operate the governor switch (GS) to decrease this difference.

Switch one of the frequency meters to the bus and the other frequency meter to the after-running generator, and compare their readings.

#### LOAD SHARING

The parallel operation has been achieved by the procedure mentioned so far. Then that should be done to have the load shared by the second generator. This is accomplished by increasing the input of engine. This is equal to saying that the revolution number of the second generator has only to be increased by means of the governor switch "GS". In this case the first generator loses load and gainrevolution number causing the frequency to rise. To prevent this the governor, switch "GS" of the first generator must be turned toward the "LOWER" side. This action also cause the load to be transferred to the first generator. Now, the generator has entered the stage of perfect parallel operation. To stop the operation, reverse the procedure for load sharing.

#### **Procedure for Parallel Running:**

- a. Start the generator and allow the speed to rise to the rated value.
- b. Raise the voltage to the rated value by means of the voltage regulator "VR"
- c. Confirm that the bus voltage equals the voltage of the generator to be put to parallel operation.
- d. Confirm that the bus frequency equals the frequency of the second generator.
- e. Set the synchroscope switch "SYS" to the side of the second generator
- f. To synchronize, adjust the engine speed by means of the governor switch "GS" and confirm the equality of voltage.
- g. After the voltage has been equalized and the rotation of the index slowed down, close the air circuit breaker the moment the index closes on the position indicating perfect synchronism.

- h. Inch the governor switch "GS" of the second generator toward the "RAISE" side to have a small portion of the load shared.
- I. Inch the governor switch "GS" of the first generator toward the "LOWER" side to have a small portion of the load alleviated. By so doing, equalize the load of the two generators.
- j. In stopping a generator, reverse the preceding procedure.

## EARTH LAMP CIRCUIT

The earth lamp circuit makes it possible to examine on display lamps if the circuit is earthed or not, by manipulating the pushbutton switch (ES). The circuit, the voltage of E/ 3 will be applied to each of the three lamps so that the lamp for each phase will light up with the same brightness, which is a little lower than that of other display lamps (regardless of the earthing condition).

When the switch is set to "ON" the neutral point of the star connection will be earthed. If this setting does not cause a change in the brightness of the lamps, the circuit is normal. Now we assume that the line of phase R is earthed. Then the lamp for phase R will be supplied with a voltage of the same voltage of the same voltage and will go off, which the voltage E is applied to the lamps for phases S and T, which will therefore become brighter.

It is rare that the circuit is completely earthed (lamp off). The three lamps may be different in brightness. However, by repeating change-over of the switch between "ON" and "OFF" even slight earthing can be found. Make periodical checks. If, upon the setting to "ON", any of the lamps has become less bright, even slightly, than when the switch is "OFF", the line of the phase can be considered to have been earthed. So, proceed without delay to inspection of the circuit.

#### **INSTRUMENTS AND DEVICES INSTALLED**

The generator panel are equipped with ammeter, voltmeter, frequency meter, wattmeter and running hour meter for measuring the output of the generator, the air circuit breaker, reverse power relay, over current relay for generator protection, the disconnecting bar for main circuit, the protection fuse, the transformer, the space heater and transfer switch, various types of signal lamps, etc. The external wire connection terminals are on the back side of the panel.

The synchronizing panel is equipped with double frequency-meter, double voltmeter and wattmeter for measuring the output of the generator, the voltage relay and frequency relay for generator alarm, the instrument transfer switch and auxiliary equipment, the synchroscope necessary for parallel operation and the synchronizing lamp, the protection fuse, the transformer, etc. The external wire connection terminals are on the back side of the panel.



## METHOD OF OPERATION:

When circuit breaker or line switch 89 is put at ON position, lamp source LP glow, introducing power at control circuit from 440V to 220V which is step-down by control power transformer CPT.

To start, push button 3C energizes the contactor coil (4), closing normally open contacts 4/13-14, 4/33-34 and 4/43-44 simultaneously, thus energizes the contactor coil (8) and closing normally open contactor (8), then 3-phase motor is connected to supply line 440V and running lamp L indicated on operation.

To **stop**, push button 3-0 is pressed, the contactor coil ④ is de-energized, opening the closed contacts 4/13-14, 4/33-34 and 4/43-44 simultaneously, thus de-energized contactor coil ⑧ and opening the closed contact 88, and the 3-phase motor is disconnected from supply line and running lamp off.

#### **Symbols Designation**

R, S, T	-	Standard marking for Supply source
U, V, W	-	Standard marking for Motor connection
A1, A2	-	Standard marking for Contactor coil
01, 02, - 10	-	Designated number of Wires
95, 96	-	Standard marking for normally closed Overload Contact

# FORMULAS FOR ELECTRICAL PROBLEMS

# a) Ohms law

	Ampere	=	volts resistance	A	=	V R
	Volts	=	amperes x resistance	V	=	A x R
	Resistance	=	volts amperes	R	=	V A
b)	Power Rule					
	Watts	=	volts x amperes	W	=	V x A
	Volts	2	amperes	V	=	W A
	Amperes	=	wattsvolts	A	=	W V
C)	Efficiency	=	output input			
d)	Power Factor	=	<u>true power</u> = apparent power vo	watt olt-ampe		<u>kw</u> kva
e)	Frequency of AC	Generato	$r = \frac{\text{no.of poles x rpm}}{120}$	<u> </u>	_ <b>P</b>	<u>× N</u> 120
f)	Direct Current		AC	- Three	Phase	9
					_	

		740 -	I	=	746 Hp
I	=	746 np			1.73 x E x Eff x pf.
		E x eff.	I	=	1000 Kw
I	=	1000 kw			1.73 x E x pf
		E	I	=	1000 Kva
KW	-	I x E			1.73 x E
		1000	Kva	=	I x E x 1.73 x pf
HP	=	Ix Ex eff			1000
		746	Kva	=	I x E x 1.73
	•				1000
			Нр	=	IXEX effxpf
					746

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#### where:

wg	on	Series	circuit:			· · · · · · · · · · · · · · · · · · ·
pf		-	power factor in decimals			
ef	f	=	efficiency in decimals	hp	=	horsepower ouput
Ε		-	volts	kva	=	kilovolt: - amperes
I		=	amperes	kw	=	kilowatts

## g) Laws on Series circuit:

Current  $_{Total}$  =  $l_1 + l_2 = l_3$ Resistance  $_{Total}$  =  $R_1 + R_2 + R_3...$ Voltage  $_{Total}$  =  $E_1 + E_2 + E_3...$ we on Parallel circuit:

## h) Laws on Parallel circuit:

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



V <sub>Total</sub>	=	E1	=	E2	=	E3
i <sub>total</sub>	=	I,	+	۱₂	+	l <sub>3</sub>

i)	Frequency	=	no. of poles x rpm
			120

Rpm	=	120 x frequency
		poles

120 x frequency **Poles** = rpm



#### **BASIC SYMBOLS**

SYMBOL	DESCRIPTION	DESCR	IPTION	DESCRIPTION	
·	ONE CONDUCTOR OR A GROUP OF SEVERAL CONDUCTORS	108	» «	DISCONNECTING SWITCH OR MOLDED CASE CIRCUIT BREAKER	
	TWO CONDUCTORS (MULTILINE REPRESENTATION)				
	TWO CONDUCTORS (MULTILINE REPRESENTATION			MOLDED CASE CIRCUIT BREAKER (WITH SHUNT TRIP COIL)	
^n	n CONDUCTORS (SINGLE-LINE REPRESENTATION)		20 <u></u>		
	CROSSING WITHOUT ELECTRICAL CONNECTION	(	♪ 	UNDER VOLTAGE TRIPPING COIL OF CIRBUIT BREAKER	
	JUNCTION OF CONDUCTORS	4	6	SWITCH (GENERAL) SINGLE THROW	
0	TERMINAL CONNECTION OF CONDUCTORS	-~~	<u>\$</u>	SWITCH (GENERAL) DOUBLE THROW	
000	JOINT TERMINALS				
RR	RESISTANCE OR RESISTOR	TERMIN	IALS		
	INDUCTANCE OR INDUCTOR	212	2 63	TERMINAL MARK	
	WINDING	P · 2 TPYS	-8.0	CABLE SIZE	
	CAPACITANCE, CAPACITOR	00	0		
-0	RELAY COIL, GENERAL SYMBOL	6		EQUIPMENT OF OUTSIDE	
÷	HULL CONNECTION (EARTH)		==1		
	MECHANICAL COUPLING GENERAL SYMBOL	-20	<u></u>	EQUIPMENT OF OTHER UNIT	
6	SWITCH, GENERAL SYMBOL				
-0×0-	THREE POLE SWITCH, SINGLE REPRESENTATION	POWER	& RELA	Y CONTACT	
0520		a -00-	<u>в</u> -со-	CONTACT (GENERAL) OF MANUAL CONTACT	
4	CHANGE OVER CONTACT BREAKE BEFORE MAKE	40	-0.9-	MANUALLY OPERATED AUTO RESET CONTACT	
<u> </u>	MAKE BEFORE BRAKE CONTACT (OVER LAP CONTACT)			(WITH LOCKING DEVICE)	
	CONTACTOR NORMALLY OPEN (MAIN)	-00-	-0.9-		
	CONTACTOR NORMALLY CLOSE (MAIN	-0-	-4.0-	HAND RESET CONTACT	
-00	MAKE CONTACT (a CONTACT) GENERAL SYMBOL	-00-	-20-	RELAY CONTACTOR OR AUX. SWITCH CONTACT	
	BREAK CONTACT (5 CONTACT) GENERAL SYMBOL			CONTACT WITH TIME LIMIT OPERATION	
	(MAKE AND FEMALE)				
	RESISTOR WITH MOVING CONTACT GENERAL SYMBOL	-670-		CONTACT WITH THE LIMIT OPERATION (OFF DELAY TYPE)	
	FUSE	-5"0-	-0.0-	RUCHING RELAY CONTACT	
<u> </u>	GENERATOR		-100	MAIN CONTACT OF	
(M)				ELECTRO MAGNETIC CONTACTOR	
	WITH TWO SEPARATE WINDINGS	-010	<u> </u>	GANG SWITCH MANUAL OPERATED	
	AUTO TRANSFORMER THREE PHASE				
	SEMICONDUCTOR DIODE OR RECTIFIER GENERAL SYMBOL	1	<u> </u>	C CONTACT	
$\bigcirc$	VOLT METER		4-	CONTROL SWITCH OR CONTROLLER CONTACT	
Ø	AMMETER	1			
	CURRENT TRANSFORMER				
Ð	PILOT LAMP (FOR ELECTRIC SOURCE "ON")			ELECTRICAL SYMBOLS	
6	INDICATING LAMP (FOR MOTOR RUNNING)	]			
•	STAND-BY INDICATING LAMP	]			

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## FOURTH ENGINEER - 1989-90 BOARD EXAMS

1. A generator is producing 150 Amp. at 220 V. Find the KW output and total external resistance. SOLUTION:

Ρ	=	Volts x Amperes
	=	(150) (220)
	=	33,000 watts 1000
	=	33 Kw
R	=	P 1 <sup>2</sup>
	=	33,00
		(150) (150)
		1.46 ohms.

2. A 150 BHP engine drives a 90 percent, efficient 220-V generator. Find the current produced.

## SOLUTION:

hp output of gen.	=	input	x	efficie	эпсу	
	=	150	x	.9	-	135 hp
watt output of gen.	=	135	x	746	=	100,710 watts
ourropt		watt	100,710			
COLLENT	-	voltage	220	-		
current	=	457,772 a	mps.			

A resistance of 18 ohms is connected in Series with 3,4 and 6 ohms in parallel. 3. What is the total resistance?

#### SOLUTION:

 $\frac{1}{R_{o}} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6} = \frac{4+3+2}{12} = \frac{9}{12}$  $R_{g} = \frac{12}{9} = 1.333$ = Rs + R<sub>a</sub> R<sub>T</sub> = 18 + 1.333 = 19.333

4. Twenty 100-W bulbs and Fourteen 60-W bulbs are in a 120-V circuit. Find the current.

Total watts	E	(20 x 100) + (14 x 60)
	=	2,000 + 840 = 2840 W
Ampere	=	$\frac{W}{V} = \frac{2840}{120} = 23.666 \text{ amp.}$
Ampere	=	watt voltage
	=	2840
		120
	=	23.666 amp.

## THIRD ENGINEER

1. A 100 HP, 220 V motor is 75 percent efficient. Find the current required to drive it at full load?

## SOLUTION:

SOLUTION:

output in watts	=	output in hp x 746
	=	100 x 746
	=	74,600 watts
input in watts	=	<u>output</u> = <u>74.600</u> efficiency .75
	=	99,466.66
current	=	<u>watt</u> = <u>99.466.66</u> volt 220
	=	452.1212 amps.

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2. A 40 ohm resistor is connected to a 20 ohm relay. The operating voltage is 120 V. Determine the current and power in this relay circuit.

SOLUTION:

$$R_{T} = R_{1} + R_{2}$$

$$= 40 + 20$$

$$= 60 \text{ ohms.}$$
a) Current = Volt  
Resistance  

$$= \frac{120}{60}$$

$$= 2 \text{ amperes}$$
b) Power = current x volts  

$$= 2 \times 120$$

$$= 240 \text{ watts}$$

- **3.** A 50 HP engine drives a DC generator. If the generator has an efficiency of 84%. How many a) Kw b) HP. does it deliver.
  - a) Kilowatt delivered

$$= 50 \text{ HP} \times \frac{746 \text{ w}}{1 \text{ HP}} \times \frac{1 \text{ kw}}{1000} \text{ w}$$
$$= \frac{50 \times 746}{1000}$$

- = 37.3 Kw
- b) Horsepower delivered

= 50 x 0.84

- = 42 HP
- 4. An AC generator is rated at 227 KVA at 86% power factor. What is the Kw rating.

Power Factor = 
$$\frac{Kw}{KVA}$$
  
 $Kw = Power Factor x KVA$   
 $= .86 \times 227$   
 $= 195.22$ 

## SECOND ENGINEER - 1989-90 BOARD EXAMS:

1. A resistance of 12 ohms is connected in series with 4,5 and 6 ohms in parallel. What is the total resistance?

## SOLUTION:

_ <u>1</u> Ra	=	$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
	=	$\frac{1}{4}$ + $\frac{1}{5}$ + $\frac{1}{6}$
	-	$\frac{15 + 12 + 10}{60}$
1/Ra	=	<u>37</u> 60
Ra	=	<u>60</u> = 1.62 ohms 37
RT	=	Ra + Rb
	=	1.62 + 12
	=	13.62 ohms.

2. Two 220 V, 50 Kw generators are in parallel. Find maximum current, voltage and resistance.

## SOLUTION:

Current in gen.	=	<u>50 (1000)</u> 220
Current total	=	227.27 amps.
	=	227.27 + 227.27
	=	454.54 amps.
Resistance total	=	<u>V</u> = <u>220</u>
		A 454.54
	=	- 0.484 ohms.
Voltage Total	=	Ι <sub>τ</sub> x R <sub>τ</sub>
	=	454.54 x 0.484
	=	220 V

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3. Simple series circuit in which two batteries, whose emfs are 6 and 12 volts and two resistors of 4 ohms and 8 ohms. Neglecting the resistance of the batteries, determine the current in the circuit.

**GIVEN:** 

E1	=	6V	R1	=	4 ohms
E2	=	12V	R2	=	8 ohms

SOLUTION:

 $E_{T} = E_{2} - E_{1}$  = 12 - 6  $E_{T} = 6V$   $R_{T} = R_{1} + R_{2}$  = 12 ohmsCurrent Total =  $E_{T}$   $R_{T}$   $= \frac{6}{12}$ Current Total = 0.5 amp.

4. Determine the required horsepower of a primemover having 80% efficiency to drive a 500 KW generator.

**GIVEN:** 

Gen.output Effeciency	8	500 kw 80%	1kw = 1.34	4 hp
Efficiency	=	output input	Checked:	
	=	$\frac{80}{100} = \frac{500}{X}$	Eff	= <u>500 kw</u> 625 kw
x	=	<u>50000</u> 80		= .8 x 100 = 80%
HP	=	625 kw x 1.34		
HP	-	837.5 Required	80% of 625	= 500 kw
			80% of 837.5	= <u>670</u> HP 1.34
				500 kw

## CHIEF ENGINEER

- Resistance of 4,5 and 6 ohms are in series with another in a 220 V. 1. Circuit. Calculate.
  - a) Total resistance
  - b) Line current
  - c) Voltage drop across each resistance
  - d) Total power consumed

## SOLUTION:

- a)  $R_{T} = R1 + R2 = R3$ =4 + 5 + 6 $R_{\tau} = 15$  ohms.  $= \frac{V}{RT} = \frac{22\sqrt{15}}{15}$ b) A = 14.66 amps.  $= 14.66 \times R1 = 14.66 \times 4 = 58.64 V$ c) V1  $= 14.66 \times R2 = 14.66 \times 5 = 73.30 V$ V2 = 14.66 x R3 = 14.66 x 6 = 87.96 V V3  $V_{\tau} = 219.90$
- d) Power =  $A \times V_{T}$  $= 14.66 \times 219.90$ = 3,223.7 watts.
- 2. A single phase A.C generator supplies 400 amp. at 220 V with a P.F. of 0.95. Find apparent and true power?

#### SOLUTION:

Apparent Power = 
$$\frac{V \times A}{1000}$$
  
=  $\frac{220 \times 400}{1000}$   
=  $88 \text{ KVA}$   
True Power = app.power x power factor =  $88 \times .95$   
=  $83.6 \text{ kw}$ 

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3. Three resistors of 100,120,150 ohms are connected in parallel. Determine value of current to parallel system which will make current in 120 ohms resistors equal to 1.0 amp.

GIVEN R R R I	l: = = =	100 120 150 1A		Rec	iuire It E <sub>B</sub> E <sub>B</sub> E <sub>B</sub>	d: = = = = = = = = = = = = = = = = = = =	? ]b∙Rb (1) (12 120V Ea =	20) Ec =	Et =	120
Rt		F	A R <sub>B</sub> R <sub>C</sub>							
;		(R <sub>A</sub> R <sub>B</sub> )	$+ (R_B R_c) + (R_c$	, R <sub>A</sub> )						
	=		100 (120)(1	50)						
		(100 x 1	20) + (120 x 1	50) +	(150	) x 1	00)			
	=		800000				կ	=	E <sub>T</sub>	
		12000 +	18000 +15000	_			an se		R <sub>T</sub>	
	=	1800000	_					=	120 V	_
		45000							40	
Rt	=	40					Ļ	=	3 amp	s.

4. A storage battery of EMF 24 volt and internal resistance R= 0.2 ohms is to be charged from 117 volt. Supply as shown in the adjoining figure. What resistance must be placed in series with the battery to limit the charging rate to 15 ampere.

#### Solution:

Total potential drop in circuit clockwise for a to c = 117 V Ir drop + potential drop due to opposing smf + IR drop = 117

(15) (0.2) + 24	15R =	117
3 + 24 + 15R	Ξ	117
27 + 15R	=	117
15R	=	117-27
15R	• • =	90
R	=	90/15
R	=	6 ohms

# **BOARD QUESTIONS**

## FOURTH ENGINEER

1.1.1

## ELECTRICITY

#### 1. If two generators are connected in series:

- A. voltage is added and current stays the same
- B. current is added and voltage stays the same
- C. both current and voltage stay the same
- D. none of the above

2. A generator interpole always has the same polarity as the:

- A. pole preceding it
- C. opposite the main pole
- B. pole following it

D. none of the above

3. Interpoles are connected in:

- A. series with the armature
- C. parallel with the armature
- B. series with the shunt field D. parallel with the series field
- 4. A.D.C compound wound generator that has a voltage drop from no load to full load is said to be:

Α.	under compounded	С.	flat compounded
В.	over compounded	D.	none of the above

#### 5. The part of a D.C. generator into which the working voltage is induced is the:

- A. yoke B. field poles C. armature D. commutator
- 6. The proper sequence for securing a D.C. generator in parallel operation is to:
  - A. reduce current to near zero, open circuit breaker and switch and secure the driving unit
  - B. open the circuit breaker, secure the driving unit and cut in resistance to the field.
  - C. open the circuit breaker, reduce the current to zero and secure the driving unit
  - D. none of the above
- 7. Interpoles or commutating poles are connected in compound D.C. generators in:
  - A. series with the shunt field
  - B. series with the series field
  - C. series with the armature
  - D. series with shunt and series field
  - E. series with the armature but in parallel with each other

- 8. The only type of compound generator commonly used aboard ship is the:
  - A. stabilized shunt
- C. over compounded

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- B. flat compounded D. cumulative compounded
- What are commutators made of? 9.
  - A. soft copper bars insulated with mica
  - B. hard drawn copper bars insulated with mica
  - C. soft solid copper with cutaway slots for mica
  - D. hard drawn solid copper with cutaway slots for mica
- 10. A shunt-wound generator is one in which the field windings are in parallel with the:
  - A. armature B. brushes C. commutator D. field poles
- 11. An "exciting current" is required to:
  - A. build up a dead circuit
     B. create a magnetic field C. excite a synchronous motor
    - D. build up the voltage in a battery
- 12. Which of the following are not in a D.C. commutator and armature?
  - A. interpole B. mica C. copper bars D. vee ring
- 13. If the brushes in a generator are not positioned to the neutral plane, sparking may occur between the brushes and the:
  - C. armature windings A. yoke D. field pole windings B. commutator
- 14. A rheostat is a device that regulates the strength of an electric current by:
  - A. varying the resistance in the circuit
  - B. varying the voltage in the circuit
  - C. increasing the magnetic field in the circuit
  - D. varying the current in the circuit
- 15. Which of the following is not found on a D.C. generator?
  - A. pigtails C. stationary armature
  - B. brushes D. brush holders
- 16. Which of the following will not cause a generator to vibrate?
  - A. loose pigtails C. misalignment
  - D. fruity speed governor B. loose bolts
- 17. Most generators will withstand as overload of:
  - A. 15 percent B. 25 percent C. 30 percent D. 35 percent

18.	. A series-wound generator has the field windings in series with the:			
	A. armatureOB. brushesD	commutator field poles		
19.	The pole pieces mounted in a D.C. go laminations riveted together to:	enerator are built up of sheet steel		
	A. fit the curvature of the frame B. reduce eddy current losses	C. allow for necessary air gap D. allow for easy assembly		
20.	What is the primary reason for comm	utating poles in a D.C. generator?		
	<ul> <li>A. prevent sparking of the brushes</li> <li>B. increase field strength</li> </ul>	C. neutralize armature reaction D. aid in a commutation		
21.	Sparking and grooving of commutator	may be caused by:		
	<ul><li>A. overload</li><li>B. strength of field</li></ul>	C. wrong type of brushes D. any of the above		
22.	The voltage of a D.C. generator depe	nds on which of the following?		
	A. speed of armatureC. numB. strength of fieldD. all of	ber of armature conductors		
23.	To correct the polarity of a generator,	you should:		
	<ul> <li>A. Rotate armature</li> <li>B. lift brushes and rotate armature</li> <li>C. lift brushes and apply D.C.</li> <li>D. lift brushes and run generator</li> </ul>			
24.	Which of the following groups of moto	ors are D.C. motors?		
	<ul> <li>A. series, shunt and compound</li> <li>B. series and induction</li> </ul>	C. compound and synchronous D. induction and synchronous		
25.	A series-wound motor is used to run a the motor will:	pump driven with a belt. If the belt breaks,		
	<ul><li>A. overspeed and run out of control</li><li>B. stop</li><li>C. slow down</li><li>D. keep running at the same speed</li></ul>			
26.	AC circuits contain resistance, inductar tance of a circuit is expressed in:	nce and capacitance. The capacitive reac-		
	A. ohms B. mhos	C. henrys D. farads		
27.	A shunt motor would be best suited f	or:		
	<ul><li>A. constant speed results</li><li>B. an anchor windlass</li></ul>	C. a cargo winch D. any of the above		

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28. If the resistance is increased in the shunt field of a motor, the motor will

- C. run at the same speed A. speed up
- B. slow down

- D. stop
- 29. Which of the following is the distinguishing feature of a shunt motor?
  - A. it has a high starting torque
  - B. a lead will not affect it if running at high speed
  - C. it has a stable speed through a wide load range
  - D. it will not drop in speed if overloaded
- 30. Which of the following will not cause a hot motor bearing?
  - C. overload A. loose brushes
  - D. misalignment B. insufficient lubrication
- 31. In an induction motor, rotor currents are circulated in the rotor by:
  - C. inductive action of the rotating stator flux A. slip rings and brushes
  - B. armature and brushes D. external variable resistors
- 32. A device which normally prevents an action occuring until all other required conditions are met is a/an:
  - C. modulator A. interlock B. monitor D. limit
- 33. A circuit breaker and a fuse are similar because they both:
  - A. can be reset to energize the circuit
  - B. should open the circuit when overloaded
  - C. burn out when an over current flows
  - D. any of the above
- 34. The electroplyte in a lead-acid storage battery consists of water and:
  - A. sulfuric acid C. hydrogen chloride
  - B. calcium chlorid D. muriatic acid
- 35. The state of charge of a lead acid storage battery is best indicated by the:
  - A. specific gravity of the electrolyte
  - C. individual cell voltage B. ampere hour capacity D. total cell voltage
- 36. Electrical leads and insulation on a motor should be painted with:
  - A. insulating varnish C. heat-resisting enamel
  - B. heat-resisting aluminum D. insulating white lead
- 37. Voltage generated by most AC generators is brought from the machine to the bus by means of:
  - A. brushes on a commutator B. brushes on slip rings
- C. slip rings on a commutator
- D. direct connections from the stator

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- 38. A degree of control over the speed of a slip ring induction motor can be obtained by:
  - A. inserting resistance into the rotor circuit
  - B. changing the number of phases to the motor
  - C. inserting resistance into the stator circuit
  - D. adjusting governor linkage
- 39. A circuit breaker differs from a fuse in that a circuit breaker:
  - A. melts and must be replaced
  - B. is enclosed in a tube of insulating material with metal ferrules at each end
  - C. gives no visual indication of having opened the circuit
  - D. trips to break the circuit and may be reset
- 40. The basic unit of inductance is the:
  - A. coulomb B. ohm C. farad D. henry

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- 41. Battery rooms must be well ventilated to:
  - A. prevent sulphation during discharge
  - B. supply oxygen
  - C. dissipate explosive gases
  - D. prevent moisture formation
- 42. The alarm system for an engine order telegraph uses small selsyn motors attached to the indicators. The alarm sounds when the rotors are:
  - A. not synchronized, current is flowing, and the relays are closed
  - B. in synchronous position, no current is flowing and the relays are closed
  - C. not synchronized, current is flowing and the relays are open
  - D. in synchronous position, no current is flowing and the relays are open
- 43. As a general rule, the first troubleshooting action to be taken in checking faulty electric control apparatus is to:
  - A. draw one line diagram of the circuitry
  - B. test all fuses and measure the line voltage
  - C. take megger readings
  - D. insulate the apparatus from the ground
- 44. The most common type of AC service generator found aboard ship is the:
  - A. armature-rotating electromagnetic field type
  - B. electromagnetic field-oscillatory armature type
  - C. armature-oscillatory electromagnetic field type
  - D. electromagnetic field-revolving armature type
- 45. The main purpose of the auxilliary winding on a split-phase single-phase motor is to:
  - A. limit the starting current
  - B. increase the starting current
  - C. start the motor
  - D. keep the motor running in the event the main winding should fail

- 46. When you are choosing a battery for a particular application major consideration should be given to the battery's:
  - A. amp-hour

- C. stability under charge
- B. terminal polarity
- D. ambient temperature rise
- 47. Of what significance is ambient temperature in relation to the service life of electronic components?
  - A. Ambient temperature should be as high as possible to drive off moisture
  - B. Increased ambient temperature decreases the service life of electronic components
  - C. Ambient temperature is not significant as long as the relative humidity is kept low
  - D. A reduced ambient temperature causes a corresponding reduced service life
- 48. Which device should always be connected in series with a circuit?
  - A. Ammeter C. Wattmeter
  - B. Megohmeter D. Voltmeter
- 49. A flickering ground detection lamp on a DC system would indicate a
  - A. ground in an armature coil of an operating machine
  - B. short between two adjacent bars of the generator commutator
  - C. multiple around in the distribution system
  - ground in a motor accompanied with a short D.
- 50. A fuse will "blow" if
  - A. the electrical current exceeds the rated value of the fuse
  - B. the flow of current to the device protect is reversed
  - C. unequal resistors are connected in parallel
  - D. an electrical motor is stopped suddenly by opening a switch
- 51. Which bus is normally located in the main switchboard?
  - A the 24 volt DC bus C. the emergency power bus
  - B. the shore power bus D. the lighting bus
- 52. Etched or burned bands on the contact faces on brushes in a direct current generator could be caused by
  - A. copper embedded in the brushes
  - B. brushes improperly positioned
  - C. copper drag on the commutator
  - D. high mica segments
- 53. What is indicated if a lead-acid battery begins to gas violently when it is first put on charge?
  - A. normal charging rate
- C. Insufficient circuit in a cell
- B. excessive charging rate D. A short circuit in a cell

- 54. An accidental path of low resistance which causes an abnormal flow of current is known as a/an
  - A. ground reference pointC. polarized groundB. open circuitD. short circuit

- 55. When a megohimeter is used to test insulation, the initial dip of the pointer toward zero is caused by
  - A. the dielectric-absorption effect of the insulation
  - B. the leakage of current along the surface of nearby insulation
  - C. good insulation
  - D. the capacitance of the circuit
- 56. The main purpose of an electric space heater installed in a large AC generator is to
  - A. prevent the windings from becoming brittle
  - B. prevent moisture condensation in the windings during shutdown
  - C. keep the lube oul warm for quick starting
  - D. prevent acidic pitting of the slip rings
- 57. When a flourescent lamp has reached the end of its useful life, it should be replaced immediately, or the resultant flashing may
  - A. blow the lamp's breaker
  - B. explode, causing glass to fly in all directions
  - C. short circuit the ballast transformer
  - D. damage the starter and the ballast
- 58. When you are choosing a battery for a particular application major consideration should be given to the battery's
  - **A.** amp-hour capacityB. terminal polarity C. stability under charge
  - D. ambient temperature rise
- 59. What statement is true concerning the cleaning of contacts?
  - A. the contact surfaces should be greased to increase contact resistance
  - B. Magnetic brushes should be used to remove metallic dust
  - C. Delicate parts should be cleaned with a brush and an approved safety solvent
  - D. Compressed air should be used to blow out metallic dust
- 60. What do you call values which can change continuously such as temperature, pressure, or level?
  - A. digital valuesB. humpless values C. binary values
  - D. analog values
- 61. What type of battery charging circuit is used to maintain a wetcell lead-acid storage battery in a fully charged state over long periods of disuse?
  - A. Normal charging circuit C. Quick charging circuit
  - B. High ampere charging circuit D. Trickle charging circuit

- 62. The voltage of an operating 60 hertz alternator is generally adjusted by varying the
  - A. number of poles C. number of series conductors
  - B. prime mover speed D. magnetic field strength
- 63. The total number of watts in one horsepower is
  - A.
     746 watts
     C.
     500 watts

     B.
     663 watts
     D.
     1,000 watts
- 64. Why are transformer aboard ship used with AC generators?
  - A. to permit higher voltage for motor operation and low voltage for lighting circuits
  - B. to change frequency
  - C. to increase power output
  - D. to decrease power output

# THIRD ENGINEER

- 1. When a lead-acid storage battery discharges, what would the effect be on the electrolyte?
  - A. specific gravity decreases
  - B. specific gravity increases
  - C. specific gravity remains the same
  - D. none of the above
- 2. The lead plates in a storage batteries are separated by:
  - A. rubber C. glass B. Wood D. any of the above
- 3. In cold weather the specific gravity of a battery:

Α.	rises	C.	remains	the	same
B.	lowers	D.	none of	the	above

4. According to battery manufacturer's specifications what hydrometer reading will be obtained from a fully charged portable lead-acid battery?

Α.	1.280 to	1.300	C.	1.100	to	1.150
В.	1.180 to	1.182	D.	1.750	to	2.750

- 5. Dirty lead-acid type batteries should be cleaned off with:
  - A. soap and water
  - B. sodium chloride
  - C. baking soda (sodium bicarbonate)
  - D. potassium hydroxide

6. A fully charged battery reads from:

Α.	1.280 to 1.300	С.	1.050 to	1.350
В.	1.025 to 1.075	D.	1.200 to	1.500

7. A dead cell of a lead-acid battery is checked by:

Α.	megger	C.	test light
B.	hygrometer	D.	hydrometer

How many 1.5 volt batteries are required to supply a load of 12 volts if the batteries 8. are connected in series?

B. 6 C. 12 D. 10 **A**. 8

How many 1.5 volt batteries are required to supply a load of 12 volts if the batteries 9. are connected in parallel?

B. 6 C. 3 D. none of the above A. 12

- 10. The rating of a storage battery that delivers 15 amps for 12 hours is:
  - A. 180 ampere hours C. 27 ampere hours B. 150 ampere hours D. 360 ampere hours
- 11. Which of the following items is necessary to keep a storage battery in good operation?
  - A. maintain proper specific gravity
  - B. keep cool and well-ventilated
  - C. maintain proper level of electrolyte
  - D. all of the above
- 12. What type of battery-charging circuit is used aboard ship to maintain storage batteries in a condition of readiness over long periods of disuse?

  - A. trickle charging circuitC. 20-amp charging rate circuitB. quick charge circuitD. test discharge circuit

- 13.  $H_aSo_a$  is:
  - A. sulphuric acidC. hydraulic acidB. hydrochloric acidD. muriatic acid

- 14. The total voltage and amperage of two 50-amp 6-volt batteries connected in series is:

А.	12 volts, 50 amps	C. 6 volts, 100 amps
<b>B</b> .	12 volts, 100 amps	D. 6 volts, 50 amps

15. The total voltage and amperage of two-50 amp 6-volt batteries connected in parallel will be:

Α.	6 volts, 100 amps	С.	12 volts, 100 amps
Β.	6 volts, 50 amps	D.	12 volts, 50 amps

- 16. The voltage of a battery is equal to the:
  - A. voltage of a single cell times the number of cells in series
  - B. amperage of a single cell times the number of cells in series
  - C. efficiency of the number of cells times the resistance
  - D. voltage of a single cell times the number of cells in parallel
- 17. Three 12-volt storage batteries connected in parallel will give you a total voltage of:
  - A. 12 volts B. 24 volts C. 36 volts D. 48 volts
- 18. Indicate the proper procedure for mixing battery electrolyte:
  - A. use distilled water, add acid to water
  - B. use alkaline water, add acid to water
  - C. use distilled water, add water to acid
  - D. use alkaline water, add water to acid
- 19. D.C. generators are classified according to the manner in which:
  - A. they are used
  - B. the field windings are connected to the load
  - C. the armature circuit is connected to the load
  - D. the field windings are connected to the armature circuit
- 20. The purpose of the commutator and brushed on a D.C. generator is to:
  - A. change A.C. to D.C. current
  - B. change D.C. to A.C.
  - C. neutralize armature reaction
  - D. carry current to the outside circuit

## 21. When two D.C. generators operate in parallel, they are protected against motorizing bv:

- A. blow out coilsC. undervoltage tripsB. governor relayD. reverse current trip D. reverse current trips
- 22. How is the rotation of a D. C. generator reversed?
  - A. reverse field connections C. switch armature leads B. switch armature leads D. both B and C

- 23. On la D.C. generator where is the pigtail located?
  - A. feather spring
- C. brush holder
- B. conductors D. spiral adjusting spring
- 24. Which of the following D.C. generators has the largest percentage of voltage drop between no load and full load?
  - A. under compounded C. shunt
  - B. flat compounded D. stabilized shunt
- 25. A.D.C. generator that has a voltage rise from no load to full load is said to be:
  - A. under compounded C. flat compounded
  - D. under flat compounded B. over compounded
- 26. If a D.C. generator was rotated in the wrong direction, it would fail to come up to voltage because the:
  - A. armature field would oppose the field current
  - B. generator would burn out
  - C. brushes would burn out
  - D. circuit breaker would not energize
- 27. A generator operates on the principle that:
  - A. when a field revolves, current is generated
  - B. when an armature revolves, a magnetic field is induced
  - C. voltage is induced when a conductor cuts a magnetic flux
  - D. a small voltage in the primary high voltage in the secondary because of the large number of coils in the secondary
- 28. With an increase in load on a flat-compounded D.C. generator, the voltage will:
  - A. remain the same C. increase B. decrease D. reduce to half
- 29. D.C. generators are rated in
  - A. KVA C. Kw B. KwA D. HP
- 30. The voltage output of a compound D.C. generator is adjusted by rheostat placed:
  - C. across the series field A. in series with the shunt field
  - B. in series with the series field D. across the shunt field

- 31. The electrolyte used in a nickel-cadmium battery is hydroxide.
  - A. potassium

- C. sodium
- B. cadmium D. calcium
- 32. The device which most commonly utilizes the principle of electromagnetic induction is the:
  - A. transformer C. transistor
  - B. diode D. rheostat
- 33. A tubular fuse should always be removed from a fuse panel with:
  - A. a screwdriver C. any insulate object
  - B. a pair of insulated pliers D. fuse pullers
- 34. One of the factors which determine frequency of an alternator is controlled by the:
  - A. number of magnetic poles
  - B. number of turns of wire in the armature cell
  - C. strength of the magnets used
  - D. output voltage
- 35. Which of the following logic gates is/are considered to be a BASIC building block (basic logic gate) used in logic diagrams?
  - A. OR B. NAND C. NOR D. All of the above
- 36. Which motor is fitted with an instantaneous overload relay?
  - A. Winch C. Fan
  - B. Pump D. Machine Tool
- 37. A molded-case circuit breaker provides protection against short circuits by using a/an:
  - A. electromagnet
  - B. shading coil
  - C. arc quencher
  - D. burn away strip
- 38. The rated temperature rise of an electric motor is the:
  - A. normal temperature rise above the standard ambient at record hold
  - B. average temperature of any given latitude
  - C. average temperature rise due to resistance at 10% overload
  - D. permissible difference in the ambient temperature of the motor due to weather
- 39. The number of cells in a 12 volt lead-acid battery is:

A. three B. four C. six D. twelve

- 40. The Wheatstone bridge is a precision instrument used to measure:
  - A. resistance

- C. inductance
- B. capacitance D. amperage
- 41. The greatest detrimental effect on idle electrical equipment such as cargo pump motors is:
  - A. loss of residual magnetism
  - **B.** absorption of moisture in the insulation
  - C. insulation varnish flaking
  - D. dirt collecting on the windings
- 42. The frequency of an operating alternator is controlled by the:
  - A. relative speed of the rotor poles
  - B. number of turns of wire in the armature coil
  - C. strength of the magnets used
  - D. output voltage
- 43. What does a wound-rotor induction motor have which a squirrel cage motor does not?
  - A. slip rings

- C. a centrifugal switch
- B. end rings D. end plates
- 44. The current at which a magnetic-type overload relay tends to trip may be decreased by raising the plunger further into the magnetic circuit of the relay. This action:
  - Α. increases magnetic pull on the plunger and requires less current to trip the relay
  - B. reduces magnetic pull on the plunger and requires less current to trip the relay
  - C. increases magnetic pull on the plunger and requires more current to trip the relay.
  - D. reduces magnetic pull on the plunger and requires more current to trip the relav
- 45. Protection against sustained overloads in molded-case circuit breakers is provided by an/an:
  - A. overvoltage release C. thermal overload relay B. thermal acting trip D. current overload relay
  - B. thermal acting trip D. current overload relay
- 46. Motorization of an alternator is undesirable because
  - A. it puts an additional load on the bus
  - B. all of the above
  - C. the alternator will be damaged
  - D. high voltage pulses are induced in the bus

- 47. The unit "hertz" is equivalent to
  - A. revolution per minute C. revolutions per second B. cycles per second
    - D. coulombs per second
- 48. How are fuses rated?
  - A. amps and volts B. amps only C. watts D. volts only
- 49. The unit of electrical resistance is the
  - A. ohm B. watt C. amper D. volt
- 50. The line voltage generated by an alternator is adjusted by varying the
  - A. prime mover speed
  - B. equalizer bus
  - C. excitation voltage
  - D. residual magnetism of the field
- 51. The standard unit of wire cross-sectional area used in American wire tables is the
  - A AWG C. cubic inch
  - B. square millimeter D. circular mil
- 52. Which of the following characteristics is most critical in determining the size of cable to be used in a particular circuit?
  - A. voltage rating
  - **B.** current rating
  - C. inductance per unit length
  - D. Weight per unit length
- 53. A ground is indicated by the ground-detecting system. The first step in locating the actual ground is to
  - A. Check circuit with a megohmeter
  - B. change over generators
  - C. close all switches in the distribution panel until the ground detector indicates normal
  - D. open the indidual circuits one by one until the ground detector
- 54. A DC generator supplying direct current to maintain an generator field is known as a/an
  - A. stator B. rotor C. armature D. exciter
- 55. The frequency of an AC generator is adjusted by means of the
  - C. main alternator field rheostat A. equalizing reactor
  - B. prime mover governor control D. exciter field rheostat

56. The inductance of a conductor is measured in

- A. henries
- B. volts ohms D. amperes
- 57. The voltage of an operating AC turbogenerator is raised or lowered by adjusting the

C. ohms

- C. generator governor controls
- A. generator field exciterB. phase sequence switch D. synchronizing switch
- 58. Under normal conditions, storage batteries for starting the emergency diesel generator are maintained in a charged state by which of the following methods:
  - A. trickle charging C. equalizing charging
  - B. reverse charging D. fear charging
- 59. A current-carrying conductor that makes electrical contact with a wiring conduit is indicated by a
  - A. reading of 1.0 on the power factor meter
  - B. totally dark switchboard ground-detecting light
  - C. low switchboard wattmeter reading
  - D. high switchboard wattmeter reading
- 60. What statement is true concerning the cleaning of contacts?
  - A. delicate parts should be cleaned with a brush and an approved safety solvent
  - B. compressed air should be used to blow out metallic dust
  - C. the contact surfaces should be greased to increase contact resistance
  - D. magnetic brushes should be used to remove metallic dust
- 61. What is the preferred method of cleaning dust and foreign particles from electrical equipment?

A. wiping	C. compressed air
B. cleaning solvent	D. vacuum suction

- 62. Sparking at the brushes of a running motor could be an indication of
  - A. normal operation C. a dirty commutator
  - B. increased brush capacity D. water vapor absorption
- 63. What is the overall result of increasing the load on the secondary of a transformer?
  - A. decrease in the primary current
  - B. decrease in the primary voltage
  - C. increase in the primary voltage
  - D. increase in the primary current

- 64. What is the process of reversing the direction of the current in an armature coil as the commutator segments to which the coil is connected pass under a brush called? 1
  - A. dynamic excitation

C. commutation

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B. armature reaction

D. slip

- 65. The air gap in induction motors should be checked periodically with a feeler gauge to guard against an unequal air gap and
  - A. increased power factor
  - B. decreased motor magnetizing current
  - C. hysteresis loses
  - D. mechanical damage to the rotor
- 66. Which is a function of voltage regulators used with AC generators?
  - A. to cut in generators automatically as they are needed
  - B. to divide the KW load equally between generators operating in parallel
  - C. to cut out generators when they are no longer needed
  - D. to divide reactive current between generators operating in parallel
- 67. When a megger insulation tester is being used on a direct current machine, the meter pointer will dip toward zero and then gradually rise to the true resistance value if the motor insulation is
  - B. dirty C. good D. grounded A. shorted
- 68. What should be used to measure the temperature of an electrolyte?
  - A. alcohol thermometer C. mercury thermometer
  - D. potentiometer B. thermocouple pyrometer
- 69. Voltage failure of an AC generator may be caused by
  - A. a tripped bus circuit breaker
  - B. excessive prime mover speed
  - C. failure of the exciter generator
  - D. high mica segments on the stator bus bar
- 70. Why are transformer aboard ship used with AC generators?
  - A. to decrease power output
  - B. to increase power output
  - C. to permit higher voltage for motor operation and low voltage for lighting circuits
  - D. to change frequency
- 71. When a battery is continuously exposed to low temperatures, the best procedure to keep it from freezing is to:
- A. disconnect the batteryB. remove the battery capsC. fully charge the batteryD. securely cover the battery

- 72. A three-phase, squirrel-cage, induction motor could run hot due to a/an
  - A. high power factor
  - B. reversed commutating pole
  - C. improper brush position
  - D. shorted stator
- 73. The reversal of an AC, 3-phase induction motor is accomplished by:
  - A. changing all three motor leads
  - B. interchanging any two of the three motor leads
  - C. reversing the position of the slip rings
  - D. interchanging any two brushes
- 74. Brushes in a generator must be positioned in the neutral plane to avoid sparkling between the brushes and the
  - A. commutator C. field pole windings
  - B. yoke D. armature windings
- 75. The cycles per second of the alternating current from the alternator aboard your boat are determined by °
  - A. the resistance applied to the filed rheostat
  - B. the adjustments made to the voltage regulator
  - C. the speed of the engine driving the alternator
  - D. the synchronous speed of induction

# SECOND ENGINEER

- 1. What happens in a series circuit when the voltage remains constant and the resistance increases?
  - A. current decreases C. current remains the same
  - B. current increases D. current increases by the square
- 2. The magnetic field around a current-carrying wire:
  - A. exists at all points along the length of the wire
  - B. is parallel to the current flow in the conductor
  - C. moves in the direction of current flow
  - D. exists only at the beginning of electron movement
- 3. Electric current is the flow of electrons through a conductor. This is commonly called:

Α.	voltage	С.	coulombs
В.	amperage	D.	resistance

4. One megohm is equal to:

	<b>A.</b> B.	1,000,000 ohms 10,000 ohms	•		C. D.	100,000 ohm 1,000 ohms	S	
5.	A multiconductor cable:							
	<b>A.</b> B. C. D.	has a number of separate circuits is a single circuit cable composed of a number of strands is a flexible cable to carry motor current is a special heating conductor						
6.	in D	.C. circuits, pow	er is	s expressed a	s the	product of:		
	<b>A.</b> B.	volts and ampe ohms and amp	res eres		C. volts and coulombs D. amperes and coulombs			
7.	Ar	nil is:						
	А. В.	1/10 inches 1/100 inches			<b>C</b> . 1/ D. 1/	1,000 inches 1,000,000 inc	hes	
8.	One	kilowatt is equa	l to:	:				•
	<b>A.</b> B.	1.34 horsepowe 1.25 horsepowe	er er		C. D.	1.50 horsepo 2.00 horsepo	wer wer	
9.	Defects in wiring which permit current ot jump from one wire to another before the intended path has been completed are called:				to another before			
	<b>A</b> .	grounds	в.	shorts	C.	opens	D.	breaks
10.	W	nich of the follow	ving	is not a good	i cond	uctor of electi	ricity?	
	A.	mica	В.	copper	C.	silver	D.	aluminum
11.	One horsepower equals:							
	A.	1,000 watts	В.	746 watts	C.	100 watts	D.	940 watts
12.	An	instrument often	use	d to check the	e degr	ee of motor s	haft m	nisalignment is the
	<b>A</b> . B. C. D. <b>E</b> .	Voltmeter Clamp-on amm Growler Megohmmeter Dial indicator	eter					

13. The electrical power is kilowatts used by a 220 volt motor drawing 15 amps is:

- C. 3.8 D. 4.0 **A.** 3.3 B. 3.6
- 14. A horseshoe magnet has:
  - A. two poles C. four poles B. three poles D. one pole
- 15. Retentivity is the power a metal has to retain:
  - A. the current in a circuit
  - B. magnetic lines of force
  - C. electron flow within the circuit
  - D. electricity when moving at high speeds
- 16. When selecting the size of wire to be used in a circuit, the most important item to consider is the:
  - A. amperage of the circuitC. resistance of the circuitB. voltage of the circuitD. amount of wire to be used
- 17. If a wire is increased in circular mils:
  - A. its size is larger in diameter
  - B. its resistance is lower per foot
  - C. Its size is smaller in diameter
  - **D.** A and B
  - E. B and C
- 18. The following formula is used to compute power:

A.	P =	I <sup>2</sup> R	C.	P =	E <sup>2</sup> R
В.	P =	R <sup>2</sup> E	D.	P =	E+R

- 19. High voltage and low current gain are characteristics of the:
  - A. common base circuitC. common collectB. common emitter circuitD. both A and C C. common collector circuit
- 20. Which of the following statements is true?
  - A. like poles repel each other C. unlike pole repel each other B. like poles attract each other D. none of the above
- 21. How is a lead-acid cell tested?
  - A. hydrometer
  - B. hyprometer

- C. hogometer
- D. meaometer

22.	A 24-volt lead-acid storage battery consists of:		
	A. 12 cells B. 6 cells	C. D.	8 cells none of the above
23.	If the charging rate to a battery was t	oo h	nigh, it would:
	<ul> <li>A. increase the terminal voltage</li> <li>B. increase the specific gravity</li> <li>C. increase the rate of hydrogen liber</li> <li>D. decrease the terminal voltage</li> </ul>	ratior	1
24.	In a 12-volt battery there are how man	ny c	elis?
	A. 6 B. 4	C.	2 D. 8
25.	If the specific gravity of a 12-volt batte	ery a	at 80° is 1.225, the battery is:
	<ul><li>A. dead</li><li>B. fully charged</li></ul>	C. D.	shorted partially charged
26.	The state of charge of a nickel-cadmiu of a/an	ım b	attery is determined by the use
	<ul><li>A. voltmeter</li><li>B. hydrometer</li></ul>	C. D.	ammeter potentiometer
27.	The physical size of a resistor that detabsorb heat is rated in :	term	ines the ability of the resistor to
	A. Ohms B. Volts	C.	Watts D. Farads
28.	A circuit that has infinite resistance is	call	ed circuit.
	A. A short B. A ground	<b>C.</b> D.	An Open All of the above
29.	What determines the voltage of a lead	d-aci	d cell?
	<ul><li>A. the type of electrolyte</li><li>B. the strength of the electrolyte</li></ul>	C. D.	the size of the plates none of the above
30.	Salt water in contact with storage batt	eries	s will develop:
	<ul><li>A. chlorine gas</li><li>B. nitrogen gas</li></ul>	C. D.	carbon monoxide carbon dioxide

- 31. Which statement is true concerning the maintenance of solid-silver contacts in relays and auxiliary control circuits?
  - A. When necessary, they should always be dressed with a wire wheel
  - B. They should be filed with a fine-cut file when projections extend beyond the contact surface
  - C. When black sliver oxide is present, it should always be removed from the contact surface with coarse sandpaper
  - **D.** If necessary, they should be held together with moderate pressure while emery paper is drawn between the contacts
- 32. While you are starting a main propulsion synchronous motor as an induction motor, the ampere meter pegs out at maximum and then returns to the proper value after synchronization. This means the:
  - A. motor has started properly
  - B. field windings are grounded
  - C. slip rings are dirty
  - D. power transmission cables are grounded
- **33.** The purpose of a short circuit forcing module (short time trip) installed in a branch line is to provide:
  - A. high speed clearance of low impedance short circuits in the branch
  - B. continuity of service on main bus under short circuit condition in a branch
  - C. isolation of short circuits by selective tripping of branch circuit breakers
  - D. all of the above
- 34. Electrolyte in a nickel-cadmium battery is:
  - A. potassium hydroxide
  - B. sulfuric acid
  - C. slip rings are dirty
- 35. A soft iron core with wire coiled around it and direct current passing through the wire is the description of a simple:
  - A. magnetic shield

- C. piezoelectric device
- B. electromagnet D. electromagnetic domain
- 36. To properly use a hook-on-volt ammeter when checking current flow, you must FIRST:
  - A. hook the jaws of the instrument around the insulated conductor
  - B. de-energize the circuit to allow connection of the instrument in series
  - C. connect the voltage test leads to the appropriate terminals
  - D. short the test leads and calibrate the instrument to zero
- 37. Autotransformer starters or compensators are sometimes used with polyphase induction motors to:
  - A. reduce the voltage applied to the motor during the starting period
  - B. increase the voltage for "across the line starting"
  - C. provide a back-up means of voltage regulation for emergency starting
  - D. allow the voltage to be either stepped up or down depending on the application to ensure full torque
- 38. A magnetic blowout could in a DC contactor function to:
  - A. prevent contact melting
  - B. open contact rapidly
  - C. adjust opening spring tension
  - D. provide "snap-action" in the contactor
- 39. In an AC synchronous motor Turbo electric power plant, propeller speed is controlled by varying the:
  - A. turbine speed
  - B. electric coupling field strength
  - C. number of energized main motor poles
  - D. propulsion generator field strength
- 40. A molded-case breaker provides protection against short circuits by using a/an:

Α.	electromagnet	С.	shading	coi
B.	arc quencher	D.	holding	coil

- B. arc quencher
- 41. The method used to produce electron emission in most vacuum tubes is:

Α.	photoelectric	С.	cold cathods
В.	secondary	D.	thermionic

#### 42. A microprocessor is:

Α.	Another name for a computer	C. A name for a	calculator
В.	A CPU integrated circuit	D. A small scale	integrated circuit

43. What device measures pressure and converts it into an electrical signal?

A.	transducer	С.	transforme
B.	reducer	D.	rectifier

44. Grounds found in electrical machinery due to insulation failure are usually caused by:

٩.	deterioration due to age	C. vibration
-		B all af the all

**D.** all of the above B. excessive heat

- 45. The amount of voltage induced in the windings of an AC generator depends on:
  - A. the number of conductors in series per winding
  - B. the speed at which the magnetic field passes across the winding
  - C. the strength of the magnetic field
  - D. all of the above
- 46. The type of motor that uses a rheostat in the rotor circuit to vary the speed is called a:
  - A. wound-rotor induction
- C. squirrel-cage induction
- B. regenerative braking D. synchronous
- 47. A motor controller contains three push buttons labeled "start", "jog" and "stop". When the jog button is pushed, the motor:
  - A. will run continuously after the "jog" button is released
  - B. will run until the "jog" button is released
  - C. cannot start until both the "jog" and "start" buttons are pushed
  - D. cannot stop unless the "stop" button is pushed
- 48. Which of the following precautions should you take when securing propulsion generators and motors for an extended period of time?
  - A. Lift the brushes from commutator collector rings and use the built-in heater to prevent moisture accumulation
  - B. Disconnect the brush pigtails from their contacts and discharge carbon dioxide into the units to keep them dry
  - C. Disconnect the brush pigtails from their contacts and circulate air through the units
  - D. Lift the brushes from commutator or collector rings and circulate cool dry air through the units
- 49. Non-adjustable molded case circuit breakers are classified by frame size, ampere rating and interrupting capacity. The frame size is expressed in:

Α.	degrees centigrade	C.	amperes
В.	circular mils	D.	volts

- 50. What is the purpose of the capacitors on the output of the power supplies used in today's consoles?
  - A. They filter out ripple
  - B. They act as a permanent load
  - C. They prevent overloads
  - D. They increase the output frequency

- 51. Automatic voltage regulators on DC generators detect voltage changes and adjust the

  - A. speed of the prime moverB. resistance of the armatureC. centertap of the balance coilD. resistance in the field circuit
- 52. What condition indicate (s) that a lead-acid battery is being charged too quickly?
  - A. unusually high electrolyte specific gravity
  - B. low plate potentials
  - C. sparking at the positive terminal
  - D. excessive temperatures and excessive cassing
- 53. How should the shunt of an ammeter be connected?
  - A. In parallel with the load and in series with the meter movement
  - B. In parallel with the load and in parallel with the meter movement
  - C. In series with the load and in parallel with the meter movement
  - D. In series with the load and in series with meter movement
- 54. Chattering of collector ring brushes on a generator may be remedied by

  - A. reinsulating the brushesB. lubricating brush holdersC. cleaning the collector ringsD. increasing length of pigtail
- 55. When an alternator governor control switch is moved to "raise", this will
  - A. lower the percentage of speed limit control
  - B. lower the no-load speed setting of the governor
  - C. raise the no-load setting of the governor
  - D. raise the percentage of frequency cycle
- 56. When you use a megohimeter to test insulation, good insulation will be indicated by:
  - A. a downward dip followed by a gradual climb to the true resistance value
  - B. the initial dip of the pointer
  - C. slight kicks of the needle down scale
  - D. a gradual rise in the pointer reading at the outset
- 57. When electrical cables pass through watertight bulkheads.
  - A. A watertight stuffing tube capable of taking packing should be employed
  - B. they must be bent to a radius of six diameters
  - C. they should be secured by a clamp
  - D. they should be grounded on either side of the bulkhead

58. The force that causes free electrons to move in a conductor as an electric current is called force.

- A. die-electric C. resistance
- **B.** an electromotive D. inductive
- 59. The resistance in electrical wiring decrease as increase in
  - A. temperature C. metal impurities
  - B. cross sectional area D. length
- 60. What is the first step in removing a generator from parallel operation?
  - A. remove the load from the off going generator
  - B. trip the generator off the switchboard
  - C. turn off all electrical equipment
  - D. increase the cycles of the generator staying on the line

# CHIEF ENGINEER

1. A standard wire is given the same designation as a solid wire if it has the same:

A. cross-sectional area

B. weight per foot

- C. overall diameter D. strength
- 2. Counter electromotive force is measured in:

A.	volts	C. a	amps
B.	ohms	D. (	coulombs

3. With other factor remaining constant, when the applied voltage is doubled, current flow in a given circuit will:

Α.	double	C. be divided by two
Β.	remain the same	D. be divide by four

- 4. The resistance of a copper wire to the flow of electricity:
  - A. increases as the length of the wire increases
  - B. decreases as the diameter of the wire decreases
  - C. decreases as the length of the wire increases
  - D. increases as the diameter of the wire increases
- 5. Which of the following formulas would solve for amperage?

A. R divided by E	C. E divided by R
B. R times E	D. R minus E

6. Which of the following expression correctly states Ohm's Law?

A. volts equal amps times resistance B. amps equal volts divided by resistance C. resistance equals volts divided by amps **D**, all of the above correct 7. In a parallel circuit which of the following is the same throughout the circuit? C. voltage A. impendance B. current D. resistance 8. When using Ohm's Law, E divided by R would solve for: A. amperage C. resistance B. voltage D. watts 9. When using Ohm's Law, E divided by I would solve for: C. resistance A. amperage B. voltage D. watts 10. A wire gauge is used to measure: C. current carrying capacity A. size of wire B. insulation value D. tensile strength 11. The unit of electrical current flow is the : A. amp B. volt C. watt D. ohm 12. The unit of the electrical resistance is the: B. watt A. ohm C. volt D. amp 13. Volts times amps equals: A. kilowatts B. watts C. ohms D. watt-hours 14. The unit of electrical pressure is the: A. volt B. am C. watt D. ohm 15. If the temperature varies with such conductors as copper, silver, and aluminum, which of the following statements is correct: A. as temperature increases, resistance increases B. as temperature decreases, resistance decreases

C. as temperature increases, resistance decreases

D. temperature has no effect on resistance

16. A circuit that does not provide a complete path for the flow of current is:

- C. as series circuit A. an open circuit
- B. a closed circuit D. a grounded circuit

17. In a series of circuit the total current is:

- A. the same as that of the largest branch circuit
- B. the same throughout all parts of the circuit
- C. the same as that of the smallest branch circuit
- D. none of the above

18. Static electricity is most often produced by:

- A. heat C. magnetism B. pressure
- **D.** friction

19. The total resistance of a parallel circuit is always:

- A. larger than that of the branch with the greatest resistance
- B. equal to the sum of the individual branch resistance
- C. equal to the reciprocal of the sum of the individual branch
- D. smaller than that of the branch with the lowest resistance
- 20. Dielectric strength is the:
  - A. ability of the insulator to withstand a potential difference
  - B. ability of a conductor to carry large amounts of current
  - C. opposite of potential difference
  - D. strength of a magnetic field
- 21. If the resistance of a circuit is doubled and the applied voltage kept constant, the current will be:

Α.	doubled	C.	the	sa	me
Β.	quadrupled	D.	cut	in	half

22. If the length of a wire is doubled and the cross-sectional area is reduced to onehalf, the change in resistance will be:

· <b>A</b> .	quadrupled	C.	doubled
В.	halved	D.	quartered

- 23. The purpose of a rectifier is to:
  - A. change A.C. to D.C.
  - B. change D.C. to A.C.
  - C. change the frequency of A. C. current
  - D. change the voltage of D. C. current

24. Which is the smallest diameter wire?

A. 18 B. 10 C. 6 D. 4

25. In a D.C, series circuit, all the conductors have the same:

A. power expanded in them	C. resistance to the flow of current
B. voltage drop across them	D. current passing through them

26. An increase in current:

A. increases temperature C. has no effect on temperature

B. decreases temperature D. will double the temperature

27. The horse power of an 1,800 (kilowatt) motor is:

A. 1,800 B. 2,142 C. 2,412 D. 2,421

28. Soft iron is the most suitable for use in a:

Α.	temporary magnet	C.	natural	magnet
B.	permanent magnet	D.	solid m	nagnet

29. Residual magnetism is the magnetism:

- A. in a field coil
- B. in the motor
- C. remaining in a substance after it has been removed from a magnetic field D. gained in converting D.C. to A. C.

30. Magnetic flux is best insulated by:

- A. ceramic
- D. porcelain

E. impossible to insulate

B. cambric C. rubber

31. A semi-conductor that decreases in a resistance with an increase in temperature is known as a:

Α.	resistor	C. diode	
В.	thermistor	Da thermopi	le

32. The shunt of ammeter should be connected in:

A. series with the load in parallel with the meter movement

B. parallel with the load and in series with the meter movement

- C. parallel with the load and in parallel with the meter movement
- D. series with the load and in series with the meter movement

33. Brushless generators operate without the use of:

A. brushes	C. commutators
B. slip rings	D. all of the above

- 34. An operating characteristics which appears on the name plates of shipboard AC motors is:
  - A. temperature riseC. the type of windingB. input kilowattsD. locked rotor torque
- 35. Low horsepower polyphase induction motors can be started with full line voltage by means of :

A.	compensator	C. across-the-line
B.	autotransformer	D. primary-resistor

- 36. What item is normally installed on a large turbine electric propulsion alternating current generator?
  - A. temperature detector coils inserted in the stator slots for measuring stator temperature
  - B. A CO2 fire extinguisher system
  - C. electric space heaters to prevent condensation of moisture
  - D. all of the above
- 37. What type of battery charging circuit is used to maintain a wet cell lead-acid storage battery in a fully charged state over long periods of disuse?
- A. normal charging circuitB. quick charging circuitC. trickle charging circuitD. high ampere charging circuit
- 38. A ground can be defined as an electrical connection between the wiring of a motor and its:
  - C. shunt field A. metal framework
  - circuit breaker D. interpole **B**.
- 39. External shunt are sometimes used with ammeters to:
  - increase meter sensitivity **A**.
  - B. permits shunts with larger resistance to be utilized
  - C. prevent damage to the meter movement from heat generated by the shunt
  - **D.** enable the construction of a compact meter with a virtually unlimited range
- 40. The output voltage of a 440, 60 hertz, AC generator is controlled by the:

A.	exciter	output	voltage	С.	load	on	the	alternator
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B. prive mover speed D. number of poles

- 41. Any electric motor can be constructed to be:
  - A. short B. ground C. explosion D. overload
- 42. What is the main difference between a relay and a contractor?
  - A. Contractors can handle heavier loads than relays.
  - B. A relay is series connected; a contractor is parallel connected.
  - C. Contractors control current; relays control voltage.
  - D. Contractors are made from silver; relays are made from copper.
- 43. Which of the following is true concerning a polyphase synchronous propulsion motor?
  - A. The motor is started as an induction motor.
  - B. Resistance is gradually added to the rotor circuit.
  - C. The starting current is held below the rated current.
  - D. The field winding is energized for starting purposes only.
- 44. Where a thermal-acting breaker must be used in an area of usually high, low, or fluctuating temperatures, an ambient compensating element must be used consisting a:
  - A. second bimetal element
  - B. conical spring on the contact arm
  - C. cylindrical spring on the contact arm
  - D. second electromagnet
- 45. What could be an application for a silicon controlled rectifier?
  - A. to provide power for a main propulsion motor
  - B. for use as a voltage reference diode
  - C. for sensing flame is an automated burner
  - D. to eliminate power supply hum
- 46. When using an ohmmeter to identify a short, the ohmmeter reading should indicate:
  - A. zero C. 100 kilohms.
  - B. infinite D. 1 megohm
- 47. An accidental path of low resistance which passe: ... abnormal amount of current is known as a/an:
  - A. open circuit C. polarized ground
  - **B.** short circuit D. ground reference point
- 48. An unknown resistance in a circuit is to be tested using the voltmeter method. The meters should be connected such that:
  - A. the ammeter is in series and voltmeter is in parallel with the resistance
  - B. both meters are in parallel with the resistance
  - C. both meters are in series with the resistance
  - D. the ammeter is in parallel and the voltmeter is in series with the resistance

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49. How is the DC output obtained from a brushless exciter?

- A. from collector rings mounted on the armature
- B. from the semiconductor rectifier mounted on the exciter armature
- C. directly from the commutator by indication
- D. from a semiconductor rectifier mounted on the stator
- 50. In general, *polyphase* induction motors can be started on full line voltage by means of \_\_\_\_\_\_ starters:
  - A. across-the-line C. compensator
  - B. autotransformer D. primary-resistor
- 51. The speed of a synchronous motor is varied by:
  - A. changing the voltage of the system
  - B. changing the input frequency
  - C. interchanging any two of the three live leads
  - D. increasing the field excitation.
- 52. The frequency of an AC generator is adjusted by means of the:
  - A. equalizing reactor C. main alternator files rheostat
  - B. exciter field rheostat D. prime mover governor control
- 53. The true power indicated by the pointer movement of a wattmeter depends on the current through the load, the magnitude of the potential across the load and the:
  - A. power factor of the load C. inertia of the movable coil
  - B. angle of coil displacement D. high resistance from the load.
- 54. Which section of an emergency switchboard supplies power for alarm signals under emergency conditions?
  - A. the 120 volt, 3 phase, 60 cycle bus
  - B. the generator and bus transfer section
  - C. the 450 volt, 60 cycle, 3 phase bus
  - D. the 24 volt, DC bus
- 55. Which insulation will begin to deteriorate first as a result of heat generated in the conductor it surrounds?
  - A. vanished clothes C. rubber
  - B. asbestos D. silicon
- 56. Which could you use to locate a grounded field coil in a synchronous motor?
  - A. voltmeter

C. frequency meter

B. multimeter

D. megohmeter

57.	When the operating handle of a molded-case circuit breaker is in the mid-position it indicates that the circuit breaker is:							
	Α.	off	B. or	)	C.	trip	D.	reset
58.	Arr of +	illiameter with or -2%. A met	a full sca ter readin	ale deflections of 10 mill	on rea liamp	ading of 100 millia eres would indica	ampere te a lin	s has an accuracy e current between:
	А. В.	9.8 and 10.2 8.0 and 10.0	milliam; milliam;	Deres Deres	C. D.	9.8 10.0 milliam 8.0 and 12.0 m	iperes illiampe	eres
59.	Wh	en the current	through	a copper	wire	increases, its		
	<b>A.</b> B.	temperature conductivity	will incre will incre	ase ase	C. D.	insulation will be resistance will c	urn Jecreas	e
60.	Whi	ich type of flux	x should	be used v	when	soldering wire c	onnect	ion?
	<b>A.</b> B.	Rosin flux Solid flux			C. D.	Acid flux Silver flux		
61.	Wh	en placed in a	magnet	ic field, wh	at m	aterial will have t	the hig	hest permeability?
	А. В.	glass bakelite			C. D.	aluminum soft iron		
62.	A s	hore power ci	rcuit brea	aker should	d be	closed only		
	<ul> <li>A. in a shipyard</li> <li>B. when the ship's generators have been removes from the bus</li> <li>C. when the ship's generators have been paralleled to those on shore</li> <li>D. if a quick disconnect coupling is used</li> </ul>							us on shore
63.	Whi met	ch meter uses er movement?	s a shun	t connecte	d in	series with the lo	bad and	d parallel with the
	А. <b>В.</b>	power factor ammeter	meter		C. D.	voltmeter wattmeter		
64.	Whe and	en using an oh reverse bias	mmeter t direction	o test a dio s.	de, y	ou find a low resis	stance i	n both the forward
	А. В.	open diode good resistar	nce quali	ty	<b>C.</b> D.	high power ove good capacity o	rspeedi Juality	ng
65.	The circ	purpose of th uit in the ever	e reverse nt of	ed power r	elay	in ship's service	alternat	tor panel is to trip
	<b>A.</b> B.	alternator mo main circuit d	otorizatior overload	1	C. D.	high power over generator overs	rspeedi peeding	ng J
66.	An inst	internal resista rument?	ince wou	ld be place	əd in	series with the n	neter m	ovement of which
	А. В.	AC ammeter main circuit o	overload		<b>C.</b> D.	DC voltmeter generator overs	peeding	9

<u>a</u>

# PART III

# STEAM BOILERS, ENGINES, TURBINES, INTERNAL COMBUSTION ENGINE.

THEORY, OPERATIONS AND MAINTENANCE

# **STEAM BOILERS**

#### Q. What are the two types of boiler base on their working principle?

Fire tube – consist of large tubes for low pressure heating plants and the product of combustion pass through the inside of the tubes, and outside the tubes is sorrounded by water.

Water tube – constructed with small tubes and efficient production of higher steam pressure, where the water is contained inside the tubes, with product of combustion passing around the outside of the tubes.

#### A. USE OF STEAM ON MOTOR VESSEL

- 1. Heating duties: ME Fuel oil heater, Purifier heater, Oil tank heating, Cargo heating, Air conditioning and heating plant, Calorifier, Galley supply, sea-chests, tracer lines for pipeline heating, etc.
- 2. Run Turbine Generators
- 3. Run Cargo pump turbines in Tankers
- 4. Drive steam driven deck machineries like winches, etc.
- 5. Operate bilge, stripping and other steam driven pumps
- 6. Drive boiler feed pump turbines
- 7. Evaporator/Fresh water generator heating media
- 8. Tank washing in tanker ships and general cleaning
- 9. For boiler Soot blowing and for the steam atomised burners
- 10. Fire fighting as used in steam smothering system
- 11. Main engine Jacket F.W. preheater and lub oil sump and drain tanks
- 12. Use in the waste oil, incinerator, slop tanks
- 13. Use as a steam ejector media for ejector pumps and vacuum devices
- 14. Main turbine propulsion (IF Turbine ship), etc.

# **CLASSIFICATION OF BOILERS**

Classification Criteria	For Steam ships	For Motor Ships	Additional Information
Capacity	High Capacity 100,000 kg/hr	Low or Medium Capacity 1,000–5,000 kg/hr	Units in tons/hr or, kg/hour
Pressure	High Pressure 60 bars and above	Low Pressure 6-15 bars Medium Pressure 17-30 bars	Low pr. on most motor vessels; Med. Pressure used on tankers
Shape	Drum Type, D-type	Cylindrical, Vertical both of Tank type or, D-type on tankers	Package, Tubular, Coil type are other shapes for Low pr. units
Usage	Main Propulsion Boiler or Mn Blr	Auxiliary Boiler; Donkey boiler	Assist Propulsion Hotel Purpose
Type of fuel used	Heavy fuel oil, Gas	Light Diesel, Heavy fuel, Gas	Coal, Electric, Exhaust Gas
Working Principle	Water tube	Firetube, Watertube	Steam raising method
Circulation Type	Natural	Natural Forced	Tank & Drum; Exh Gas, Coil

#### **BOILER TYPES**

Main Boller – Propulsion of the vessel.

Auxiliary Boiler – Aids the propulsion in some way; e.g., heating of heavy fuel oil using a steam heater, necessary for propulsion would qualify the supplying boiler to be referred to as an auxiliary boiler.

**Donkey Boller** – A boiler which is used only for the "hotel" needs of the ship; e.g., supplying hot water to the galley.

**Tank Boiler** – A boiler with large water carrying capacity where the shell is being used as the pressure vessel. Most low pressure auxiliary boilers will come into this category.

Vertical Boiler – Any boiler where the shell is upright and the furnace is usually contained within the shell at the lower half.

Horizontal Boiler – This is also referred to as cylindrical boiler; here, the boiler cylindrical shell is lying across its length parallel to the structure of the ship or the ground level.

Exhaust Gas Boller – Boiler operated by hot gas from engine or other exhaust gas sources. Drum Type Boiler – Water tube boilers employing steam and water drums. They are also known as bent tube type boilers.

**Package Boller** – Fully automatic, low capacity boilers packaged inside a box type casing, capable of quick steam production and flexible in being positioned anywhere; could be coil type or firetube type.

#### Q. Give the advantages and disadvantages of a Firetube

# Advantages of Firetube Boller:

- 1. Firetube boiler can use impure water, without serious damage.
- 2. They contain a large amount of water, and do not require exacting supervision as regards to water level. Also steam pressure is steadier.
- 3. Their first cost is relatively low.
- 4. They are accesible for maintenance.
- 5. Because fire is on the inside of boiler and is surrounded by water radiation losses are lower.

# **Disadvantages of Firetube boiler:**

- 1. Because they contain a large amount of water, they require a long interval of time to raise steam and are not flexible as regards to changes in steam demand.
- 2. They are most susceptible to explosion, and in such as a case, the large volume of escaping water flashing into steam upon reaching the atmosphere might cause serious damage to personnel.
- 3. High steam pressure would require extremely thick boiler plate, and thus firetube boiler are not usually capable of producing steam at high pressure and temperature.
- 4. They require large entrance into the fire room because they are generally riveted in the boiler ship and shipped in large section.
- 5. Typical efficiency is less than that of water tube boiler.

#### Advantages of watertube boiler:

- 1. They can produce steam at high pressure and temperature.
- 2. They are very flexible as regards to changes in steam demand because of their small volume of water.
- 3. Permit use of heat reclaiming devices and so are very different.
- 4. Steam pressure can be raised in a relatively short time.
- 5. They are not liable to explosion.
- 6. They are assembled in the fire room, and so large entrance into the fire room are not required.

#### Disadvantages of water tube boiler:

- 1. They must use pure water.
- 2. They must receive constant supervision as regards to steam pressure and temperature.
- 3. Boilers must be heavily insulated to minimize radiation losses.
- 4. To make repairs on tubes, boilers must be emptied.
- 5. First cost is higher than that of scotch boilers.

# SOME EXAMPLES OF POPULAR BOILER IN INDUSTRY

Medium Pressure: Water tube, Drum Type	Low pressure: Package Coil type, fire tube type	Low Pressure: Tank type Oil fired/ Composite	Low Pressure: Exhaust gas Forced circulation
Tanker Vessel	All types of vessels	All Types of vessels	All types of vessels
Babcock & Wilcox M11, M11M	Cochran Chieftain	Aalborg AQ3,AQ9,AQ12 AQ5,AQ2,AQ7	Aalborg AV series
Foster Wheeler D4	Steambloc	Sunrod CPH,CPDB	Sunrod PL,PT
Combustion Engineering	Stone-Vapour	Osaka Howden– Johnson	
Kawasaki	Clayton	Hitachi Zosen HV	
Aalborg AT4, AT8	Miura VWS	Spanner Swirlyflo	
IHI: ADM-6		IHI-CV	
		Cochran	
Mitsubishi- MAC		Mitsubishi MC, MC–C	

#### List of Boiler Mountings and Functions of Each.

**SAFETY VALVE** – Protects the shell or drum against excessive pressure from building up in a steam boiler, thus guarding the boiler from explosion.

MAIN STEAM STOP VALVE – Allows steam to leave the boiler to go into the main steam line, and from there, to the main engine or turbine.

AUXILIARY STEAM STOP VALVE – Allows steam to leave the boiler to pass into the auxiliary steam line, and from there, to pumps, generators, and other auxiliaries.

**WATER COLUMN** – Provides a stilling space so that its water level will not be greatly affected by pitching and rolling of the ship. Water in the column is cooler than that in the boiler shell or drum. Thus, no actual boiling takes place in the column, and the water level is more easily detected.

**GAUGE GLASS** – Attached to the water column or to the drum and indicates the level of the water in the boiler.

**TRY COCKS** – attached to the shell or to the water column, and are used to prove the reading indicated by the gauge glass.

SURFACE BLOW VALVE – Allows light impurities, such as oil or grease, to be blown off from the surface of the water in the boiler.

**BOTTOM BLOW VALVE** – Allows sediment to be blown off from the bottom of the boiler. It also allows a rapid reduction of the water level or a partial emptying of the boiler.

**SALINOMETER COCK** – Allows a sample of water to be drawn off from boiler so that the density of the water may be measured.

**MAIN FEED-WATER STOP VALVE** – Permits or prevents entrance of the feed water into boiler from the main feed-water line.

AUXILIARY FEED-WATER STOP VALVE -- Has the same function as the main feed-water stop valve, but is located in the auxiliary feed-water line.

MAIN FEED-WATER CHECK VALVE – Regulates the flow of water into the boiler from the main feed line and prevents water in the boiler from backing up in the main feed line in event of failure of the main feed-water pump.

AUXILIARY FEED-WATER CHECK VALVE – Has the same function as the main feedwater check valve, but is placed in the auxiliary feed-water line between the auxiliary feed stop and the auxiliary feed-water pump.

AIR VENT – Allows air to be released from the boiler prior to cutting in the boiler on the line, and to break the vacuum when the boilers is being emptied.

WHISTLE VALVE - Furnishes steam for the ship's whistle.

PRESSURE GAUGE - Indicates pressure being carried in the boiler.

**FUSIBLE PLUG** – Installed on Scoth boiler use to give alarm when water became too low, made of bronze and melt, steam passes activate alarm.

BELLY PLUG – Fitted on scotch boilers for the purpose of allowing water to drain from the boilers into the bilges.

**HYDROKINETER VALVE** – Found only on scotch boilers, and supplies steam to the hydrokineter, which is used to speed up circulation and cause even heating of the boiler when the latter is started up from cold.

# Q. What are the additional accessories of modern marine boilers?

**ECONOMIZERS** – An economizer is a boiler accessory that utilizes the heat in flue gases to increase the temperature of feed water before that feed water enters the boiler drum. It's construction either single loop or continuous loop type with header for expansion and maintenance repair.

Advantages:

- a) A saving in fuel from 5 to 18 percent results.
- b) Reduction in thermal shock. The higher the temperature of feed water, the less will be the contraction stresses upon the injection of water into the hot steam drum.
- c) Increase in storage capacity. The large quantity of water contained in an economizer provides reserve space in the event of a sudden boiler overload.

**Disadvantages:** 

- a) Original cost is high
- b) Increased maintenance costs
- c) Space occupied by the economizer also needed.

**AIR HEATERS** – Air heaters are often installed on modern boilers to heat the combustion air before the air enters the boiler furnace. The most common type consists of tubes secured in a tube sheet at each end. A forced-draft fan, mounted at the top of the boiler, forces air through the top half of the tube bank in one direction and then through the lower half of the tubes in the opposite direction. The hot air then travel through an air duct outside of the boiler proper, along the side, and then under the furnace floor, delivered to furnace chamber.

Advantages:

- 1. It increases boiler efficiency, since the stack temperatures are reduced.
- 2. It increases furnace efficiency, since hot air increases furnace temperature, which promotes better combustion.

**SOOT BLOWERS** – are often installed on economizer to keep the tubes free from carbon, soots coming from exhaust gas of the engine. It also fitted on modern marine boiler located in generating tubes, superheater tubes, and air heater in order to maintain the working effeciency of heat transfer thereby producing a better output of the boiler operating performance. It uses desuperheated steam for better cleaning method which start from topair heater - economizer - superheater and generating tubes, for free passage of burned gases from furnace to funnel to prevent soot fires.

### SMOKE INDICATOR

This is apparatus usually consist of a series of mirrors so located that the firemen can easily see the condition of the stack. A strong lamp being placed on one side of the uptake to the side is parallel leading to boiler control room.

#### Q. What are boiler mountings founds on a modern water-tube boiler and function.

STEAM DRUM – a cylindrical forged steel with both end fitted with manhole cover for repair passage. Inside the drum mounted with internal fittings like drypipe, surface blow line, feed water line and desuperheater on higher pressure boiler. On typical low pressure water tube boiler same mountings on outside connection like safety valves, main and auxiliary steam stop valves, pressure gage, air valve, water level gage, surface blow valve, main and auxiliary feed valves.

**WATER DRUM** – its main function are to equalize the distribution of water to the generating tubes and to provide space for the accumulation of scale and other solid or sludge which was blown out by bottom blow-valve.

**DOWN COMER** – consist of nipple tubes connected between steam drum and front section headers, where water leaves the drum, passes to headers for expansion without strain occur.

**DRY PIPE** – A dry pipe is a perforated or slotted pipe placed in the higher part of the steam space of a boiler to prevent priming. The steam outlet valves are connected to the dry pipe. The steam must pass down through the holes (or slots) into the dry pipe on its way to the steam valves. On making these turns, the moisture in the steam is thrown off by inertia.

**WATERWALL** – A waterwall consists of a series of vertical or inclined water tubes installed along one or more walls of the combustion chamber and exposed to direct radiant heat of the fire. These tubes are connected directly, or through headers and connecting nipples, to the circulatory system of the boiler.

Two purposes are served by the waterwall: (1) Added heating surface and boiler capacity are secured. Revamping and adding waterwalls to an existing boiler may even double its capacity. (2) Maintenance of the refractory wall is reduced greatly.

**FURNACE** – It provide space in which the fuel and air mix and atomize thus creating perfect combustion. It also increased total heat transfer to the sorrounded water wall and generating tubes.

**FURNACE REFRACTORY** – is made of bricks or tiles fitted around lower base header in order to maintain furnace temperature thus providing good combustion. It also serve to transfer hot combustion gases through the bank of generating tubes and preventing heat from escaping to the atmosphere thereby maintaining boiler efficiency.

**SUPERHEATERS** – One of the most important mounting on a modern boiler where it receives steam from drypipe and this steam, being heated by combustion gases passing around outside of the tubes, thereby increased in temperature but pressure remain constant. Consist of first and second stage rows of superheated installed near the furnace but protected by rows of screen tubes in order to avoid direct contact of heat. Prime purpose is to use on main turbine engine thus eliminate erosion on turbine bladings, prevent condensation in steam lines, carry-over, less steam consumption thus increases plant capacity. Superheaters also fitted with safety valve, to be set lower than the safety valve on boiler drum.

**DESUPERHEATER** – installed only on high pressure boiler, where superheated steam passes through piping to tubes that are immersed in the water space of steam drum, to reduce the temperature equal to saturation steam to the drum for auxilliaries equipment like cargo pumps, soothblowers, feed pumps etc. which use only low temperature steam.

GAS BAFFLES – usually fitted on three way pass boiler, used to divert the path of combustion gases from furnace to uptake.

STEAM BAFFLES – to prevent steam coming back through return tubes from blowing directly into the water in the steam to avoid turbulence effect.

SCUM PAN – fitted on steam drum where surface blow valve connected, to collect the floating impurities such as oil, grease to overboard.

### Q. What are the requirements of efficient oil burning in a boiler?

- 1. Proper amount of fuel
- 2. Proper amount of air
- 3. Proper atomization
- 4. Proper fuel and air temperature
- 5. High furnace temperature

# Q. What are the methods by which the rate of combustion is varied to meet changed in the steam demand?

The rate of combustion may be varied by changing the following:

- 1. The size of the atomize used.
- 2. The number of atomizer used.
- 3. The oil pressure used.
- 4. The fuel oil back pressure.

#### Q. What are the causes of excessive oil temperature?

- 1) Insufficient oil circulation
- 2) Improper viscosity of oil
- 3) Overloading
- 4) Overheated bearings
- 5) Jacket cooling system not effective
- 6) Late burning of fuel
- 7) Sludge coating on the crankcase
- 8) Oil cooler clogged.

#### Q. What two parts does a burner consist? What is the function of each part?

The burner consist of two parts:

- 1. Atomizer it is used to atomize the fuel into tiny spray which completely fill the furnace opening in the form of hollow cone.
- 2. Air register it allows entry of a strong blast of whirling air which catches the fuel fog, mixes with it and enters the furnace where combustion takes place.

# Q. State four operating condition that decrease the life of the furnace refractory linings.

The life of refractory lining of furnace is influenced by:

- 1. The high sustained furnace temperature
- 2. Rapid changes in temperature
- 3. Vibration or panting of the boiler
- 4. Flame impingement.

#### Q. What causes panting in a watertube boiler?

- 1. Defficiency of air
- 2. Excessive oil temperature
- 3. Poor fuel-air mixture.

#### Q. What information is found on the name plate of a boiler?

Inspection Bureau Number; Tensile Strength () lbs. per sq. inc. (p.s.i.); Hydrostatic test () p.s.i.; Original Working Pressure () p.s.i.; Built By; Steel By; Date and Inspector's Initial.

#### Q. What information is stamped on the body of a safety valve?

Name or registered trademark of manufacturer; Serial number; Inlet diameter; Operating pressure; Discharge capacity; Safe working pressure and Blowdown in psi.

#### Q. How would you make a hydrostatic test on a boiler?

- 1. Clean the boiler thoroughly both on the fire sides and the water sides.
- 2. See that all workers are clear.
- 3. See that all foreign matter, tools, rags, etc., are removed from the boiler, and close up the manholes and handholes.
- 4. All valves on the boiler must be in good condition. All valves except those through which the water for the test is to be let into the boiler should be closed.
- 5. The main steam line may be tested along with the boiler. In this case, it may be necessary to put a blank at the far end of the line immediately before the throttle valve to the main engine or auxiliary engines. If there are two stop valves in the line, it may be unnecessary to blank off the line.
- 6. Hydrostatic pressure should not be put on one side of a valve which has steam pressure on the other side. This is important when steam is up on one boiler or on a donkey boiler while another boiler is being given a hydrostatic test. Blanks have to be used if there are not two valves on the line. Two valves may be considered sufficient.
- 7. Provision must be made for a test gage
- 8. The safety valves must be gagged.
- 9. The air vent (air cock) at the top of the boiler must be left open until water runs out of it. Then it may be closed.
- 10. The pressure, applied by means of a pump, must be applied and released slowly.
- 11. A hydrostatic test must never applied to a hot superheater or boiler.

#### Q. What is the procedure in lay-up the boiler?

*Wet storage:* Used for short lay-up of less than a month and the boiler is maintained in a stand-by condition. Not suitable for boilers exposed to freezing conditions.

The boiler is completely filled with hot distilled de-aerated alkaline water. The water should overflow through the vent during filling-up. Daily checks are necessary to ensure fullness and alkalinity are maintained.

**Dry storage:** Used for longer lay–ups of more than a month. The boiler is completely dried out using heaters or on light fire or passing hot air through the boiler parts. When dry completely, all the boiler outlets are sealed tight after placing dehydrant (such as Silica gel at the rate of 2.7 kg/cu. metre) inside the boiler.

#### Q. What is the meaning, function of the following terms?

**Boller Capacity** – is the amount of work a boiler can produce a steam expressed in pounds per hour designed to generate.

**Priming** -- carryover of entrained water with the steam into the engines that affect the turbine blade, break cylinder heads, piston, valves.

*Flareback* – mostly occur during initial firing or attempting to relight a burner from a hot brickwall without proper purging caused by explosion of mixture oil vapor or gas in the furnace.

*Water Hammer* – consist of condense moisture in a steam line, which form slug ahead of steam flowing through that produce sounds like a hammer hitting a metal against elbows, fittings, valves. It can be prevent by draining and slow pre-heating of line by opening by-pass valves.

**Foaming** – a process condition of producing steam bubbles from the water level in a boiler to the steam space cause by oil presence that feed water carried over from machinery.

*Pitting* – is a form of local corrosion usually found on boiler water line system.

*Grooving* – usually found around seams rivets head or where the metal has been bent or strained.

*Carry-over* – consist of particles of water leaving the boiler with steam caused by high alkalinity, high disolved suspended solids.

*Gag* – a special clamp tools for holding the safety valves closed during a hydrostatic pressure test.

**Accumulation Test** – the actual test of the ability of the boiler safety valves to relieve the boiler of all the steam that generate during firing at full capacity. Firing time for firetube boilers forced to maximum capacity is 12 minutes while water tube boiler is 7 minutes, not exceeds 6% above maximum allowable working pressure.

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*Hydrostatic test* – filled up with water and pressure build up to boiler, to determine wether the boiler is tight and capable of safety holding its working pressure.

*Combustion* – is the rapid combination of oxygen with fuel, accompanied by the evolution of fire.

*Rate of Evaporation* – the amount of water evaporated into steam per square foot of heating surface per hour.

*Rate of Combustion* – the amount of fuel burned per square foot of heating surface per hour.

*Tensile Strength*— is the ability of material to resist stresses of tension, such as stretching or pulling it apart.

*Yield Point*—sudden yielding of the material while under tensile stress, without any increase in load.

*Elastic Limit* – is the maximum stress to which the material can be subjected without causing its permanent deformation.

*Elongation* – is the increase in length of specimen under tensile stress.

*Galvanic action* – is a form of corrosion in which the metal is eaten away by the galvanic action on non-homogeneous parts of iron and steel.

*Caustic Embrittlement* – made of molecules that produce on metal which usually occurred on riveted joints with higher concentration of alkalinity and mechanical stress.

*Corrosion* – is the process of deterioration on wearing away of some of the metal parts, for which exists in three forms, pitting, rusting or wearing and grooving. Two types of corrosion are general and local corrosions.

*Ductility* – is the property of a material which allows it to be drawn, by pulling on its ends to a smaller diameter.

*Factor of safety* – is the ratio of the ultimate strength of a material to its maximum working stress.

**Annealing** -- consist of allowing material to cool, after forging or rolling, to a temperature below the critical range, reheating it to proper temperature to refine the grain, and the allowing it to cool in the furnace.

*Normalizing* – same method to annealing except that after reheating to refine the grain, the material is allowing it to cool in the air.

*Riveting*—method of joining metal plates. A cylindrical length of metal, called rivet, is placed into holes drilled in the two plates to be joined, then each of the rivet is forced into a shape of larger area than the cross section of the rivet shank.

# SAFETY VALVES

The function of a safety valve is to prevent excessive pressure from building up in a steam boiler, thus guarding the boiler against possible explosion.

# **TYPES OF SAFETY VALVES**

Ordinary lift; High lift; Improved high lift; Full lift; Full bore; Pilot-operated; and Electro-magnetic safety valve.

Example:	Bir. Design Press	=	10 bar
•	Test Press	=	15 bar : + 50%
	Operating Press	=	8 bar
	H. P. Alarm	=	9 bar
	Set Press Safety Valve 1	=	10 bar
	Set Press Safety Valve 2	=	10.3 bar : + 3%
	Closed Safety Valve	=	9.6 bar : 1 - 4%
	Accumulation Press	=	10.6 bar : + 6%

Boilers with a heating surface in excess of 46.4 m<sup>2</sup> must be fitted with at least TWO safety valves.

Safety valves must be set to lift within the designed pressure of the boiler. Since marine boilers have normally two safety valves, the second valve may be adjusted to lift at a pressure of 3% above the boiler design pressure.

Normal blowdown range of safety values: 1 - 4% of set pressure.

To prevent leaking or "weeping" of safety valves, the boiler operating pressure should be lower than the design pressure.

The ideal lift for a safety value is 1/4 of the value (throat) diameter.

# **DESIGN FEATURES OF AN ORDINARY LIFT TYPE VALVE**

- 1. Lift of this type of safety valve will be 1/24 of its throat diameter.
- 2. A split compression ring is fitted to fill the gap between the collar of the adjusting nut (compression screw) and top of the valve cover bush. This prevents any alteration of the valve setting.
- 3. Through slots in the cap and spindle, a cotter can be padlocked in place.
- 4. An easing gear fitted enables the valve to be lifted manually from either a local or remote position.
- 5. Adequate clearances are provided in the assembly so that the valve can open freely.
- 6. A drain from the valve chest avoids the possibility of hydrostatic loads acting on the valve and seizure of the valve due to corrosion.

# **DESIGN FEATURES OF MODERN SAFETY VALVES**

- 1. Increased valve disc area to promote valve lift.
- 2. Single ring blowdown control: Raising the ring towards the valve disc increases the valve blowdown and vice versa.
- 3. Upper and lower adjusting rings: The upper ring controls the valve blowdown and the lower ring promotes the popping action and removes the valve simmer. (The clearance between both these rings control the huddling chamber pressure)
- 4. A back-pressure control valve gives a rough adjustment for the valve blowdown.

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# **PROCEDURE FOR ADJUSTMENT OF SAFETY VALVES ON TANK BOILERS**

1. At least two pressure gauges, whose accuracy has been verified recently, must be made available to give the reading of boiler pressure.

2. Screw down the compression screw on the valves a few turns more than the previous setting.

3. Steam pressure in the boiler raised and the boiler put on banked fire.

4. Slowly bring up the boiler pressure to the desired set pressure of the safety valve being adjusted (adjust only one valve at a time).

5. Slacken the compression screw of the safety valve slowly till the valve blows.

6. Stop firing the boiler, and note down the closing pressure of the valve.

7. Try out again for lifting (floating) of the safety valve to check the set pressure and to make minor adjustments to the compression screw as may be necessary.

8. The valve setting is done with a bit of trial and error procedure and with practice can be achieved fairly quickly.

9. On valves with blowdown control, the blowdown ring is initially set at a particular position as per the maker's instructions and fine adjusted during the floating of the valve.

10. The safety valve adjusted should be gagged (the gag must be finger tight only), and the other safety valve should now be floated and adjusted.

- 11. The gag from the first valve should now be removed.
- 12. Fire the boiler to confirm the satisfactory operation of the safety valves.

13. Split lock rings can now be made and fitted to lock the compression screws in place.

14. Fit back the easing gears and lift the safety valves manually.

# **OPERATING TROUBLES**

<u>Chatter:</u> Metallic hammering sound or vibratory noise. The reasons being bent spindle, improper clearances, loose blowdown ring, improper position of upper and/or lower adjusting ring positions, excessive back-pressure, etc.

**Simmer:** The first leakage of steam before the safety valve pops open, which is allowed within 1.5 to 2% of popping pressure of the valve. Prolonged simmering may be due to improper position of adjusting rings, distorted valve parts, etc. (normal)

**Leakage:** Constant hissing sound. The reasons being damaged seating, defective parts, scale or foreign matter on the sealing surfaces, distortion due to waste steam pipe fitting, interference from easing gear and spindle, etc.

Hang-up: Safety valve fails to re-seat. The reasons being improper blowdown adjustment, mechanical interference from spindle, etc.

# **ROUTINE CHECKS**

a. Check for leakages daily. *Do not stop the leak by over-tightening of the compression screw or gagging the valve.* Try blowing the valve with the aid of easing gear and turn the spindle (if possible, for low pressure boilers only) along with the disc in both directions to dislodge foreign matter or scale from the sealing surfaces.

b. Manually lift the valves (when the boiler pressure is above 75% of working pressure), to check that the valves are operational once a month.

- c. Float the valves on steam every six months.
- d. Overhaul the valves completely once a year.

#### REGULATION

Every boiler is to be fitted with at least TWO independent means of indicating the water level in it; one of which is to be a glass gauge. The other means is to be either an additional glass gauge or an approved equivalent device.

Water tube boilers are to be fitted with TWO systems of water level detection which are to be independent of any other mounting on the boiler. Both the systems are to operate audible and visible alarms and automatic shut-off device.

#### TYPES

- i. Tubular gauge glass
- II. Reflex plate gauge glass
- III. Double plate gauge glass

#### **TUBULAR TYPE GAUGE GLASS**

Suitable for low pressure boilers of design pressure below 17.5 bar.

Safety features include a *steel ball valve* on the water-side connection to shut off the water in the event of glass breaking and a *wire-insert glass cage* to prevent injury to the personnel.

#### **REFLEX PLATE TYPE GAUGE GLASS**

Suitable for boilers of design pressure below 34 bar.

Makes use of the refraction of light so that when illuminated, the series of ribs at the back of the glass plate cause the light rays to be reflected back from the steam space and absorbed in the water space. This gives a bright silvery appearance to the steam space while the water space appears dark. The strong contrast between the two enables the engineer to see clearly the position of water level.

To prevent etching of the glass plate by hot steam, a sheet of mica is to be placed between steam/water space and the glass. Due to the ribs on this glass, the reflex type can not make use of this form of protection, and therefore is not suitable for higher pressures.

#### **DOUBLE PLATE GAUGE GLASS**

This gauge assembly is suitable for use when the pressures are in *excess of 34 bar*, as the flat glass plates can be effectively protected from erosion, by sheets of mica.

The assembly consists of a hollow centre piece fitted with two plates of toughened glass held in place by means of a clamp plate. A louvre plate at the back of the glass directs the light rays at an angle to make the meniscus of the water level glow.

#### **OPERATING INSTRUCTIONS FOR A REFLEX PLATE GAUGE GLASS**

1. Valves and stopping devices to be operated slowly.

2. Turn the glass holder in the desired direction with the aid of rotatable glass holders on the upper and lower connection pieces.

3. Whenever the boiler is put into operation after it has been cleaned, some foreign matter could exist in the shut-off valves. Avoid eventual damage by frequently draining the system via the drain valve.

- 4. Blowing-through procedure:
  - a. Close the steam and water side valves and open the drain valve.
  - b. Blow-through the steam side by opening the upper valve for 1-2 seconds and close.
  - c. Blow-through the water side by opening the lower valve for 1-2 seconds and close.
  - d. Close the drain valve.
  - e. Open both steam and water side valves by turning them slowly.
- 5. Replacement of glass
  - a. Isolate the assembly by shutting-off the steam and water connections and by opening the drain.
  - b. Take off the screws of the glass holder and remove the pressure ledges.
  - c. Remove the glass insert with gaskets.
  - d. Spare glass surfaces to be cleaned thoroughly.
  - e. Install the black gasket, the spare glass with the grooves facing inwards, the red gasket and finally the thin steel sheet.
  - f. Put on the pressure ledges and tighten the screws uniformly starting from the middle and proceeding cross-wise up and downward,
  - g. Heat the new glass slowly by keeping the water side valve shut, the steam side valve crack-open and the drain fully open.
  - h. After about 30 minutes, the screws should be tightened again by applying a torque of 2.4 kp-m.
  - i. The assembly can now be put on load by shutting-off the drain and opening the steam and water side valves completely.
- 6. Reasons for a false water level indication by a gauge glass
  - a. Choked valves and passages on the steam and/or water side by sediment, scale, packing or use of a round glass which is too long.
  - b. Leaky drain valve or proffusive steam and/or water leakages from the gauge assembly.
  - c. Foaming condition inside the boiler.
  - d. Sudden changes in steam demand.

# COMBUSTION AND EQUIPMENT

#### **ROTARY CUP BURNER**

The burner assembly consists of a *rotary cup atomiser*, which is hinged to the air register and the combustion chamber with refractory lining. The rotary atomising cup is fitted on the burner shaft, driven by an electric motor through v-belts.

The fuel oil is metered in the oil *compund regulator* and flows through the oil inlet pipe, the oil nozzle, and the oil distributor into the rotary cup. Here the fuel oil is spread out uniformly by centrifugal force on the inner wall and flows to the edge of the cup where it is thrown off tangentially at high velocity (cup rotates at 4600 to 6000 rpm)

The <u>atomising air</u> (*primary air*) enters between the rotary cup and the cup shroud, where it strikes the oil film directly as it leaves the cup. The oil film is broken into very fine droplets by the impact of the primary air. The primary air flow is controlled by a primary air damper activated by the compound regulator. The primary air is normally directed through a *swirl ring* which rotates the air in the same direction as the rotary cup. A small quantity of primary air (*Tertiary air*) is directed to keep the burner cool during operation.

The <u>secondary air</u> is supplied to the wind box, where the uniform distribution of the secondary air is achieved by a *radial vane ring unit* provided with *fixed guide vanes*. The combustion air is guided into the flame by individually adjustable air vanes.

Correct control of the secondary air is the most important factor which contributes to the high combustion efficiency throughout the *turn-down range* of the burner. Draught control is performed by means of a *secondary air damper* connected to the compound regulator.

#### Primary air

The primary air representing less than 10% of the total air requirements, establishes a stable primary flame. The *primary air nozzle* converts the high pressure primary air into high velocity air, which then flows through *swirl blades*. The swirl blades rotate the air flow in the opposite direction to that of the oil cone delivered by the fuel burner.

#### Secondary air

The secondary air flow, representing about 90% of total combustion air requirements, is used to establish a suspended secondary flame of correct shape and dimensions to suit the furnace shape, as discussed earlier. Swirl vanes deliver the secondary air to the furnace in the desired manner to promote complete combustion.

#### MAINTENANCE

**Weekly :** Clean the rotary oil cup (sharp edge in the front of cup must be clean and smooth without any cuts. Do not use any scrapper or any hard too)

*Monthly*: Check flame scanner for dirt, dust and carbon deposits and clean. (*Caution: If the two cable connections are interchanged, the photocell will not function!*);

Primary & secondary air switches; Test safety interlocks; Clean the igniter tube & electrodes Check the condition of refractory.

Yearly: Clean & lubricate burner motor/shaft bearings. Clean all combustion air ducts.

# **TROUBLE SHOOTING**

Trouble indication	Possible cause	Remedy
No ignition/failure of ignition flame	Ignition burner faulty. Dirty electrodes. Too high sec. air pr <b>ess</b> Faulty burner control. Faulty transformer.	Check oil/air setting Clean/re-adjust. Close air damper. Check & repair. Replace transformer.
Main flame failure during ignition	No pilot flame. Oil v/v not opened. Oil pr/temp – high/low. Blockage in oil system	See above Check air pressure. Check/adjust. Check and rectify.
Unstable main flame	Oil flow/temp too low. Too much primary air. Cup dirty or damaged.	Raise oil flow/temp. Readjust primary air. Clean or replace cup.
Black smoke / incomplete combustion	Improper oil temp/visc. Insufficient air supply. Increased furnace and/or uptake back pressure. Poor quality of fuel.	Check and re-adjust. Check and re-adjust. Clean the gas passage to remove blockage. Can not be eliminated by adjustment.

# PROBLEM

#### Problems in the boiler due to feed water can be categorised as:

- 1. corrosion
- 2. scale formation
- 3. carry-over

# INTERNAL WATERSIDE CORROSION

#### Electrochemical Corrosion

If the hydrogen ion concentration (low ph) is increased, the rate of corrosion would increase since there would be more H<sup>+</sup> ions to receive electrons at cathode.

The metal ion combines with the OH<sup>-</sup> ions to form atoms of ferrous hydroxide which dissolves in the water thus wasting the metal away.

Therefore, electrochemical corrosion cells with cathodic and anodic areas will have a current flow through the electrolyte from anode to cathode and back through the metal from cathode to anode; during this process, material from anode is transferred to the electrolyte resulting in corrosion of the anode.

### FORMS OF ELECTROCHEMICAL CORROSIONS

- 1. General Wastage
- 2. Pitting
  - a. Air bubble pitting
  - b. Scab pitting

#### 1. General Wastage Type Corrosion

General wastage is a term expressing electrolytic corrosion of a more uniform nature rather than selective attack by pitting. It implies reduction in metal thickness over comparatively large areas in a fairly uniform manner. Here, the anodic surface constantly changes position, hence attack occurs over a wide area. If dissolved oxygen is present, the hydrogen polarising layer is destroyed by formation of water and even in the absence of dissolved oxygen, this form of corrosion can take place when water has pH values below 6.5.

#### 2. **Pitting**

Apart from the general wastage type of electrochemical corrosion, another form of corrosion which form pits on the metal surface can be termed under corrosion due to differential aeration, oxygen absorption or simply pitting type corrosion. There are types of pitting corrosion:

(a) Air bubble pitting – found in the roof of steam drum in the boiler. In the air bubble type pitting, an electrolytic action is initiated between the oxygen reach surface under the bubble and the surrounding water areas which are less rich in oxygen. By experiment it is found that if a portion of a metal becomes partially inaccessible to oxygen, it becomes anodic and so, differential oxygen levels on a surface can give rise to active corrosion cell.

The ferric hydroxide as the corrosion product settle over the bubble, forming a semipermeable membrane which permits free passage of ions but not oxygen. When oxygen gets exhausted, a reversal of galvanic currents occur, thus causing the metal under the "cap" less noble and hence highly localised corrosion proceeds.

(b) **Scab** pitting – A hard cap of corrosion product occurs in hotter areas of generating surface; mostly found on the side of the fire row tubes. The hard, black scab is difficult to detect, remove and arrest, once initiated.

# SCALE FORMATION IN BOILER & TREATMENT OF BOILER WATER

#### SCALE FORMATION IN BOILER

Scale forms in boilers due to the presence of various salts which come out of solution and deposit because of the effects of temperature and density.

When steam bubble forms on a heating surface, the evaporation of water involved causes local concentration of solids, some of which do not re-dissolve when the bubble escapes, but remain, to form small circles of crystals on the surface. Repeated formation of these, build up the scale deposit, often forming in a series of layers of different compositions. The rate of scale formation increases by the presence of corrosion products and oil. The latter will not only increase the rate of scaling, but also give further insulating effect.

# **Composition of scales**

Chemical analysis shows that the chief constituents of hard scales are calcium suphate, and calcium and magnesium silicates, while the softer loose sludge is composed mainly of calcium carbonate and magnesium hydroxide. Corrosion products of iron and copper are also found in scales.

## Effects of scaling

1

The serious results caused by scale deposition are:

- i) The efficiency of the boiler reduces due to poor heat transfer across heating surface.
- ii) Lack of proper heat transfer, may cause overheating of tube metal with possibility of distortion and failure, in effect reducing the factor of safety of the boiler.

# NATURE OF SCALE FORMING DISSOLVED SOLIDS

Dissolved solids in the water which can lead to the formation of deposits can be divided in the three hardness groups:

a) Alkaline hardness: or temporary hardness, is due to the bi- carbonates of

Calcium (Ca) & Magnesium (Mg), which are slightly alkaline in nature. These decompose upon heating, forming  $CO_2$  and corresponding carbonates which then deposit as a soft scale, or sludge.

 $Ca(HCO_3)_2$  \_  $CaCO_3 + CO_2 + H_2O$ 

b) Non-Alkaline Hardness Salts: also known as permanent hardness salts, are due to the presence of sulphates, chlorides, nitrates and silicates of calcium and magnesium.

With the exception of silicates and the calcium sulphate, the permanent hardness salts are all very soluble in water and do not normaly produce scale, but they are electrolytes and their presence, therefore, favours corrosion by galvanic action.

*Calcium Sulphate (CaSO)* is the worst scale forming agent in the water, depositing as a thin, hard gray scale at temperature above 140 deg. C, or at densities above 96,000 ppm.

Solubility of this salt decreases with a rise in temperature of the water. When a steam bubble is formed on the heating surface the evaporation process causes a local concentration of solids in the water surrounding the bubble. In the case of CaSO<sub>4</sub> saturation point is very quickly reached and this solid precipitate forms a hard grey scale on the heating surface

*Magnesium Chloride* is soluble under normal boiler conditions but can to some extent breakdown inside the boiler to form magnesium hydroxide (which deposits as a soft scale) and hydrochloric acid-this can set up an active corrosion action with the boiler metal.

 $MgCL_2 + H_2O = Mg(OH)_2 + HCI$ 

**Calcium carbonate,** which is an alkaline hardness salt, by itself, deposits as a white sludge but with  $CaSO_4$  present, form a composite scale of carbonate and sulphate. Greater percentage of carbonate makes the scale progressively softer.

Silica – is found in most water and is also present in the plant, especially when new, from erection detritus (dust particles), casting sand and welding flux. In low pressure boilers  $SiO_2$  combines with Ca and Mg to form calcium and magnesium silicates which can precipitate, and form hard scale. In high pressure boilers, silica volatilizes with steam and deposits in turbines, causing severe loss in efficiency; the silica scales are glassy, extermely hard and difficult to remove. At high peformance boiler, of say 100 bar, must not have silica content over (highest value recommended by Drew Chemicals).

c) **Non-Hardness Salts:** These consist mainly of sodium salts which remain in solution, and do not deposit under normal boiler density. It can come out of solution at very high densities above 225,000 ppm and deposits as a soft incrustation.

Other scale forming salts may be present in the feed water in very small quantities and can be generally neglected.

#### Nature of the scale deposit

The minerals most often found in scale deposits are:

- (a) Calcium carbonate.
- (b) Calcium silicate.
- (c) Magnesium hydroxide.
- (d) Magnesium silicate
- (e) Calcium sulphate.

There is also possibility of getting a large amount of iron and copper in a scale deposit.

Both copper and iron are picked up from the pre-boiler circuit; copper from the evaporator condenser and iron from the service piping and storage tanks.

#### **TREATMENT OF WATER**

Boiler and the feed system has to be treated to inhibit corrosion and scale formation and all possible contaminants in the form of metal salts, gas, oil, suspended particles must be guarded against and this is done by both external and internal treatment. Contaminants that cause most trouble in the boiler:

Co Ext	ntaminants from Sources ternal to the Ship	I SourcesContaminants from SourcespInside the Ship		
1. 2. 3. 4. 5. 6.	Calcium salts Magnesium salts Chlorides Silica Carbon dioxide Oxygen	1. 2. 3. 4. 5.	Oil Iron Copper Carbon dioxide Oxygen	

#### External Treatment

This refers to the treatment given before feed water enters the boiler.

In both high and low pressure systems on board, the boiler feed water used is normally good quality distilled water obtained from evaporation of sea water by the distiller. The evaporation by itself is a process of getting rid of many harmful constituents but the make-up feed produced by the evaporator does entrain some of the salt water particles and produce an acid feed water rich in carbon dioxide. The feed system is also prone to atmospheric contamination at various points of the feed system.

Even a very good quality distillate may not produce a pH of more than 6.5 and would contain certain amount of sea salts of Ca and Mg which may cause problem.

In high pressure systems above 20 bars, a mechanical deaeraton by having a **Deaerator** helps in removing most of the oxygen and the treatment is completed with liquid hydrazine dosing at the deaerator outlet. The problem from CO<sub>2</sub> and acidity is countered by dosing amines (morpholine and monocyclohexylamine or CHM) at another point in the feed system and a mildly alkaline pH condition can be easily maintained.

For a lower pressure system, the feed system is of an open feed type and the dissolved oxygen does not cause a serious problem provided correct alkalinity is main-tained.

The make-up water should be a good quality distilled water with a low T.D.S. and the system normally would have simple feed filters in the hotwell or the cascade tank to keep contamination under control. The hotwell temperature should also be maintained above 60 to 70°C to promote oxygen deaeration through the open vent of the hotwell tank.

In some auxiliary boiler system, raw fresh water make-up is used. This water should be 'soft' and have minimum of 'hardness' salts of Ca and Mg.

But in all auxiliary low pressure system, the boiler may expect to have contaminants of calcium and magnesium salts plus a good amount of harmful gaseous products.

The recommended chemical parameter limits are more generous in a low pressure boiler system due to the low heat rate and lower rates of evaporation prevailing; the temperatures within the low pressure boiler also remains moderate and some of the salts, whose solubility decreases with higher temperatures constitute less of a problem.

The treatment consists of chemical injection into the boiler and regular blowing down to remove the precipitated sludge deposits while keeping the boiler water within a safe density or T.D.S. level.

#### Internal Treatment

This refers to the final stage of treatment given to the boiler water and the chemicals are dosed into the boiler proper for the following objectives:

- 1. Keep boiler water in a slightly alkaline condition and removal of dissolved oxygen and carbon dioxide.
- 2. To precipitate any scale forming salts which may be in solution.
- 3. Keep the precipitated solids in a non-adherent sludge form so that they can be easily removed by blowdown.
- 4. Prevention of carry over and foaming.

The chemicals which are in use, serve the dual purpose of precipitating hardness salts and counteract any acidity that develops in the system. These include sodium hydroxide, various sodium phosphates and sodium carbonate. Apart from the above chemicals for the prevention of scaling and corrosion, other chemicals for conditioning sludge, removal of slight oil contamination, preventing carry over and oxygen scavenging are also added along with the phosphates and alkalis.

# **BOILER WATER TESTING**

Boiler and feed water are tested regularly for Alkalinity, Chloride level, excess phosphate and hydrazine and also for hardness, pH-value and total dissolved solids or conductivity.

The recommended limits of boiler water conditions vary from one maker to the other but remaining generally within the given parameters mentioned in the following pages.

An increase of T.D.S. and chloride value indicates S.W. leakage and the solution is to identify the leakage source and isolate the leakage plus blow down to reduce the dissolved solids.

Low alkalinity requires alkaline chemical dosing in the form of caustic soda or sodium phosphate.

Low hydrazine reserve indicate inferior de-aeration and further need of hydrazone addition.

#### Hydrazine Test

Hydrazine is a volatile compound and highly soluble in water. To safeguard the boiler system from  $O_2$  – corrosion it is continuously added using a dosing pump. The bulk of the  $N_2H_4$  turns into  $NH_4OH$  adding to the alkalinity of the boiler water. However, if too much dosage of  $N_2H_4$  is added, at boiler temp. above 175°C, it can decompose to form ammonia.

Ammonia can attack copper alloys in the condensate system in the presence of oxygen. So, presence of hydrazine in excess of 0.3 ppm should be guarded against.

# **Dissolved Solids**

The basis of this determination lies in the fact that the electrical conductance of water is proportional to the quality and nature of the substance dissolved in it.

Conductivity in microhms per cm at  $20^{\circ}C \ge 0.67 = TDS$  in ppm.

A permanently installed instrument can be used for the above giving direct reading for TDS in ppm. Highly alkaline solutions tend to affect the above reading and for a more accurate result, strong alkalis (Na<sub>2</sub>CO<sub>3</sub>) should be neutralized before the test.

## Methods of Drawing Samples for Testing

Any water samples for testing must be truly representative of the whole, otherwise the results would be misleading.

A sample cooler fitted with cooling coil is very good for this purpose.

Before drawing the sample, water from the boiler is run to waste for a time sufficient to flush out the sampling lines. The collecting vessels should be rinsed twice with water to be tested. Samples should be tested as soon as possible after drawing.

# Problems in Handling Water Treatment and Testing Chemicals

Care should be taken in dealing with all chemicals used in water treatment and testing.

1. *Concentrated Mineral Acids*. Can cause extensive damage to human tissue, specially to the eyes.

2. **Concentrated Alkalis**. Caustic Soda can cause severe damage to human tissue. Substantial heat is release when NaOH is dissolved or diluted and small controlled additions with constant stirring is recommended. Careful handling and storing is important as spillage can cause damage to the ship structure.

Hydrazone is destroyed by contact with air and the fresh sample (after filtration, if required.) should be immediately tested to avoid atmospheric contamination. Use of a sample cooler to obtain water sample between 20 - 30 deg. C is good practice as the sampled water and ambient temperature would be similar.

3. Alkalinity Test. The two part "p-alkalinity" and "Total Alkalinity" tests reveal presence of hydroxyl (OH), carbonate ( $CO_3$ ), and bi-carbonate ( $HCO_3$ ), which are responsible for making boiler water alkaline.

The P-test actually finds the presence of OH, and half of carbonate and the next test picks up the presence of the remaining carbonate and bi-carbonate.

In a sample, OH and  $HCO_3$  cannot be present simultaneously. From the respective readings, a fair judgement can be made of the identity of salts, (e.g. NaOH, Na<sub>2</sub>CO<sub>3</sub>) responsible for alkalinity in the sample.

4. *Chloride Test.* This gives the quickest indication of any salt water leakage into the boiler and must be carried out dailly.

5. **Phosphate Test**. Presence of phosphate in sample means there won't be any hardness salts present. The  $Na_3PO_4$  added to the boiler is very efficient in precipitating all scale forming hardness salts of calcium or magnesium. So with a phosphate test done, there is no need to do a "hardness" test.

6. *pH-Value*.Once the alkalinity has been measured with titration tests, there is no need to check pH-value as alkalinity & pH-value are proportional. However, as a quick reference, a litmus strip can be used using raw sample and colour change compared against the ones given on the litmus case to indicate the possible range of pH.
# RECOMMENDED CONTROL LIMITS

Bollers up to 32 bars	in ppm	Means of Adjustment
Total hardness P–alkalinity (CaCO <sub>3</sub> ) Total Alkalinity (CaCO <sub>3</sub> ) Phosphate Hydrazine Chlorides T.D.S. pH–value Conductivity	< 1.0 100 - 150 200 - 300 20 - 40 0.1 - 0.2 300 500 - 550 10.8 - 11.3 700 mmho/cm	GC GC Adjunct B Amerzine Blowdown

# ADVANTAGES OF CHEMICAL TREATMENT

The focus of any water treatment should be to minimize the above problems and try to:

- a. maintain a clean, scale-free heat-transfer surface.
- b. prevent metal loss due to corrosion.
- c. ensure efficient production of steam without priming, foaming or carry-over contamination.
- d. prevent formation of deposits in steam/condensate systems.
- e. minimize heat loss through excessive blowdown from boilers.
- f. achieve all of the above at minimum cost and best efficiency.

**pH-value** is a measure of acidity or alkalinity in water. p(power) and h(H<sup>+</sup> ion conc.) makes the pH-value which is the logarithm of the reciprocal of the hydrogen ion concentration in water.

ph = 5

H+		OH-
10-5	X	10 <sup>-9</sup> solution acidic.

- $10^{-7}$  x  $10^{-7}$  solution Neutral. ph = 7
- $10^{-9} \times 10^{-5}$  solution Alkaline. ph = 9

# **TEST PROCEDURE**

# 1. CONDENSATE pH TEST: TEST IMMEDIATELY AFTER DRAWING SAMPLE.

- 1. Collect 50 ml cooled condensate sample and pour into dish.
- 2. Add 3 drops phenolphthalein. Sample should turn pink
- 3. Add sulfuric acid N/10 drop by drop until pink color disappears.
- 4. Refer to chart for dosage adjustment.

# 2. HYDRAZINE TEST

Prepare fresh Hydrazine Reagent every two weeks.

- 1. Empty one capsule of Amerzine Reagent A into amber bottle.
- 2. Measure 45 ml of Amerzine Reagent B in a graduated cylinder and add to the powder in amber bottle.

3. Shake to dissolve. Keep tightly closed in a cool place. Alternate Method: Measure 1 plastic spoonful of Hydrazine Reagent A. Measure out and add 45 ml Hydrazine Reagent B.

TEST PROCEDURE: TEST IMMEDIATELY AFTER DRAWING SAMPLE.

- 1. Collect a cooled boiler water sample and fill amerzine test tube to 5 ml mark.
- 2. Add prepared Hydrazine Reagent to 10 ml mark.
- 3. Compare color with standards in block. Refer to chart for dosage adjustment.

# **3. EXCESS PHOSPHATE TEST**

- 1. Collect and filter cooled boiler water to 5 ml mark on phosphate test tube.
- 2. Add molybdate to 17.5 ml mark.
- 3. Add one brass spoonful Dry Stannous Chloride.
- 4. Stopper and mix well. allow to stand 3 to 5 minutes.
- 5. Compare color with standards in block.
- 6. Refer to chart for dosage adjustment.

# 4. PHENOLPHTHALEIN ("P") ALKALINITY TEST

- 1. Collect 50 ml. of cooled boiler sample.
- 2. Pour into dish. Add four drop phenolpthalein.
- 3. Pink color Alkaline. No color- "P" alkalinity zero.
- 4. Add sulfuric acid N/10 until pink color disappears.
- 5. Note the level of acid in buret. Convert ml to ppm using chart at right and record result in ppm as "P" alkalinity. Keep sample for "T" alkalinity test. Refer to chart for dosage adjustment.

# 5. TOTAL ("T") ALKALINITY TEST

- 6. Add 3 drops Total alkalinity Indicator-GP.
- 7. Add sulfuric acid N/10 until pink color develops.
- 8. Note the level of acid in buret. Convert ml to ppm using chart at right and record result in ppm as "Total Alkalinity". Keep sample for Chloride Test. Refer to Chart for dosage adjustments.

# 6. CHLORIDE TEST

- 9. Add one dropper full Potassium chromate Indicator.
- 10. Add silver nitrate N/10 until first permanent yellow to red brown color change.
- 11. Note level of silver nitrate in buret. convert ml to ppm using chart at right and record result in ppm as chloride. Refer to chart to adjuest blowdown.

# 7. CONDUCTIVITY TEST

- 1. SEE METER INSTRUCTIONS.
- 2. Fill cylinder to 100 ml (top) mark with cooled boiler sample.
- 3. Add 2 drops phenolpthalein and mix.
- 4. Add gallic acid to pink sample, while mixing, until color disappears.
- 5. Measure temperature of sample and adjust temperature dial.
- 6. Rotate conductivity dial until both lights remain lighted at the same time.
- 7. Refer to chart to adjust blowdown.

# BOILER WATER TREATMENT - CONTROL AND DOSAGE CHART

Steam Generating Equipment - Up to 32 kg/cm<sup>2</sup> (450 psig, 3200 kN/m<sup>3</sup>)

	MEANS OF ADJUSTMENT	TEST RESULTS (control Limits in Blue) DO	SAGE CALCULATION			
Condensate PH test	SLCC-A Condensate Corrosion Inhibitor	NO PINK WITH PHENOLPHTHALEIN	INCREASED BY 25%			
		PINK COLOR 1-2 DROPS N/10 ACID TO CLARIFY	SATISFACTORY NO CHANGE			
		PINK COLOR-3 OR MORE DROPS N/10 ACID TO CLARIFY	DECREASED BY 25%			
		INITIAL DOSAGE 0.15 LTR (0.3 PT) X TONS=				
		LESS THAN 0.10 ppm ING	REASED BY 25%			
HYDRAZINE	AMERIZINE Corrosion Inhibitor	0.10 — 0.20 ppm	SATISFACTORY – NO CHANGE			
1201		OVER 0.20 ppm	DECREASED BY 25%			
		INITIAL DOSAGE 0.15 LTR (0.3 PT) X TONS=				
	ADJUNCT-B Phosphate Boiler Water Treatment	0 – 10 ppm	30 gm (1 OZ) X TONS			
		10 – 20 ppm	15 gm (0.5 OZ) X TONS			
TEST		20 – 40 ppm	SATISFACTORY			
		40+ ppm	HIGH BLOWNDOWN REDUCE DOSAGE			
		INITIAL DOSAGE 30 GRAM (1 OZ) X TONS=				
		ML SULFURIC PPM ACID N/10				
		0-0.3 0-30	0.15 ltr. (0.3 PT) X TONS			
"P" ALKALIN-		0.4 - 0.7 40 - 70	0.10 kr. (0.2 PT) X TONS			
TEST	GC	0.8 - 0.9 80 - 90	0.05 ltr (0.1) X TONS			
	Concentrated Alkaline Liquid	1.0 – 1.5 100 – 150	SATISFACTORY			
		1.5+ 150+	HIGH, BLOWNDOWN REDUCE DOSAGE			
		TOTAL ALKALINITY TEST RESULT MUST BE LESS THAN TWICE THE "P" ALKALINITY.	IF NOT, DOE 1 LTR (2 PTS) OF GC REGARDLESS OF THE "P" ALKALINITY. TEST AGAIN IN 2 HOURS			

1

			SATISFACTORY BLOWDOWN									BLOWDOWN				
Chloride Test		ml N/10 Silver Nitrate	0.1	0.2	0.3	0.4	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.2	OVER 4.2
		PPM Chloride	7	14	21	28	36	71	106	142	178	213	248	284	300	OVER 300
	Conductivity in µmhos	UP TO 700 µmhos									700 µmhos AND OVER					
Blowdown should be carried out as per boiler man Blowdown is necessary to reduce dissolved an sspended solids are noticed in boiler water sample of chlorides test results. weekly flash blow is advis sludges and to ensure clear operational lines.							ıfact d su s, blo sable	urer' spen wdo to r	s inst ided a wn re emove	ructions. solids. If gardless e normal						

#### NOTE:

#### LIQUID COAGULANT - NO TEST REQUIRED

Daily dosage 28 ml (1.0 Ounce) per day for each ton of water capacity to condition suspended solids (oil and sludge) for removal by bottom blowdown. Flash bottom blow and scum blow several times at 20 minute intervals after dosing the liquid coagulant. Dose for 2 weeks or until oil removal is compete. If severe contamination persists, the possibility of continuing oil leakage should be investigated and eliminated.

#### WASTE HEAT BOILER PROBLEMS AND MAINTENANCE

Problems in exhaust gas economizer can be classified under categories such as:

- a. low temperature cold end corrosion.
- b. fouling of the gas and the water side.
- c. tube failure due to vibration.

**Gas side fouling** could be kept under control by wider tube pitching or in-line fitting of fins on to the tubes and use of regular soot-blowing at individual tube banks. Good quality combustion goes a long way in reducing the amount of soot deposits; although the quality of fuel is constantly deteriorating, proper centrifuging and treatment would be helpful in reducing the harmful combustion products promoting fouling. Many shipping companies use some fuel treatment chemicals to keep the harmful contaminants under control. Tube externals would still get fouled and periodic cleaning by water washing is the most effective way of keeping the tube externals clean. Cleaning is either done through fixed nozzles inside the boiler banks or done through spray nozzles and connecting pipes which are moved around as required. Water at about 60°C should be used for cleaning and precautions should be taken to ensure that the drained water with high acid content do not flow into the main engine exhaust duct. Water side scaling and corrosion is mainly attributed to the poor quality of feed water used. If the water used is alkaline with low T.D.S. and has less contamination from oxygen, tubular boiler tubes should run for long time without giving any problem. But, the water used is normally the water from the open feed system hotwell and scaling/corrosion problem would be impossible to overcome completely. Certain improvements and reasonable running period could however be achieved by keeping the T.D.S. content and chloride level low by regular blowdown and chemical treatment and dosing of appropriate chemicals (e.g., NaOH) would maintain the water in an alkaline condition; oxygen level could be kept within acceptable margin by chemical treatment (hydrazine) and keeping the hotwell temp. high. Certain operational precautions like venting while starting, draining the boiler or keeping it full up, as shutting down would help in reducing corrosion.

Fouled water side could only be effectively cleaned by chemical cleaning.

Tube problem from vibration is sometimes a problem. Modern boilers are made considerably large and takes up a sizable part of the uptake. The supporting box-type casing built on a system of beams are made fairly rigid. If the arrangement is too rigid, problem from fatigue failure is again possible. Heavily stiffened support steelwork and casings do reduce the effect of pulsating gas stream. There is no easy solution to a vibration problem if it starts, but this is a problem better considered at the design stage.

#### Important maintenance steps

- 1. Regular soot blowing
- 2. Maintain good main engine combustion
- 3. Adhere to correct centrifuging and other fuel treatment methods
- 4. Take advantage of additional chemical treatment on the gas side (e.g., soot sticks, etc.
- 5. Correct water treatment and testing procedures
- 6. Maintain right hotwell temperature
- 7. Vigilant watchkeeping, particularly in monitoring exit gas temp from the EGE
- 8. Regular in port inspection and manual/water wash cleaning of the gas side
- 9. Correct operation in terms of circulation, shut down, by-passing, etc.

#### SURVEY AND MAINTENANCE OF BOILERS

Boiler are surveyed to maintain the classification of a ship. Regular internal and external examination during such survey constitute the preventive maintenance schedule the boiler goes through for a safe working condition.

#### FREQUENCY OF SURVEYS

Water tube main propulsion boilers are surveyed at 2 yearly intervals. All other boilers including exhaust gas boilers are surveyed at 2 yearly intervals until they are 8 years old and then surveyed annually.

For auxiliary boilers of water tube type, the classification may allow the 2-year incidence to continue even after the expiry of 8 years period.

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A complete boiler survey allows us to check out if any build-up of deposits has taken place, and deformations or wastage of platework, piping or any of the various parts, which may compromise the safe working order of the unit. The survey should include finding reasons for any anomalies found and should also ensure that any repair carried out does not affect the safe working order of the boiler. A complete survey means full internal and external examination of all parts of the boiler and accessories such as superheaters, economiser, air-heater and all mountings. The examination may lead the surveyor to require hydraulic testing of pressure parts or thickness gaugings of plate or tubes that appear to be wasted and eventually assign a lower working pressure. The collision chocks, seating stools and rolling stays are also to be checked for good working condition.

2.

The survey is not complete until the boiler has been examined under steam and the following items dealt with:

- 1. pressure gauge checked against a test gauge.
- 2. testing of water level indicators and protective devices.
- 3. safety valves adjusted under steam to blow off at the required pressures;
- 4. the oil fuel burning system examined.
- 5. testing of remote control gear for oil fuel shut off valves.

#### **ARRANGEMENT BEFORE SURVEY**

a. Boiler must be sufficiently cleaned and dried to make a thorough examination possible. Sludge deposits continue to be the prime cause of non-operation of internal controls and overheating of furnace in vertical boilers. Boilers should be manually wire-brushed to clean the internal surfaces.

In case of difficulty in manual cleaning, a chemical cleaning with hydrochloric acid plus an inhibitor to prevent acid attacking the metal without affecting removal of deposits is the best procedure.

For oil contamination, alkali boil-out using trisodium phosphate solution (which produces a detergent action) is essential prior to acid cleaning.

A thorough water flushing must be carried out after acid cleaning to avoid acid concentrating in crevices and captive spaces.

- b. All internals which may interfere with the inspection has to be removed.
- c. Wherever adequate visual examination is not possible, surveyor may have to resort to drilling, ultrasonic or hydraulic testing.
- d. All manhole doors and other doors must be opened for a reasonable time previous to survey for ventilation.
- e. If another boiler is under steam arrangement of locking bar and other security devices must be in position preventing the admission of steam or hot water to the boiler under survey. The smoke trunking (separating device), exhaust-gas shut-offs etc. must also be in position and in proper working condition.
- f. Ship's staff or repairer's staff should stand by the manhole in case of emergency and to note any repairs required.

## **SURVEY OF SUNROD CPH TANK BOILER**

Poor condition in this type of boiler may stem from:

- Poor workmanship during construction or repair.
- Deterioration due to leaks or deposits.

- Local overheating.
- Combined effects of mechanical stress and corrosion.

#### Damage condition would show up in the form of

- wastage, 'grooving' or 'pitting' corrosion or
- distortion or
- crack.

### **Survey Routes**

Any boiler to survey, the inspector must plan out a route for his movement. Almost always, the inspection must start at the furnace. The reason being, the furnace reveals the quality of combustion and its effects and any distortion at the crown or the tube walls signifying the problems originating at the water side. In fact, a good clean furnace with no signs of distortion could assure the inspector that the boiler is in good running condition. The next in succession should be the **burner unit**, the bottom header and the boiler bottom. Mounting attachments on the upper shell will follow before entry is made through the manhole to inspect the water side of the steam space. Top mountings will be checked before entering the gas space through the inspection door for a look at the sunrod tubes. The inspection will end with a check on the dismantled mounting parts arranged in order for the purpose. If in doubt of gas side corrosion, checks on the gas uptake could be done as a final step in the survey route.

## I. FURNACE

Overheating distortion on the furnace crown is due mainly to a deposit of oil, scale or sludge deposits on the heating surface or due to water shortage. Direct flame impingement resulting in deformation of the crown or a local bulge in wall tubes opposite the burner opening is also possible. If the lower section of the crown around the U-shaped area is affected, it could be due to the sludge deposits on the boiler bottom causing overheating distortion. In the same area where the furnace U is connected to the shell, there may also be welding cracks due to rapid fluctuation of thermal and mechanical stresses, results of improper starting up/shutting down procedures.

Furnace crowns which have suffered a gradual deformation can be jacked back to their original shape with or without heat. A sharper deformation may require the plating to be slotted so that the metal can extrude into the gap during heating and jacking. The slot is butt welded on completion. A much neater repair is to burn out the affected area and replace with a butt welded insert section cut from a salvaged furnace. For a severely damaged furnace with a pronounced large belly, replacement could be the only answer.

Dry cracks in furnace mouth, crown or the furnace tubes caused by flame impingement is possible due to scale encrustations at the water side and forcing of the boiler. Areas suffering from poor circulations or relatively uncooled areas are also susceptible to the above failure.

Deep cracks on plating should be stopped by drilling a hole at each end, opening up and then welding.

Indifferent feed water may cause pitting of the furnance crown. A careful examination through the bottom manhole door would be required to detect the above "grooving"

Furnace tubes must be inspected for correct alignment and the tubes together must form a circular tube wall: anywhere the tubes are deformed, the furnance shape will show up as missaligned. Distortion to a very small extent could be accepted, but beyond that renewal of tubes will be mandatory.

Furnace tube, if damaged (cracked, holed or deformed) need be renewed with new tubes; only under emergency conditions, one could be allowed to operate boiler at low load, with plugged furnace tubes; plugging could be carried out with tapered steel plugs on each tube ends. The bottom plug will have to be inserted through the bottom header; difficulty in doing that may also compell cutting windows on tubes from the furnance end and manipulating the tapered plug in position (similar to that done in membrane wall boiler panels).

Brickwork protecting the foundation, if damaged, may cause distortion of the bottom plating underneath the furnace. Damaged brickwork need be removed to inspect the bottom plating for distortion before repairs to the brickwork is carried out.

Any sign of corrosion on plating should be chipped clean brushed clear. It is also possible to build up the weakened areas by means of electric welding. Pitted areas are difficult to protect from further corrosion due to the difficulty in maintaining the protective magnetic oxide layer.

#### **II. BOTTOM HEADER**

This contains the furnace tubes and the down comer tubes. No of handhole doors are provided for internal inspection and repairs to the tubes. Inspection for deposits of sludge must be carried out during the survey. Regular blowing down from this header will be necessary to keep it clear of sludge deposits.

#### **III. SUNROD TUBES**

Internal wastage due to waterside corrosion and pitting is the main reason for renewal. It is diffucult to determine the condition of tubes by visual examination and the tubes suffer more at ends towards the fire; A metal rod inserted at the tube ends and worked up or down may reveal a weak tube - a method sometimes employed to tubes selected at random.

The reason for corroded tubes is almost always the bad quality feed used giving rise to heavy scaling and corrosion.

Thermal cracks may develop at the tube ends at the hot gas entry zone.

The elements could be corroded on the outside due to the hot gas containing Sodium (Na) and Vanadium (V), referred to as high temperature corrosion; in this collection of ash containing Na and V may promote melting of oxide deposits across the tubes and cause scoring of metal at the tube externals.

#### **IV. SHELL**

Internal examination is made for cracks, corrossion wastage or deformation of shell plating.

Any oil trace must be removed by alkali-boilout. Corrosion may be expected at positions with poor circulation and places which can harbour deposits.

Pitting corrosion in way of water level to be checked for, specially on idle boilers where liberated dissolved gas was not removed from the boiler with the steam. Boilers left with undisturbed water level for some length of time can develop serious pitting.

External corrosion can be caused by persistent leakage at mounting flanges and manhole or handhole doors. Engine room floor underneath the boiler may have occasional bilge water and possess a damp atmosphere; there may also be oil deposit and stored rags or paints drums; these are all potential hazards.

The wasted shell plating may be reinforced by welding but in case of extensive wastage, renewal of plating is the only remedy.

#### V. SUPPORT AND SECURING ARRANGEMENTS

Attachment between boiler and ship's structure should have adequate provision for expansion. Restriction of movement imposes loads on the connections and if the part is unable to yield or bend, cracking will occur.

Welded attachments such as cradies, feet and rolling stay lugs should always be inspected carefully. Cracks due to stress concentration at the welded connections may propagate into the shell plating.

# VI. MOUNTINGS AND FITTINGS

Major mounting are removed, dismantled and inspected. Gauge glasses, safety valves, feedcheck valves, steam stop valves, are all checked for corrosion, erosion, strength and correct operations. Internal feed and chemical injection pipes are inspected for oxygen pitting and corrosion. Waste steam pipes are hammer tested and all drains in the exhaust system checked. Soot blower nozzles are vulnerable to burning and to be checked for correct sweep pattern. The air registers are to be checked and cleaned. Clearance at the manhole and mudhole doors to be checked and should have a spigot clearance not exceeding 1.5 mm all around. Leakage from manhole doors has been cause of serious shell wastage. Where this is exceeded, the clearance can be restored by building up the door spigot with welding and hand-dressing to suit.

Wastage of manhole landing faces is difficult to rectify by welding – fitting a false sealing ring could be the recommended repair.

A careful check is made for strained door studs, stripped and slack nuts and distorted doors. A badly fitted door can cause a joint to blow out under pressure.

When under steam, the surveyor always checks if manhole doors have been pulled up when hot and the doors are correctly positioned.

Cracks can occur in valve body due to water carry-over and quenching or may originate from shrinkage defects in the castings propagating in service. The only positive solution is to replace the manifold entirely with a similar but fabricated construction. Repair by welding the defects in the steel castings is also possible but this presents the problem of distortion.



# SURVEY ROUTE PROCEDURES

# BOILER OPERATION AND SAFETY

Before the boiler is put into service for the first time, it is to be boiled out for removal of all protecting remedies and impurities in tubes and drums.

# **BOILING OUT:**

- 1. Boiler is filled with a solution containing 4-5 kg Tri–Sodium Phosphate (Na<sub>3</sub> PO<sub>4</sub>) per ton of boiler water capacity.
- 2. Add the chemical through the manhole and top up with water until the solution is just visible in the water level gauge.
- 3. Raise the steam pressure in the boiler to working pressure and maintain the pressure for 6-8 hrs with closed main stop valve, after which fat and other impurities should be boiled from the interior surfaces of the boiler.
- 4. Make sure that the water level is 20-30 mm above the scum funnel and skim off the floating contaminants through scum blow.
- 5. After the boiling out operation has been completed, the water in the boiler is blown out, the boiler internal is flushed. The boiler is now filled with fresh treated water to a little below normal water
- 6. If during service, the boiler shows a tendency to priming, it is recommended to carry out an extra boiling out. In any case, after a period of 2-3 months after commissioning, another boiling out operation is strongly recommended for new boilers.

# POINTS TO NOTE WHILE STARTING A BOILER: (with no "Superheater")

- 7. Check that the boiler is properly closed-up (after repairs).
- 8. Check (physically) that all appropriate valves are shut or open for safe starting of the boiler.
- 9. Boiler filled to slightly below normal level.
- 10. Starting treatment chemicals may now be added to the boiler water.
- 11. Check and clear the furnace of any flammable materials.
- 12. Ensure that the boiler uptake passage is clear.
- 13. Pre-purging of furnace for a specified amount of time is necessary to clear the gas-side of flammable gases, to avoid starting explosion!
- 14. On a cold boiler, the firing-up must not be speeded up too much in order not to overstrain the boiler material unnecessarily by quick, uneven temperature raises.
- 15. Keep the boiler vents open until a heavy steam jet is flowing out (until a pressure of 1-1.5 bar).
- 16. Before the boiler is put on load, blow-through the gauge glasses, test the safety valves using easing gear and try out the safety cutouts.

# POINTS TO NOTE WHILE THE BOILER IS ON LOAD:

- 17. Operate the boiler at a load where its efficiency is the highest.
- 18. Maintain correct air/fuel ratio; under perfect conditions a brownish hazy colour of exhaust smoke is noticed from uptake.
- 19. CO, CO<sub>2</sub>, O<sub>2</sub> contents as monitored in the exhaust gas will indicate the combustion condition inside the boiler.

- 20. Every morning mud is blown from the boiler through the bottom blow-off valves and float chambers.
- 21. Ensure that all safety cut-outs are operational.
- 22. Maintain the feed water quality as recommended by the manufacturer.

# **BOILER DATAS**

	Sunrod CPH-45	Sunrod CPH-5
Capacity	45,000 kg/cm <sup>2</sup>	5,000 kg/cm <sup>2</sup>
Operating Pressure	16.0 bar g	6.0 bar g
Design Pressure	18.0 bar g	18.0 bar g
Feed water temp.	85-90°C	85-90°C
Efficiency (F/Load)	81.4%	85.8%
F.O. Consumption	3,440 kg/h	360 kg/h
Water volume	17.1 m <sup>3</sup>	5.7 m <sup>3</sup>
Outside diameter	4,100 mm	2,600 mm
Height	9,660 mm	5,720 mm
Dry weight	50,000 kg	13,000 kg

#### **BOILER DESCRIPTION**

- 1. Vertical design with 2 combined steel compartments or cylinders
- 2. Lower cylinder contains the furnace
- 3. Upper cylinder used for steam evaporation
- 4. System of piping connects the upper and the lower cylinders for water circulation
- 5. Furnace is water cooled with riser tubes forming the wall
- 6. Ring shaped distribution header at the furnace bottom supplies water to the furnace water call
- 7. The lower end of the upper cylindrical compartment is dome shaped which makes the furnace roof
- 8. The bottom support for the boiler is provided by the support ring and steel plate fabrication
- 9. The support ring is welded to the distribution header
- 10. Flue gas flows through the vertical uptakes
- 11. Vertical uptakes contain sunrod tubes which is connected to the water and the steam place
- 12. Each vertical uptake and its sunrod tubes makes one sunrod element, acting as convection unit
- 13. Flue gas is discharged into flue gas receiver and then to the atmosphere via the funnel
- 14. Downcomer tubes are fitted between the lowermost part of the pressure vessel and the distribution header to improve the circulation

## THE SUNROD ELEMENT

- 1. The sunrod element consists of a plain steel tube, enclosing a Sunrod pin tube
- 2. Large number of steel pins are welded around the outside of the seamless steel pin tube

- 3. The Studs increase the heating surface area and also creates turbulence in the gas flow, thereby improving upon the heat transfer and making the sunrod element more efficient than a conventional plain tubing
- 4. The number of sunrod elements depends on the boiler capacity

# **CIRCULATION AND STEAM RAISING**

- 1. Water circulation is on the principle of natural circulation or density difference of feed water
- 2. Water occupies the pressure vessel, the sunrod tubes, the furnace wall tubes, the downcomer tubes and the distribution header
- 3. Under steady state operation of the boiler, the radiation heat of the furnace will create steam water emulsion within the water-wall and the fluid will rise through the risers into the pressure vessel, drawing from the distribution header
- 4. As water is fed into the risers from the distribution header, a suction is created at the downcomers which feed the header
- 5. The emulsion rises through the furnace roof and into the sunrod elements; the water at the sides of the pressure vessel tends to be denser and flows down to the downcomers
- 6. Rapid evaporation inside the elements and steam bubbles formed and the greatly decreased density fluid rises rapidly in the tube
- 7. The upward flow of water/steam mixture creates a suction effort at the lower end, causing the boiler water to flow into the tube
- 8. The steam/water mixture is discharged into the steam space, where the heavier water particles separate from the steam and fall back into the water
- 9. 50% of the steam generated is through the Sunrod tubes and the rest by radiant heat from the furnace

# **EMERGENCY AND ABNORMAL RUNNING CONDITIONS**

The following are the guide lines for an engineer on duty to respond to emergency situation in a boiler plant:

#### High water level:

- a. Check and reduce firing rate.
- b. Operate blowdown system.
- c. Throttle feed check valves.
- d. If bad water hammer due to carry-over is experienced, close steam outlet valve to prevent damage to pipe lines and machinery.

#### Water level below gauge glass:

- a. Shut-off burner (if not cut-out automatically).
- b. Take the boiler out of load.
- c. Ensure no internal damage due to overheating.
- d. Do not bring-up the water level in haste until the boiler parts are cooled down.

# Tube failure:

Small leak:

- 1. More make-up feed required.
- 2. Drop in total dissolved solid content of feed water.
- 3. Difficulty in water level maintenance.

# Large leak:

- 1. Water level vanishes.
- 2. Bursting noise.
- 3. Drop in steam pressure.
- 4. Flame may be put-off by steam.

# Actions:

- 1. Put off fire (by stopping the burner if necessary).
- 2. Isolate the boiler.
- 3. Try and maintain the water level until the boiler is cooled.
- 4. Test and plug the tube as per the recommended procedure.

# **EMERGENCY OPERATION DUE TO FIRE**

Fires can occur in the air heaters, economisers, superheaters and exhaust gas heat exchangers. These heat extracting units are all situated in the path of combustion gases and under certain conditions, fortunately rare, can experience disastrous fires. These fires are two types:

- 1. Soot fire
- 2. Hydrogen fire

# Soot Fires:

- 1. The ignition of an accumulation of soot immediately after lighting-up or during periods of light load operation.
- 2. Air heaters and pin-tube elements are prone to this fire.
- 3. Indicated by a very high uptake temperature of gases.
- 4. Shut-off fuel and air supply to the burners and close all dampers.
- 5. Flood the area with water and do not use water spray.

# Hydrogen fires:

- 1. Steam breaks up into Hydrogen and Oxygen at a temp of 2500°C.
- 2. Iron will burn in steam with reproduction of free Hydrogen at much lower temperatures of about 700°C.
- 3. Indicated by a tube rupture and very high flue gas temperature.
- 4. Cut-out the burner and stop feed water supply to the boiler.
- 5. A Hydrogen fire stops only when the supply of steam/water is exhausted.

EXAMPLES OF MARINE CHEMICAL SELECTION GUIDE USE ON BOARD								
Type System	Problem	Drew Chemical Use	Type System	Problem	Drew Chemical Use			
Evaporator Treatr	nents		Maintenance Chem	icals-General				
Evaporators and fresh water generators of the flash, submerged huba and plata type	Scale , Foarning and carry over	AMEROYAL evaporator treatment	Diesel engine air coolers, turbo- charger, intercoolers, filtèrs, etc.	Oli/organic deposits	ACC-9 air cooler cleaner. ACC/CIRCU-KLEEN air cooler cleaner			
High temperature evaporators of the vapor compression	Scale Foaming and carry over	AMERET evaporator treatment	Boiler, steam generator and evaporators	Oil organic deposits Scale, sludge and corresion	HDE-777 heavy duty emulsifier SAF-ACID descaling compound			
commonly used in the Offshore Industry			Buildheads, decks, railings and other	Rust and corrosion Oil/organic deposits	AMEROID RSR O&GR oil and grease			
Boiler Water Trea	tment Chemicals			(Heavy Duty)	remover, DEGREASER AP ceneral			
Auxiliary, exhaust gas system boilers with distilled water make-up All pressure (up to	Corrosion, Scale, Deposit formation and carry over Corrosion, Scale,	AGK - 100 boiler and feed water treatment			DEUREASER AF general purpose degreaser AMERCID OWS quick separating degreaser, EDGE heavy duty cleaner			
60kg/cm² -850 psi)	Deposit formation	water treatment and Control		Light outy	cleaner			
boilers with fresh water make-up	and carry over	Program ADJUNCT-8 phosphate boiler water treatment,	Electrical equipment and parts	Oily deposits (Fast Dry)	DREW ELECTRIC motor and parts cleaner			
		GC concentrated alkaline liquid, AMERZINE corrosion inhibitor, SLCC-A condensate corrosion	Purifier/Separator discs	Petroleum sludge deposits	AMEROID DC disc cleaner			
	Sludge, and Oil contamination	LIQUID COAGULANT boiler sludge conditioner (up to 42 kg/cm² -600 psi only)	Engine cooling water systems	Oil/organic deposits Light oil, scale and	HDE-777 heavy duty emulsifier AMEROID OSC one-step cleaner			
Low/medium speed diesel engine	Corrosion	DEWT NC diesel engine water treatment		Scale and rust	SAF-ACID descaling			
acket, piston, njector and other pooling systems	Corrosion and scale	LIQUIDEWT cooling water treatment NCL diesel engine water treatment	Engine pistons, rings, valves, parts exposed to combustion	Carbon deposits, varnish and gummy matter	CARBON REMOVER solvent cleaner BUNKERSOL-D sludge solvent/dispersant			
Medium/high speed diesel engine cooling systems	Corrosion, Scale and Cavitation	MAXICARD diesei engine water treatment	Fuel heaters and lube oil coolers (oil	Oil/organic deposits	KDE-777 heavy duty emulsifier,			
Fuel Treatments			sicie)		CARBON REMOVER solvent cleaner			
Fuel tanks	Sludge build-up	ANIERGY 222 fuel oil conditioner BUNKERSOL-D sludge	Oil spills (on water, pier, etc.)	Oil/petroleum organics	OSD/LT oil spill dispersant			
	Biological	Solvent/dispersant, F.O.T. fuel oil treatment	Wire ropes	Corrosion	NEVAMELT wire rope conditioner			
	contamination of distillate fuels	microbiocide	Ballast Tanks	Silt and mud	MUD CONDITIONER ballast tank water treatment			
Combustion spaces-Diesel/	incomplete combustion	AMERGY 1000 combustion improver	Lay up Ballast	Corrosion	PROTECSOL-100 seawater corrosion inhibitor			
Diese!	deposits and incomolete	AMERGIZE deposit modifier/ combustion improver	Void Spaces	Corrosion				
Boiler slagging	combustion Sulfur/vanadium	METONATE fireside slag	Seawater cooling systems	Biological fouling	AMERSEPERSE 280 seawater cooling treatment			
Exhaust system-	slag deposits Soot build-up	and corrosion inhibitor	Potable water systems	Corrosion	CIL corresion inhibitor			
Diesel . Steam	Soot build-up	combustion catalyst, SOOT STICKS soct combustion catalyst	Bilges	Oil/organic contamination	TC #4 tank cleaner ATW/ROLL KLEEN tank cleaner			
Tank Cleaners 💡	مر میرون بر هم معرف و رو ا	EDGE home date deser		Oil/water separator systems	AMEROID OWS quick separating degreaser			
Cargo tanks	Vegetable and animal cits	LAC liquid alkaline cleaner TC #4 tank cleaner ATW/ROLLKLEEN tank cleaner	Steward's Dept., Galley and Hotel Accomodations	Oil/dirt and environmental soils	ENVIROMATE it all purpose cleaner ALL PURPOSE DETERGENT powdered detorgent			
Fuel cits and DEGHEASEH IK heavy duty			<u> </u>	l				

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# **INTERNAL COMBUSTION ENGINE**

## Q. What is the differences between the following?

**INTERNAL COMBUSTION ENGINE** – an engine in which the fuel is burned directly within the working cylinder. Both gas and diesel engines are examples of internal combustion engines.

**EXTERNAL COMBUSTION ENGINE** – is one in which the fuel is burned outside of the power cylinder. For example, in a steam engine the fuel is burned and heats the water in a boiler which produces the steam that is sent into the cylinder.

DIESEL ENGINE – is an engine which uses a low grade oil for fuel and ignite it directly in the cylinder by the heat of air compression.

GASOLINE ENGINE – requires high-grade gasoline for fuel which is ignited by an electric spark after the gasoline has been mixed with air in a carburetor, injected into the cylinder, and the mixture compressed.

FOUR CYCLE ENGINE – four stroke of the piston are required to complete one cycle or series of events which must take place, in regular order, to operate the engine.

TWO CYCLE ENGINE – two strokes of the piston are required to complete one cycle or series of events must take place, in regular order, to operate the engine.

SINGLE-ACTING ENGINE - is one in which the pressure produces the power stroke is exerted upon only one side of the piston.

DOUBLE-ACTING ENGINE – is one which operates similarly to a single acting engine, except that pressure producing the power strokes is exerted first on one side of the piston, then on the other end, which makes each piston stroke a power stroke.

#### Q. Classification of Internal Combustion Engines.

- 1. As to power motion
  - a. reciprocating
  - b. rotary
- 2. As to cycle used
  - a. otto
  - b. diesel
  - c. brayton
- 3. As to method of charging
  - a. two-stroke
  - b. four-stroke

- 4. As to ignition
  - a. spark-ignition
  - b. compression ignition
- 5. As to general design
  - a. single-acting
  - b. double-acting
- 6. As to cylinder arrangement
  - a. in line
  - b. V-type

- c. X-type
- d. radial
- e. barrel type
- 7. As to method of cooling
  - a. liquid-cooling
  - b. air-cooling
- 8. As to method of supplying air
  - a. naturally aspirated
  - b. supercharged
  - c. scavenged

# Q. What are the four strokes in the four cycle D.E.?

- 1. Intake stroke -- means drawing or supplying air into the cylinder
- 2. Compression stroke means compress the air by upward motion of the piston
- 3. Power stroke hot air and fuel mixed produce power by the burning gases
- 4. Exhaust stroke expel or release of product of combustion.

# **Q.** List the series of events in the 4 stroke cycle D.E.

The series of events taking place in a cylinder of a four-stroke cycle engine and making upon complete cycle are the following:

- 1. First, the inlet-air valve opens, permitting air to be drawn into the cylinder by the downward stroke of the piston.
- 2. Second, the valve is closed and the piston start upward, compressing the air for producing the heat needed to ignite the fuel.
- 3. Third, the fuel valves opens and the fuel oil is injected into the hot air where it ignites.
- 4. Fourth, the burning fuel form gases which create pressure and send the piston downward, this is the power stroke of the engine.
- 5. Fifth, when the piston has completed its power stroke, the exhaust valve open and permits the burned gases to escape.
- 6. Sixth, the piston returning upward forces out the remaining gases in the cylinder. The exhaust valve closes and the cycle repeats.

# Q. What are the two strokes in a two cycle D.E.?

- 1. One stroke compresses air in the cylinder to ignite the fuel oil.
- 2. The other stroke is produced by the burning gases. It is the power stroke.

# **Q.** List the series of events in the two-stroke cycle D.E.

- 1. Air, under slight pressure, is blown into and fills the cylinder through the open valves in the head.
- 2. The piston is starting upward to compress the air for producing heat to ignite the fuel.
- 3. The air is fully compressed and very hot.
- 4. The fuel valve opens and fuel oil is injected into the hot air where it ignites.
- 5. The burning fuel form gases which create a pressure and send the piston downward, this is the power stroke.
- 6. The scavenging and charging valves in the head then open and air under pressure forces out whatever remaining gases maybe in the cylinders, leaving clean air for the next compression.

## Q. What are the relative advantages and disadvantages of a 2-cycle Diesel engine?

## Advantages:

- 1. Less weight and space per horse power.
- 2. Greater horsepower per cylinder.

- 3. More uniform turning effect.
- 4. Less complicated cylinder head.

# **Disadvantages:**

- 1. Less volumetric efficiency.
- 2. Greater fuel consumption than the 4-cycle.
- 3. A scavenging air pump is required.
- 4. Trouble with cylinder liners due to intake or exhaust ports.

# Q. What are the relative advantages and disadvantages of a 4-cycle Diesel engine?

# Advantages:

- 1. Better volumetric efficiency.
- 2. Lower fuel consumption.
- 3. No air scavenging pump needed.
- 4. Less cylinder liner trouble, since there are no ports.
- 5. Higher engine speeds.

# **Disadvantages:**

- 1. More weight and space than the 2-cycle.
- 2. More complex cylinder-head casting.
- 3. More valves and moving parts than the 2-cycle engine.

# **Q** Describe the operating principle of an Opposed piston engine.

All opposed-piston engines are the 2 stroke cycle type. They have two pistons in each cylinder and as they come together, air is compressed between them. When the pistons reaches a point at which they are closest together, maximum compression pressure is reached. This point is referred to as "compression dead center." As the piston approach the combustion dead center fuel is injected. Due to the heat of compression the mixture of fuel and air burns and expands forcing the pistons outward to deliver the power.

# Q. State the advantages and disadvantages of an opposed-piston engine.

Advantages: Light weight per horsepower; absence of complicated casting (no cylinder heads); absence of valves and valve-operating gear; convenience and ease in overhaul, repair and inspection, due to accessibility and fewer parts.

**Disadvantages:** The principal disadvantage is the inaccessibility of the lower crankshaft. The opposed-piston engine eliminates most of the difficulties, however, encountered in design of double-acting engines, exposure of the piston rod to the temperature of combustion, unsatisfactory combustion in the lower cylinder, piston cooling and seizure of the piston rod in the lower cylinder-head stuffing box.

# Q. Describe the Otto cycle?

The Otto cycle is a 4 stroke cycle in which the volume of the cylinder is constant at the point of ignition. The first stroke (down) of the piston suct in the gas-air mixture and

compress it during the second stroke (upward) and ignite it at approximately top dead center. The expansion of the ignited gas drives the piston downward again and on the return upward stroke forces the burned gas from the cylinder.

#### Q. What are the two types of liner?

*Dry Liner* – usually a very thin liner, which does not come in direct contact with the cooling water.

*Wet Liner* – a cylinder used on larger engines, which comes in direct contact with the cooling water and fitted some rubber sealing on top and bottom portion of the liner in order to prevent leakage of cooling water into the engine sump that might contaminate the lube oil system.

## Q. What are the types of piston usually used on merchant ship now?

*Crosshead-type* – fitted on slow and medium speed engines, consist of a short skirt and has a piston rod either bolted or screwed to the piston. The piston rod is connected to the connecting rod at the crosshead. Usually two stroke cycle engine built this type like a main engine.

*Trunk-type-piston* – usually used on small high speed engines, which has a long skirt and connected rod directly attached to it by means of oscillating wristpin to the crankshaft. Four stroke cycle engine like auxiliary engines design to it.

#### Q. What are the two major types of fuel injection system?

*Air injection type* – an air compressor produce air at a constant pressure of 600 to 1000 psi to all spray valves on the engine. A fuel pump discharge enough amount fuel oil into the spray valve chamber, at proper time in the stroke, the valve gear causes the needle valve to open and air blows the oil in the chamber violently into the cylinder, breaking it up into a fine mist particles.

*Mechanical solid injection type* – usually fitted on individual fuel pumps each cylinder of the engine consist of plunger and barrel, when the injection check timing occurred by the camshaft, fuel injection check valve open producing higher pressure leading into high pressure pipe to fuel injector valve for atomization.

## Q. Describe various method of piston-ring construction and joints?

**Compression rings** – usually close-grained cast iron, square in section with a thickness of approximately 1/40 of the cylinder bore. It is also tapered on top of the crown vicinity to allow expansion being introduced to the hottest part where combustion take place. The purpose is to have gas tight seal during the process in order to have higher engine output.

*Scraper rings*—is beveled on the bottom to form a scraping edge and a number of small holes drilled through the piston skirt to drain off the oil scraped from the cylinder wall. Fitted mostly on a trunk type, high speed 4 cycle engines.

#### Piston ring design ends cut as follows:

- a. Square butt
- b. Bevel jointed
- c. Step cut
- d. Overlapped

### Q. What types of metal are used in the following diesel engine parts?

- a. Bedplate -- cast iron or steel plate
- b. Holding Down Bolts high corrosion resisting steel
- c. Frames alloyed cast iron or welded steel frame
- d. Crankshaft cast or forged steel
- e. Connecting rods soft steel
- f. *Pistons*, larger engine : head forged steel, skirt cast iron smaller engine: aluminum alloy.
- g. Liners closed grain cast iron or cast steel
- h. Water jackets cast iron
- i. *Cylinder head* cast iron or aluminum alloy.
- j. Fuel valves forged steel or cast iron
- k. Inlet Exhaust-valves cast iron cage or carbon steel with stellite seats used.
- I. Cams forged steel
- m. Cams roller forged steel
- n. Valve springs spring steel
- o. Piston rings cast steel or cast iron
- p. Bearings shell; cast iron or cast steel; surface babbitt or copper nickel alloy.

## Q. Describe the operating principles of a governors; types and kinds?

**Governors** – consist of two weights attached to a spindle, driven by the engine. As the engine speed up and slows down, centrifugal force actuates the fuel control linkage by means of attached weights, thereby control the fuel, measuring and stabilizing engine speed by varying fuel flow.

#### **Types:**

- a. Centrifugal
- b. Inertia
- c. Inertia and centrifugal combined
- d. Hydraulic

#### KINDS

1. Isochronus Governor — maintain constant speed from zero up to full load.

% Speed Reg. = <u>no load speed - full load speed</u> x 100 full load speed

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Speed drop actuate governor rotating speed output shaft (fuel control) to move from full open to full closed. Momentary speed changed causes hunting due to sensitivity and quick action for correction.

- 2. Constant Speed Governor single speed type from no loads to full load vice versa.
- 3. Variable Speed Governor speed regulation can be selected from idling (zero) to full (max) speed.
- 4. Speed Limiting Governor control minimum to maximum speed.
- 5. Overspeed Type Governor does not regulate the engine speed but it will prevent the engine from exceeding a certain predetermined maximum speed, usually found on main propulsion engines.

# Q. Describe at least four different types of pre-combustion chamber?

- 1. The antechamber it is an added chamber to the main chamber in which the fuel is partially burned and then injected into the main chamber for complete burning.
- 2. The air cell-it is modification of the antachamber. It is placed in the piston crown and furnished highly turbulent air to the combustion chamber on the upward stroke of the piston.
- 3. The energy cell used in the lanova system of combustion. It is similar to the aircell except that it is divided into two sections by a narrow throat.
- 4. The turbulence chamber it is an auxiliary chamber that is placed to one side of the cylinder head and is used to give increased turbulence.

# What are the different parts of a modern diesel engines and operational functions?

## I. BEDPLATE AND HOLDING DOWN ARRANGEMENTS

Bedplate is the most heavily loaded (especially the main bearing saddle) structural component of the main propulsion engine. Propulsion engine bedplates are fabricated from mild steel plates, cross girder is steel casting and welded together. Main advantage of fabricated bedplate is lightness and lower cost. These are of deep box pattern with flat bottom.

Bedplate connected to engine seating through chocks which are part of holding down arrangement. Chocks are either made of steel or epoxy resin. Holding down arrangements use long bolts with spacer. Engine uses sides and end chocks to take up side and end loads. Bolts are free through the chocks, bedplate and tank top.

Most heavily loaded part of the bedplate is central portion of the transverse girder and the junction welds between transverse girder and longitudinal girder. All parts of bedplate contribute to strenght. The cross girder is made of cast steel according to requirements. The construction provides good resistance to twisting along its length. Longitudinal strength obtained by making the each side of the bedplate in the form of girder. Bedplate

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is supported through chocks along the longitudinal girder. It has no support at the centre of the cross girder.

# Following parts of bedplate require utmost care:

1. Central part of cross girder or bearing saddle which is very heavily loaded and has no support;

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- 2. Junction welds between cross girder and longitudinal girder;
- 3. All welded joints;
- 4. All tightening holes, tie bolt holes.

# Following parts of holding down arrangements require attention:

- 1. Bedplate holding down bolts often run loose;
- 2. Loose chocks (supporting, side and end);
- 3. Crack spacers;
- 4. Bolts are hydraulically tightened (never tighten in a running engine)
- 5. These are heavily loaded bolts, so bolt axis and nut seating to be normal;

## II. FRAMES

On large main propulsion engines frames are basically transverse members stradding on each cross girder. They are strong transversely and to impart longitudinal strength, girder type of construction have been adopted in longitudinal direction.

*Frames* in way of guides are extremely heavily loaded during engine operation. The side thrust due to the connecting rod angularity is transmitted through the guide to the frame. Frames need to be strong longitudinally to give the cylinder block a substantial support so that cylinder liners remain at clamping points.

Frames are prone to cracking behind guides, in way of welds, any bolt holes, at change of sections. Prone to fretting on top and bottom if tie bolts are running loose.

## **III. TIE BOLTS**

The firing load from the cylinder covers is transferred through cover studs to the cylinder blocks or beams. The beam transfers the load through the tiebolt nuts and tiebolts to the bedplate cross girder. Tiebolts keep the structure under compression.

*Tiesbolts* are subjected to severe tensile loads on modern highly rated engines. They tend to vibrate excessively during resonance zone, so guide bushes or pinching screws are provided. Slack tiebolts may result in fretting and severe structural misalignment.

Refer to engine builder's manual for tiebolts' checking of pretension, slackening and tightening. Slack tiebolts will result in severe structural damage. Tiebolt slackening, tightening should always be done in stages, correct sequence and pairs. Start from midship then athwarship, alternate from forward and aft. cylinders.

# IV. GUIDES

Guides are fitted in 2 stk crosshead type engine with high "stroke " bore" ratio to take up the side thrust due to connecting rod angularity. This side thrust is enormous which makes the guides heavily loaded.

*Guides* keep the running gear aligned and take up side thrust due to connecting rod angularity, so in ideal cases liner will not be subjected to side thrust.

Large main propulsion engine, guide and guide shoe clearances have very little latitude. Improper clearance may result in guide shoe, crosshead bearing running hot and resulting crankcase explosion. It may also result in piston misalignment, excessive wear of piston rod and stuffing box.

#### V. BEARING

Bearing – Following parts require special attention:

- a. Main bearing bottom half;
- b. Bottom end bearing top half;
- c. Crosshead bearing bottom half;
- d. Bearing surfaces for damage and marks;
- e. Bearing clearance in admissible range; (Excessive and less clearance, both are detrimental)
- f. Improper clearance may result in severe damage to the shaft, bearing surface and eventual crankcase explosion.

#### VI. BEARING BOLTS

Following areas to be inspected:

- 1. In way of fillets and any change of section;
- 2. Bolts surface for any damage and scratch marks;
- 3. Overall stretch in the bolts by trammed gauge;
- 4. Healthy sound from the bolt.

#### VII. CYLINDER LINER

Cylinder liners are centrifugally cast with the upper end like a flange cast integral with the liner. Underside of the flange rests on the cylinder block. The cylinder cover holds the liner in place when the cover studs are hardened down. Lower portion of the liner is usually of thinner section. Most of the modern engines have been using bore cooling to combat both high mechanical and thermal stresses. Larger engine liners are of wet type where cooling water comes directly in contact with liner metal.

Cylinder liners of modern large highly rated engines burning extremely poor quality residual fuel are subjected to severe mechanical and thermal stresses and possibilities of cold corrosion is high if correct liner metal temperature and cooling water outlet temperature not maintained as specified by makers. Liner flange is subjected to bending moment especially if the cylinder cover unevenly tightened.

# During overhauling of units

- 1. Inspect liner surface without clearing, the state of liner lubricating oil spread, carbonisation's hand pump lubricators to estimate lubricating oil flow through quills, carbonisation in way of scavenge ports, etc.
- 2. Clean thoroughly and check for cracks and burning marks at top part of liner, cracks in way of scavenge ports, scoring marks on the surface, cracks in way of liner flange.
- 3. Calibrate liner thoroughly using maker's template giving special attention to the top part (wear rate of liner should be < .1 mm/1000 hrs).
- 4. In case the liner has to be renewed, follow engine builder's instructions step by step.

*Example:* Cylinder liner bore = 900 mm; change should be 1% inside diameter of the bore = 9 mm. max.

For: Slow speed (liner wear) – 0.1 mm/1000 hrs. Medium speed (liner wear) – 0.015 mm/1000 hrs.

#### Formula:

Wear rate = <u>increase in dia. (total)</u> x 1000 Running hrs. (total)

= \_\_\_\_ mm/1000 hrs.

#### **Reasons for maximum wear**

- 1. gas load behind ring minimum
- 2. cylinder hottest in this region
- 3. corrosive wear cylinder temperature high but may lower than dew point
- 4. viscosity oil film minimum, film may breakdown
- 5. 2 stroke engine have higher wear above parts

#### Causes of excessive wear

- 1. low sulphur fuel with high TBN cylinder oil
- 2. Inefficient combustion
- 3. scavenging air temperature too low
- 4. overloading engine
- 5. contamination of lubricating oil
- 6. unsuitable liner material

- 7. piston ring clearance incorrect
- 8. inadequate oil supply
- 9. distortion of cylinders
- 10. misalignment of piston
- 11. improper running-in of engine

#### **Cylinder Lubrication**

Modern large engines are highly loaded and at the same time have been using extremely poor quality fuel. Cylinder lubricating oil has to be thermally stable at high temperature and at the same time reduce the possibilities of cold corrosion. Role of cylinder lubricating oil in modern highly rated engines is extremely demanding. Oil with proper characteristics, correct feed rate and at the right time are essential. S.G. 0.948; Flash pt. 238°C; Pour pt.-20°C; Viscosity 89-85, TBN 70.

## **Lubricant Requirement**

- 1. sliding friction minimum
- 2. adequate viscosity at high temperature
- 3. effective oil seal (ring and liner)
- 4. burn without deposit
- 5. neutralize corrosive acids

# **Lubrication Consumption**

Depend on design, load, fuel construction, fuel quality, temperature gradient across liner.

## **VIII. PISTONS**

*Pistons* of large highly rated engines are subjected to very high mechanical and thermal stresses. To combat the same, number of engine builders have been using bore cooling. Modern approach has been also to use forged alloy steel for piston crown to withstand high thermal stresses (nickel chrome steel or molybdenum steel).

During operation, the piston is subjected to very high compressive and tensile stresses due to gas pressures, inertia effects and thermal stresses. Gas pressures and inertial effects result in bending action of piston crown. Thermal stresses in piston set up due to difference in temperature across a section. Hottest part of piston crown is at the junction of side wall and top plate. Ideally, the piston is not subjected to any side thrust in crosshead type engine.

## During overhauling:

- 1. Inspect, without cleaning, piston crown and side wall for carbonisation, accumulation of oil, water, lubricating oil presence, ring movement, etc.;
- 2. Thoroughly clean inspect crown for cracks, burning, external contour with template, internal area for coking, cracks;
- 3. Side wall and ring grooves for cracks;
- 4. Wear ridges on skirt, piston rods;
- 5. Piston rods for any scratch and scoring marks.

## Faults:

- a. Crack in crown -- thermal/mechanical stress.
- b. Crack in piston wall fluctuating gas load.

## **Reasons:**

Material, scaling, inefficient cooling, local inpingement, poor atomization, water in fuel.

## IX. PISTON RINGS

*Piston rings* are heavily loaded mechanically with maximum pressure, MIP going up in engines. Ring grooves in cases have been chrome plated to increase wear resistance.

Generally, piston ring material is made much harder than material of the liner to control high wear rate compression rings exert considerable pressure on the liner wall in modern engines (for 900 mm bore engine). Efficient lubricating oil film is essential.

Overhauling internal is so long in modern engines, it is advisable to renew all the rings during overhaul.

- 1. Thoroughly measure all new rings axially, radially and butt clearance in a ring gauge;
- 2. Check ring grooves for wear giving special attention to uneven wear (in case of excessive uneven wear, ring groove to be reconditioned);
- 3. Roll new ring around in the groove, make sure ring is not sticking out;
- 4. With rings in place, check with feeler gauge the axial clearance and make sure in admissible range.

# X. STUFFING BOX

It is mounted with a flange bolted to the bottom of the scavenge air box. Top set of rings are sealing rings to prevent scavenge air flowing down the piston rod. Lower set of rings scraper/case oil off piston rod.

# During overhauling:

- 1. Uppermost scraper ring and sealing ring, sealing rings, lower scraper rings to be checked for:
  - a. clearance between sealing ring section and groove;
  - b. clearance at ring ends;
  - d. total clearance
- 2. Check greater spring tension.

# XI. CRANKSHAFT

*Crankshaft* of large main propulsion engine are mostly of semi-built type. Some of modern engines, namely MAN – B&W have been using welded crankshafts. Modern design has increased fatigue strength considerably by adopting continuous grain flow method. Welded crankshafts are considerably lighter reducing the inertia forces.

Analysis of stresses on the crankshaft during operation are complex, it is better to consider one unit of the crankshaft. The crank pin is subjected to tensile and compressive stresses with complete load reversal. Similar nature of stresses are applicable to the webs. The crankshaft is subjected to shear stresses in way of web and journal. This may result in slipping. The web is subjected to bending due to connecting rod angularity. The crankshaft is subjected to fatigue.

# During Overhauling

- 1. Crankshaft deflection should be taken in a condition suggested by makers (Deflection readings are often over rated.)
- 2. Crankshaft deflection should be inspected for cracks in way of fillets, crankpins, pins, central portion of webs, slipping in way of journals;
- 3. Pins to be accurately measured for ovality, scoring, rubbing marks;
- 4. No repairs to be taken up without owner's knowledge.

# XII. CONNECTING ROD

Cross section adopted for connecting rod follows from study of the loads on connecting rods and the cost of manufacture. Round section connection rods are adopted for large engine. Connecting rod is considered as a struct, pin-jointed at each end and subjected to lateral loading from inertia combined with thrust from end loading through pins. These are made of forged steel.

In operation, connecting rod is swing about the crosshead bearing, the swinging movement being constrained by the bearing on the crankpin. The action set up inertia loads. In slow speed engines, round section connecting rods of normal length are strong enough to sustain the corrected gas loading and the inertia whip loading is not of sufficient consequence.

May fail from fracture or cracking in vulnerable areas or may buckle. Failure of connecting rod in operation extremely rare in slow speed engines. Cases of slight buckling have been found in same instances where water or oil leaked into cylinder spaces.

#### XIII. CROSSHEADS

In large slow speed engines, the gas pressure acting on the piston and through the piston rod puts a load of approximately 600 tonnes on the crosshead pins when the pressure in the cylinder is at maximum value. Loads of this high value cause some deflection. The pin and the bearing has to be kept aligned and modern engine pins are designed to be rigid.

Crosshead pin to be inspected for scoring and rubbing marks at the bottom half, to be checked for ovality. Thoroughly to be inspected for any cracks.

#### XIV. CAMSHAFT

Camshaft is built with number of camshaft sections, joined together by means of flange couplings using fitted bolts and nuts.

Each camshaft section has fuel pump, exhaust valve and indicator drive cam.

Camshaft is carried in underslung shell type bearings. The bearing nuts are hydraulic tightened.

The coupling flanges and fuel and exhaust cams are shrunk onto the shaft by heating.

Dismantling of flanges is effected by forcing lubricating oil between shaft and flange. Adjustment of fuel cam timing, or adjustment of camshaft for elongated chain is also done by forcing lubricating oil between shrink fitted surfaces.

Camshaft rotates at same speed as crankshaft. During reversing, follower rollers are displaced to alter the pump timing.

#### XV. CHAIN DRIVE

The camshaft is driven by a chain drive.

Chain drive consists of two identical chains running over chain wheels fitted on camshaft and camshaft.

Chains are kept tightened by chain tightener placed between the crankshaft and intermediate wheel.

From camshaft, a small chain drive operates cylinder lubricator, distributor and governor.

Long free length of chains are guided by rubber clad guide bars.

Lubricating oil is supplied by spray pipes fitted at the guide bars and chain wheels.

# SCAVENGING

Pushing out exhaust gases with the help of fresh air intake so that a fresh charge of pure air is available for compression that follows.

# TYPES

DIRECT SCAVENGING- in the direct scavenging the inlet ports are located on one side of the cylinder opposite the exhaust ports. The flow path of the scavenging air is from one side to the other side.

LOOP SCAVENGING- in the loop scavenging the intake and exhaust ports are located at one side, the exhaust over the intake ports. The flow part of air is from the intake port across to the opposite side and up towards me cylinder head and then make a loop to the exhaust ports above the intake ports.

UNIFLOW SCAVENGING- in the uniflow intake ports are located at the side of the cylinder and exhaust at the cylinder head. The air enters the intake and moves up towards the cylinder head where exhaust valve are installed.

# **The Actual Process**

Consists partially of perfect scavenging, mixing and short-circuiting.

Certain amount of combustion products is initially pushed out of the cylinder without being diluted by fresh air.

Gradually, mixing and short-circuiting causes the outflowing products to be diluted by more and more fresh air until the situation is same as for perfect mixing.

So, the first phase of scavenging process is Perfect Scavenging which then changes into complete mixing process.

## Scavenging Stages

- 1. Blow down
- 2. Scavenging
- 3. Containing of air

## Importance of Scavenging

- 1. Engine efficiency depends on scavenging
- 2. Inefficient scavenging gives less power output per weight
- 3. Incomplete scavenging results in increased fuel consumption per unit power
- 4. Incomplete scavenging leads to greater Piston ring and liner wears.
- 5. Inefficient scavenging gives higher mean temperatures



ADVANTAGES	DISADVANTAGES	Examples of Use
Cross Scavenge *Simple *Less Maintenance *Low Cost	*Short Circuit *Lower Efficiency *Less BMEP	*Suizer *RD, RND
Loop Scavenge *Higher Efficiency	*Piston/Liner Distortion due to Temp. gradient from exhaust to	*M.A.N
*Simple	*Crankcase/under piston space more dirty.	*RND-M Sulzer
*Less Maintenance	*Exhaust port carboni- sation excessive.	
*Reliable	*Uneven piston ring wear.	
*Simple Cylinder – can sustain higher thermal stresses.	*Less efficiency due to overmixing	
Uniflow Scavenge *No short circuiting *No overmixing *Very high efficiency	*More complex *Higher cost *More maintenance	*B & W *SULZER-RTA

# SUPERCHARGING

Process of pushing a higher pressure air charge into the cylinder greater than atmospheric pressure, thus increasing power output of the engine.

# **Advantages Gained**

- 1. Higher output
- 2. Better combustion
- 3. Less specific fuel consumption
- 4. Improved thermal efficiency
- 5. Less weight/space/cost to produce a particular power
- 6. Lower exhaust temperature

## Disadvantages

- 1. Higher initial cost
- 2. Higher thermal loading due to higher maximum pressure

## Methods of Supercharging

- 1. Independently driven compressor
- 2. Engine driven compressor
- 3. Underpiston supercharging
- 4. Exhaust gas turbocharging
- 5. Combination of the above

## Types of Equipment that can be used

- 1. Positive displacement pump
- 2. Positive displacement blower (roots blower)
- 3. Centrifugal blower (electric driven)
- 4. Turboblower (exhaust gas driven)

## **Principle of Operation**

- 1. Pulse system ME
- 2. Constant pressure system Generator

## Valve timing periods

Scavenge ports open at approximately 35 degrees b.d.c. and close 35 degrees after b.d.c. The exhaust valve will open ahead of the scavenge ports to give a blow down period and close at some time to leave the correct amount of air in the cylinder for the combustion of fuel. The open period for the exhaust valve will be about 80 to 90 degrees of crank rotation and the valve will open about 45 degrees before b.d.c. It should be noted that considerable variation may be found in valve timing figures for various engines.

# TURBOCHARGING

Very effective pressure charging. Utilizes 20% of waste heat in exhaust gas which Contains 35% of fuel heat. It consist of two parts, the blower and exhaust turbine side fitted in one motor shaft.

# Advantages

- 1. Higher plant efficiency.
- 2. No separate power source required.
- 3. Power demand low,
- 4. Attempts to cater for overloading condition.
- 5. More efficient than other forms of supercharging.



# **Exhaust Turbocharging**

## **Pulse System**

Pulse operation needs:

- 1. Exhaust pipes short narrow minimum bends Losses in pipe minimum. Small volume flow.
- 2. Exhaust pipes connection to same TC inlet from different units to be arranged such that no interference of pulses happen this may otherwise affect scaveng-ing operation.
- 3. Period between discharge of successive cylinders into a common manifold to be more than 240° for a 4-stroke and 120° for a 2-stroke engine to avoid interference.

Not more than 3 cylinders firing successively can be exhausted into a common manifold. Engines with more than 3 cylinders will have more than 1 TC or 1 TC with multi-entry arrangement.

# Advantages

- a. Highly responsive
- b. Good turbocharger acceleration
- c. Good low load and low speed performance
- d. Scavenging assistance not necessary
- e. Better scavenging

## **Disadvantages**

- a. Poor turbine efficiency at high ratings
- b. Turbine operation rough and inefficient
- c. Exhaust piping complex

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## **TURBOCHARGER OPERATING PROBLEMS**

## SURGING

If due to any reason, the air pressure generated in the blower, falls below delivery pressure, there will be a sudden breakdown of air delivery, followed immediately by a backward wave of air through the blower which will continue until the delivery resistance has decreased sufficiently for air discharge to be resumed. This periodical breakdown of air delivery is called "surging", and is manifested as irregular howling noise from the Turbocharger.

## Stages of surging

- I. Humming
- II. Snorting
- III. Howling

# SYMPTOMS OF SURGING

- 1. Howling Noise
- 2. Rapid surges in scavenge air pressure
- 3. "Gulping" of air by blower
- 4. Repeated irregular violent thud from air intake to blower.
- 5. Alternate "suck-in" and "push-out" at blower air intake.

#### Causes

- 1. Dirty air filter
- 2. Power imbalance between cylinders
- 3. Engine racing
- 4. Faulty injection
- 5. Fouled/damaged Turbine
- 6. Fouled Air Cooler
- 7. Overpressure at Scav. manifold
- 8. Mismatch of Engine/TC.

## Remedy/Control

- 1. Proper matching
- 2. Larger dia scav. manifold
- 3. Reduce speed and ease pressure



## **TURBOCHARGER SURGING**

Surging can be divided into two main categories

- I. Restrictions in the air/gas system;
- II. Variations in cylinder load.

## **CHECK THE FOLLOWING**

- 1. *Fuel oil system* such as filters, fuel pump, fuel injector, fuel timing, air in fuel, fuel viscosity, load distribution, etc.
- 2. Exhaust System. Back pressure, valve opening & timing, pressure fluctuation, etc.
- 3. Turbocharger. Fouled or damaged turbine or compressor side, fouled fitter.
- 4. Scavenge Air System. Fouled air cooler, choked scavenge ports, high scavenge temperature, load variations.
- 5. Governor. Hunting

#### Q. What are the meanings, functions of the following terms?

*Piston displacement* – is the volume swept or travel by the piston from top dead center to bottom dead center

*Compression Ratio* – the ratio of the piston displacement plus the clearance volume to the clearance volume.

*Flash point* – the temperature at which flammable liquid will give off sufficient vapor to support a flash flame but will not support continuous combustion.

**Specific gravity** – the weight of a solid or liquid as compared with an equal volume of water at 62°F.

**Calorific value** – the highest amount of heat that can be produce from a given quantity of fuel by complete combustion is called heat or calorific value.

Viscosity - is the internal friction or resistance to flow of a liquid at certain temperature.

**Volumetric efficiency** – the ratio of the weight of the air which is trapped in the cylinder at the beginning of the compression stroke and the weight of air could be contained in the cylinder under conditions of atmospheric pressure.

*Counter weights* – fitted to the crankshaft of the engine in order to balance the revolving weight of the crankpins, webs, and the lower portion of the connecting rod thereby reduce vibration.

Jacking gear - is an arrangement of gears used to rotate the engine crankshaft. Consist of warm gear which engages a gear-toothed flywheel.

**Shims** – are pieces of metal or other material use for plating or equal spacing between two connected metal parts like the engine frame, bearings and motor basement.

**Pyrometer** – is a millivolt calibrated in temperature units, attached through a selector switch to each individual cylinder exhaust thermocouple.

**Thermocouple** – is made of 2 rods of different metals that are welded together at one end, when heated at the welded junction, an electromotive force is produced between the terminals.

**Isochronous** – governing keeps an engine running at a constant speed regardless of load. This gives perfect speed regulation and no speed drop.

Speed Droop – is a decrease in the speed of an engine from no load to full load conditions.

**Sensitivity** – is the change in engine speed before the governor makes its corrective change to the fuel control. It is usually expressed as a percent of the normal or average speed of the engine.

Stability - is the ability of a governor to settle down to a steady after a change of load.

*Hunting* – is the unstable operation of a governor. It will not maintain a steady speed caused by overcorrection.

**Deadbeat** – is the inability to change the speed when a new load requires such a change.

*Oil Mist Detector* – fitted in the main engine crankcase, that give a more reliable and quicker warning of oil mist formation, which connected pipe line sample air from each crankcase compartment. The detector will give an alarm at a mist concentration of 2-5% of the inflammable quantity, for safety precaution, have ample time to stop the engine before ignition of the mist can take place.

# Q. When making an order or inquiry for engine parts, what are the essential data in order to supply you the correct parts for the individual engines?

When ordering engine spare parts you should state the following:

- 1. Ship's name
- 2. Classification
- 3. Type of engines and numbers of cylinders

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- 4. Engine numbers
- 5. Main engine builders
- 6. Name of parts required
- 7. Plate no. of engine parts
- 8. Item no. of engine parts
- 9. Quantity required.

# Q. In modern main propulsion engines, what are the major parts of the engine need proper maintenance and attention?

Modern crosshead type main propulsion engines are highly rated, super long stroke and bearing extremely poor quality residual fuel. Following components of engine will need proper maintenance and attention:

- 1. cylinder liner top part subjected to severe mechanical and thermal stresses;
- 2. Frames and guides are subjected to high side thrust because of super long stroke arrangement.

- 3. Bedplate cross girders and at junction welds between longitudinal and cross girders;
- 4. Holding down arrangements;
- 5. Exhaust valves, air springs and hydraulic actuating arrangements;
- 6. Piston crown and top of side walls subjected to severe thermal stresses;
- 7. Crosshead bearings and guideshoes are heavily loaded;
- 8. Crankshafts are welded type, special attention to fillets, webs and crank pins.

**NOTE:** No repairs specially involving welding, hot work to be carried out on major engine components such as bedplate, frames, crankshafts etc without owner's knowledge under any circumstances.

#### Q. What are the desirable characteristics of a good fuel oil (Diesel)?

- 1. A maximum heat value.
- 2. A maximum of water, sediment, sulphur, sand, and other impurities.
- 3. A fluidity such that it can be pumped without heating it too much.
- 4. The oil should not be too slow-burning, so as to cause delayed ignition in the cylinder.
- 5. The oil should burn completely without leaving any carbon residue in the form of ash or soot.

#### Q. What factors would you say controlled combustion in a diesel engine?

Proper amount of air; proper amount of fuel; proper mixture of fuel and air and proper temperature of Fuel and Air for ignition.

## Q. Discuss ways of cleaning lube oil in a diesel engine driven ship?

- 1. By settling method used of gravity tank
- 2. By centrifuging used of centrifugal purifiers
- 3. By filtering method used of filtering material

## Q. What are the effect of early and late fuel injection?

Early fuel injection causes oil to ignite too soon causing a back pressure on the piston and a resultant loss of power. Pre-ignition may cause damage to cylinder and cylinder heads or even bent rod. Late ignition causes smoky exhaust, losses of power and incomplete combustion. Incomplete combustion results in carbon accumulation which affect piston rings and valve stems. Will carbonizer also a silencer and may caused fire

#### Q. What is the cause of "detonation" or "fuel knock" in a diesel engine cylinder?

During the ignition delay period injection of the fuel is contained so that there is a greater amount of fuel in the cylinder prior to ignition. When ignition does takes place the whole accumulation burns violently. This rapid burning results in an extremely high pressure in the cylinder accompanied by pressure waves. This rapid increase of pressure and vibrating pressure waves results in a noise known as fuel knock.

# Q. If your engine shows a very black and smoky exhaust, where would you look for trouble?

Find out if the engine is overloaded, check the exhaust pyrometer and see that the cylinders carry an equal amount of the load and adjust fuel valves and spray valves accordingly. Check fuel oil for cleanliness and water. Check fuel pumps and fuel lines for entrapped air. Check scavenging air on a two-cycle engine. Check injection air on injection engines. A poor grade of fuel oil may also cause smoky exhaust.

#### Q. Describe an open cooling system?

The circulating pump take suction from the sea and circulate salt water through the engine and then overboard the engine being cooled directly by salt water.

#### Q. Describe a closed cooling system?

The engine is being cooled by fresh water from the storage tank which is circulated through the engine by a fresh water pump. This water is cooled by a heat exchanger using sea water as cooling medium.

#### **ADVANTAGES:**

1. No danger of scale formation

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- 2. No danger of galvanic action due to sea water
- 3. Better efficiency since the engine can be operated at higher temperature.
- 4. These is better control of engine temperature

# **Q.** Would you shut off the cooling water immediately after stopping a diesel engine? Explain.

No. The reason for keeping the cooling water circulating after the engine is stopped is to prevent the lubricating oil from being evaporated from cylinder walls and piston rings. In case the engine is cooled directly by salt water, there would be formation of scale on account of excessive heat after the engine is stopped.

# **Q.** With respect to jacket cooling water of a diesel engine; which is advisable; with a higher temperature or lower temperature? If so, why?

With higher temperature because diesel engine is a compression ignition engine and it is susceptible to frequent change of temperature on mechanical parts from higher to lower temperature thereby to prevent stresses.

#### Q. Why is oil used instead of water for cooling pistons of a diesel engines?

If water is used and leak occured it would leak into the crankcase emulsifying the oil and spoiling its lubricating properties thus burning out bearings and causing great damage to the engine.
### Q. Why should the lube oil pump be run before starting and after stopping a diesel engine?

Before starting to ensure a complete oil film on all bearings in stopping a diesel engine, the lube oil pump should run until the difference in temperature between the inlet and outlet is from 2° to 5°. This allows the bearing to cool evenly.

### Q. How many degrees is the intake valve open? How many degrees it is closed?

Intake valve opens a few degrees before top dead center around 5 degrees before top dead center (TDC) And closes at around 5 degrees after BDC. Duration of opening is 190 degrees and closing duration is 170 degrees.

#### Q. What is usual fuel valve timing for high speed diesel engine using light fuel?

Fuel valve timing is usually started or open at 12 degrees before top dead center. This average.

Q. What are the usual angles between the cranks of 2 stroke cycle and 4 stroke cycle having 3,4, and 6 cylinders?

2 cycle	4 cycle
3 cylinders-120°	1200
4 cylinders-90°	180º
6 cylinders-60°	120º

#### Q. What is the valve timing of the air starting valve of two cycle diesel engine?

Air starting valve must open to admit starting air to the cylinder at five (5) degrees after top dead center (TDC) and closes approximately 90 degrees.

### Q. State the timing of the different value of 4 cycle diesel engine in terms of crank angle in reference to top dead center and bottom dead centers.

In two stroke cycle engine, intake valve opens 48 degrees before bottom dead center and closes 48 degrees after bottom dead center duration of 96 degrees at open position. The exhaust valve opens at 92.5 degrees after top dead center and closes at 44.5 degrees after bottom dead center. Exhaust valve is opened for a duration of 137 degrees in the crank angle. Injection valve opens at 17.5 degrees before TDC.

#### Q. Describe at least three methods of driving camshaft?

- a) By a train of gear, which drive the camshaft gear on the crankshaft of an intermediate gears and a driven gear on the crankshaft.
- b) By a chain which is driven from a gear on the crankshaft and driven camshaft gear.

c) By gear and a vertical shaft there is a level gear on both the camshaft gear, and crankshaft and a shaft has a pinion gear on each and is place between the camshaft and camshaft gear.

#### Q. Name the types of wristpin and describe each

- 1. SECURED WRISTPIN this type has the wristpin secured tightly in the bosses of the piston casting. A screwed dowel is used to secure the pin.
- 2. FLOATING WRISTPIN in this type wristpin is free to move in both eye of the connecting rod and the bosses of the piston casting. A spring clip retainer is placed in grooves in each end of the piston boss in order to prevent the pin from scraping the cylinder wall.

## Q. Describe the various methods used to introduce water or oil into diesel engine pistons for cooling purpose.

- 1. The packed and unpacked telescopic pipe In this type the moving member of the telescope assembly is attached directly to the underside of the piston and the stationary member to the engine housing or frame.
- 2. The swing-joint type This type is being used on crosshead engines. The inlet and outlet pipes from the piston are fixed and lead to the crosshead then to the outer end of the bracket bolted to the crosshead where connection is made to the moving member of the telescopic assembly.

#### Q. Name three methods of starting a diesel engine.

- 1. Electric motor requiring that electric energy be readily available.
- 2. Auxiliary gas engine may be attached directly to diesel engine.
- 3. Hand starting for small engines and compressed air previously stored for the purpose of starting.

### Q. Explain why the main journal bearing caps on 4 stroke cycle engine are made of heavier construction than those of the two stroke cycle engine?

The main journal caps of 4 stroke cycle engines are made of heavier construction because during the latter part of the exhaust stroke there is an upward thrust on the bearing caps due to the inertia and centrifugal force of moving parts. In the 2 stroke cycle this upward force is overcome by the compression of the air in the cylinder.

#### What are the method of reversing 4 cycle and 2 cycle engine?

- 4 cycle engines can be reversed by changing the timing through the insertion of a set of reversing cam. The camshaft is moved in such a mannerthat a set of cams slide under the valves so that so that the firing of any cylinder is 180 degrees to its former position with the ahead cam.
- 2 cycle engines reversing method is to rotate the crankshaft 30-40 degrees thus putting the opposite flank of the cam under the fuel valves or pump similar to Stephenson link motion used in steam engines.

#### Q. Describe the path of the fuel oil from the storage tank to the engine cylinder?

The fuel is taken from the storage tank by means of oil transfer pump to settling tank where oil is preheated and settled, passed through a centrifugal purifier for efficient cleaning and deliver it to the service tank in operation, the oil is led to one of the two electrically driven supply pumps, which deliver the oil under pressure through a flow meter, then to fuelcirculating pumps passes it through the oil heater – viscosity regulator – filters then supplied to individual fuel pumps each cylinder to the fuel injector valves for combustion process.

#### Q. Trace the path of lube oil system 2 cycle diesel engine.

Lube oil Pump draws the oil from the sumptank through suction filters, forces it through the lube oil cooler, passing auto backwashing filter, before it deliver it to the engine where it is divided into two branches: It supply to main part where oil is sent to the piston cooling manifold, where it is distributed between piston cooling and bearing lubrication. From the crosshead bearings, the oil flows through bores in the connecting rods, to the crankpin bearings. The remaining oil goes to lubrication of the main bearings, engine base and sump tank.

Camshaft lube oil system is separated from main lube oil system which is also fitted a tank - suction filters – coolers to the main engine cam drive system, then back to the tank passing magnetic filters.

#### Q. Trace the path of cooling water system 2 cycle diesel engine.

The fresh cooling water is circulated through the cooler by means of fresh (Jacket) water pumps where the water enters the engine through the bottom of each cylinder jacket and upward to the cylinder head and exhaust valve if fitted; controlled by thermostatically regulating valve, such proportion that the temperature of the outlet water from the main engine is maintained at specified normal temp. set point like 80 degrees centigrade in order to avoid cylinder wear and condensation of sulfuric acid on the cylinder walls. To prevent air accumulation to the system, a venting tank is fitted on outlet piping and expansion tank for make up the difference in the water volume at changes of temperature or leaking.

#### Q. Describe cylinder lubrication system of a diesel engine.

The lubricator are usually supplied with oil from a day tank, through gravity which equipped with a built in float, strainers and stop valves. The oil is pumped into the cylinder by lubricator pump via non return valve, passing a number of lubricating orifice during the upward stroke. The oil feed rate or dosage should in accordance with the engine builders recommendation and should be increased during starting, maneuvering and large changes in engine load.

While on high speed diesel engine, cylinder is lubricated by bearing oil thrown from the crankpin, which is splash method of lubrication found on a trunk type diesel engine.

## Q. What are the preparations for starting up engines after installation, longer standstill or major overhaul?

a) Crankcase should be cleaned well and all internal parts wiped off if necessary. Use rags, not cotton waste. Adjust and secure all internal bolts. Be aware that any loose cotter pin, bolt, screw or nut may have serious consequences, especially when these cannot be adjusted during operation.

STARTING AIR:

- b) Starting air bottle pipes should be blown free of any mud, dirt or water.
- c) Check pressure of starting air bottles. It should be between 25 and 30 kp/cm<sup>2</sup>.
- d) Grease roller bearing in starting air relay.

#### LUBE OIL

- e) Before filling the lube oil, check oil sump, canals and pipes carefully. Remove any mud and rust. When wiping off use rags.
- f) After longer standstill periods drain any water and mud from oil sump.
- g) With the pneumatic lube oil primer pump, oil is pumped through the engine at the same time as the engine is turned. Check driving gear. See that oil is forced through to all the lube points connected to the main lube oil system.
- h) Check, and if necessary, clean the lube oil filter. Check valve gear lube oil tank before filling it up. Remove any mud and rust.
- i) If the valve gear lube oil has become mixed with fuel oil after a longer standstill (during overhaul of the fuel oil system), the oil should be changed.

FUEL OIL:

- j) Before filling fuel oil, check tanks and pipes carefully. Remove any mud and rust.
- k) After longer standstill periods drain any water and mud from oil tanks. Check oil level.
- I) Disconnect fuel oil pipes from filters and let the oil flow through until free of dirt from tank and piping. Check, and if necessary change after elements.
- m) Bleed all air from fuel oil system. When bleeding the fuel oil system, the fuel oil primer pump can be used. One must avoid to dilute the valve gear lube oil when the fuel injection pumps are bled.

#### STARTING OF ENGINE:

- a) Open the fuel valve and/the cooling water valve. Close indicator valve.
- b) Remove the turning bar from the flywheel.
- c) When the above mentioned instructions are carried out, open the main valve on the starting air bottle and admit air to the cylinders. As soon as the engine has started, the main valve should be closed.
- d) Immediately after starting, check all manometers, for temperatures and pressures.

#### PREPARATION FOR STARTING UP AFTER SHORTER STAND STILL PERIODS:

- a) If the engine has been out of operation for some time, it should be carefully checked before starting. Priming the fuel oil system should not be necessary, provided nothing has happened that would admit air to the system.
- b) Prime the lub. oil system, when turning the engine slowly, to admit oil to all the lub. points.

#### **ATTENTION DURING OPERATION:**

- Check the engine speed, pressures and temperatures at regular intervals. **a**)
- b) After each start, check that the starting air pressure is above the lower limit, i.e. 15kp/cm<sup>2</sup>. If the pressure is lower, the starting air bottles have to be charged.
- At intervals drain the starting air bottle for condensation. C)
- d) The lube oil pressure in the main system after filter should normally be 2.5 - 3.0 kp/cm<sup>2</sup>. For the valve gear lub. oil system 0.5 kp/cm<sup>2</sup> minimum.
- e) The lube oil temperature at outlet from engine should normally be 60°C.
- The cooling water pressure should normally be 1.0 2.5 kp/cm<sup>2</sup>. f)
- g) The cooling water temperature at outlet from engine must not exceed 80°C. Normal outlet temperature is 70°C. depend on engine instruction.
- The charge air temperature must not exceed 60°C after cooler. When the charge h) air temperature increases, the exhaust gas temperature will also increase. Check the charge air temperature at full load.
- Instruction for turbocharger and intercooler, separate service manual. i)
- j) k) Instruction for Woodward Governor see separate service manual.
- Measuring of pressure in cylinder by taking power diagram.

Occasionally measure cylinder pressure of all cylinders to examine if there are any faults with the fuel injection or the combustion. Measure compression and combustion pressure every time the chain, camshaft or fuel injection pumps have been dismantled or changed.

STOPPING ENGINE

a) Shorter interruptions of operation.

Run the engine on no load at idle speed until the temperature are stabilized. Stop the engine. Fuel oil and cooling water valves are closed, if needed.

If danger for frost, all the water in the engine and the pipes has to be drained. Faults observed during operation must be repaired.

Longer interruption of operation. b)

> Run the engine on no load at idle speed until temperatures are stabilized. Stop the engine.

The starting air pipes must be blown through.

The indicator valves must be opened.

Starting air bottles are drained for condensed water.

The fuel oil and the cooling water valves have to be closed.

If danger for frost, all the water in the engine and pipes has to be drained.

Water and mud are drained off the fuel oil and the lube oil tank. The lube oil must be changed if necessary.

If the engine will be out of operation for a few weeks or more, it must be cleaned and all polished parts must be lubricated with an anti-corrosive oil.

#### **STARTING DIFFICULTIES AND TROUBLE SHOOTING:** 1.

**A**. The engine does not turn when starting air applied.

#### **Possible causes:**

- 1. Air pressure too low.
- 2. One or more starting air valve have stuck. 5. Pilot valve shut.
- 3. The starting valve leaking in cylinder
- **B**. The engine does not ignite or firing
  - 1. Air in the fuel system.
  - 2. The fuel oil filter or the fuel pipes are blocked.
  - 3. Incorrect adjustment of the fuel injection pumps.
  - 4. Clogged fuel nozzles.
  - 5. Fuel By-pass open.
  - 6. Booster fuel pump failure.
  - 7. Air compression pressure too low

#### **Possible causes:**

Water in the fuel oil.

The compression pressure is too low caused by:

- Worn or broken piston rings. a.
- b. Leaking valves in cylinder cover.
- Leaking gaskets between the cylinder covers and the cylinder liners. C.
- d. Too thick gaskets between the cylinder liners and the cylinder block.

#### 2. THE ENGINE STOPS

- 1. Air in the fuel oil system.
- 2. Faults in the fuel supply.
- 3. Water in the fuel oil.
- Clogged pipe lines or fuel oil filter. 4.
- 5. A piston has seized.

#### **ENGINE RPM DROPS** 3.

- 1. Engine is overloaded.
- 2. Injection pumps are working irregularly. Air in fuel system.
- A piston or a bearing has a breakdown due to insufficient lubrication or dirt in lube 3. oil.

#### **Possible causes**

- 1. One cylinder "falls out".
- Leakage between the cylinder liner and the piston. 2.
- 3. Leakage in top gasket.
- 4. Clogged fuel oil filter.
- The inlet and/or the exhaust valves are leaking. 5.
- 6. The valve clearances are too small.
- Filter for turbo-charger is clogged. 7.

- 4. Cloaged fuel nozzles.
- 6. Starting distributor valve shut

### 4. THE ENGINE KNOCKS

- 1. Injection is too early, due to incorrect pre-injection angle.
- 2. Faults in injection valves.
- 3. A piston becomes too hot and seize.
- 4. The gudgeon pin or big end bearing have too big clearances.
- 5. Too big piston clearance. Worm cylinder liner.
- 6. Overloading
- 7. Poor fuel/air atomization

### 5. ABNORMAL EXHAUST GAS

#### A. Too high exhaust gas temperature from one cylinder:

- 1. Too high admission on fuel injection pump.
- 2. Injection is too late.
- 3. Injection valve has too low opening pressure.
- 4. Partial clogged fuel nozzle.
- 5. Injection valve leaks.

#### Possible causes

- 1. Valve clearances too big.
- 2. Clogged exhaust system.

#### B. Too low exhaust gas temperature from one cylinder:

- 1. Too low admission on fuel injection pump.
- 2. Injection is too early.
- 3. Injection valve has too high opening pressure.
- 4. Clogged nozzle holes.
- 5. Water leakage in the cylinder.

#### C. Too high exhaust gas temperature in all the cylinders:

- 1. Engine is overloaded.
- 2. Injection is too late.
- 3. Too high temperature of charging air.
- 4. Charge air pressure is too low.
- 5. Clogged charge air filter.
- 6. Clogged exhaust gas system.

#### D. Black exhaust gas.

- 1. Engine is overloaded.
- 2. Some cylinders are overloaded.
- 3. Inlet or exhaust gas outlet valve is leaking.
- 4. Faults in the fuel injection pumps or valves.
- 5. Ignition timing faulty.
- 6. Fuel Temperature too high.

#### **Possible causes**

- 1. Bad fuel oil.
- 2. Piston rings have stuck.
- 3. Injection is too late.
- 4. Exhaust manifold or exhaust pipes are clogged.

#### E. Bluish exhaust gas.

1. Too much lube oil in one or more cylinders.

#### F. White smoky exhaust gas.

- 1. Engine is too cold.
- 2. Water in cylinder.
- 3. One or more cylinder not getting enough fuel.
- 4. Too low compression pressure.

#### 6. LUBE OIL PRESSURE DROPS

#### A. Main system

- 1. Too little lube oil in circulation. The pump sucks air.
- 2. The lube oil filters are clogged.
- 3. Leakage in lube oil pressure pipes inside the engine. Loose main bearing bolts.
- 4. A bearing is damaged.
- 5. Oil temperature is to high. Oil cooler is dirty.
- 6. The oil relief valve on the bedframe or the safety valve on the pump is sticking.

#### B. Valve gear system.

- 1. Too little lube oil in tank.
- 2. Drain pipes to tank are clogged.
- 3. Lube oil is diluted with fuel oil.
- 4. The lube oil filter is clogged.

#### **Possible causes**

- 1. The lube oil pipe is clogged.
- 2. The oil relief value in the filter or the safety value on the pump is sticking.

#### 7. OVERHEATED BEARINGS

- 1. Clogging that prevents the oil supply.
- 2. Dirty filters.
- 3. Too low lube oil presure.
- 4. Too narrow clearances.
- 5. Too high lube oil temperature.
- 6. The oil cooler is dirty.

#### 8. INSUFFICIENT COOLING

#### A. The cooling water temperature on one cylinder increases.

- 1. Clogged cooling water pipes.
- 2. Cylinder is overloaded.

#### **B.** Increase of cooling water temperature on all cylinders.

- 1. Engine is overloaded.
- 2. Cooler is clogged.
- 3. Air in cooling water system.

#### **OPERATION PROBLEM AND HAZARDS IN ENGINE**

"Prevention is better than cure." Problems and accidents just do not take place without reason, they are caused. In case a problem has already taken place, you need to think why it has taken place, but your immediate task should be to take quick necessary steps so that the plant does not deteriorate any further. For example, if a piston runs hot – do something quickly so that it does not run hot any more. Now start thinking why did it run hot at all at first place.

#### **EMERGENCY PROCEDURE WHEN PISTON RUNNING HOT**

- 1. Reduce engine speed immediately (dead slow)
- 2. Cut out fuel to the cylinder troubled.
- 3. Supply maximum quantity of the coolant to the piston.
- 4. Increase cylinder lubrication.
- 5. Higher cylinder cooling temperature, do not stop the engine immediately and allow gradual cooling. If engine stop, turns by turning gear.

#### **CRANKCASE EXPLOSIONS**

Initiated by a "hot spot" in the crankcase which generated the vapour. As the "fuel: air" ratio reaches explosive limits, the same "hot spot" provides the source of heat. It could be fatal to the human being and machinery in the absence of correct positive steps to prevent an explosion.

#### Safety Features

- a. Crankcase mist detector
- b. Crankcase relief doors
- c. Strong Crankcase chamber

#### Steps to be taken immediately in case of an explosion

- a. Stop engine immediately
- b. Put turning gear "on" & start turning the engine to prevent seizure
- c. Keep lubricating oil and cooling pumps on
- d. Do not open crankcase door for at least 1/2 hour until the engine cools down
- e. Investigate the cause and remedy

#### AIR STARTING LINE EXPLOSION

The fuel comes from the air compressor lubrication through bottle and into the line in the form of oil layer. If air is present, source of heat in the form of hot gases from leaky air starting valve, suddenly opened high pressure air in the line from air bottle result in explosion.

#### Safety Device

- I. Relief valve
- II. Bursting Cartridges

#### **Precautionary Measure**

- 1. Keep air bottles free of oil by regular draining
- 2. Maintain starting line clean
- 3. Maintain air starting valves

#### **SCAVENGING FIRE**

#### Causes of fire in the scavenging air box.

- 1. Ignition of carbon deposits in scavenge air by means of prolonged blow-by
- 2. Slow combustion in the cylinder due to incorrect atomization
- 3. Blow-back through scavenge air ports due to incorrect adjusted exhaust cam disc or back pressure

#### Warnings of Scavenge Fire

- 1. Increased in exhaust temperature of effected cylinder
- 2. Turbo charger may surge
- 3. Smoke from the turbo chargers air inlet filter
- 4. Hotter scavenging air box casing.

Measures to be taken

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- 1. Reduce speed to slow and ask bridge for permission to step.
- 2. Stop the auxiliary blower if fitted.
- 3. Stop the fuel oil supply.
- 4. Put the scavenging air box fire extinguishing steam equipment into function.
- 5. After extinguish the fire, remove dry deposit and sludge from all the scavenge air boxes.
- 6. Clean and inspect respective piston rod and cylinder liner, their surfaces alignment if affected.

### **STEAM TURBINES**

#### Q. What is a steam turbine?

A steam turbine is a heat engine in which the potential energy of a steam is changed into useful work into two distinct steps:

- 1. The available energy is converted into energy of motion, kinetic energy, by steam expansion in a nozzle or suitable passage, from which the steam emerges at a high velocity.
- 2. This kinetic energy is converted into mechanical energy or useful work by directing the steam jet against blades mounted on a revolving rotor, or by the reaction of the jet itself in the expanding passage if the passage revolves.

STEAM TURBINE – consist of motor wheel with blades secured to the shaft. A high velocity jet of superheated steam is directly to the nozzles in impulse turbine or by stationary blades in reaction turbine, against the blade row to produce rotational motion of the shaft which is connected to reduce reduction gear leading to propeller. It is mounted by apparatus and steam seals in order to prevent leakage of high pressure steam to the atmosphere and air into the low pressure side.

### **Q.** What are the two basic types of steam turbines with respect to the action of the steam flow inside the turbine casing, operating principle?

#### **1. Reaction turbine**

- a. Consist of one row of moving blades and one row of stationary blades.
- b. Pressure drops as steam passes through the rows of stationary, blade and moving blades.
- c. Steam velocity increases in passage through stationary blades and decreases in moving blades.
- d. Speed of reaction blades varies directly equal to the speed of steam.
- e. It consist of several numbers of stages of moving and stationary than impulse turbine thereby occupying more cargo space.
- f. It is mostly used on low pressure, low velocity, and large volume steam on power plant.
- g. Most fitted low pressure turbine are cross compound unit.

#### 2. impulse turbine

- a. Steam expands in the nozzles with a decrease in pressure, but an increase in velocity before it strikes the motor blading.
- b. The first stage on impulse turbine often permitted to take more than equal share of the available pressure drop, thereby its advantages are:

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- 1. casing is subjected to lower striking pressure.
- 2. rotational losses is lowered due to decreased steam density.
- 3. fitted with high pressure seal.
- c. Speed of impulse blades rated varies as one half of the steam speed.
- d. It permit use of partial admission of steam, on steam chest fitted with nozzle to increase efficient operation.
- e. Impulse blade are generally attached directly to the wheels, made in longer length attached.
- f. Impulse blading is heavier and stronger than reaction turbine.

#### Q. What are the normal operating procedure in starting a Turbine Unit?

In starting any turbine unit with which he is not familiar, the engineer should thoroughly study the manufacturer's recommended procedure. The procedure given below is generalized and may differ in minor details from that furnished by any particular manufacturer:

- 1. Start up the lubricating oil pump. Check gravity tank to see if oil supply is sufficient. See that oil pressure is established on bearings and that oil is passing through sight glasses leading to reduction gear housing. If the oil temperature is less than, say, 65°, it must be passed through the heater until its temperature reaches 90 to 100°F.
- 2. Open turbine-casing and throttle-valve drains.
- 3. The turbine is then jacked over for at least one hour by using the turning gear. Check with the bridge so that the deck officer on watch can investigate mooring lines and whether or not the propeller is clear.
- 4. Start the circulating and condensate pumps. Open the recirculating valve from feed tank to condenser so that condensate pump is assured a water supply.
- 5. Check level of water in boilers. If the level is as it should be, open the main steam stop valve.
- 6. Start the second-stage air ejector and bring vacuum up to approximately 15 inches of mercury.
- 7. If control valve is actuated by oil pressure, open valve that admits oil to governing mechanism.
- 8. Put steam on sealing glands. Admit steam to steam seal regulator.
- 9. Remove jacking gear.
- 10. Open throttle valve wide enough to start the rotor turning immediately; then throttle down until the turbine is turning over slowly. On gear-driven installations, steam should be first admitted to the astern element.
- 11. Check the emergency-governor mechanism. Trip the turbine out, reset, and readmit steam to turn rotor slowly.
- 12. Listen for unusual noises.
- 13. On *electric drive*, keep rotor turning over slowly. On *gear drive*, alternate rotation of turbine slowly, ahead and astern.
- 14. Start up first-stage air ejectors and bring vacuum to normal.
- 15. Circulate sufficient cooling water through oil cooler to maintain temperature of oil entering bearings between 110 to 120°F
- 16. Stand by to maneuver. Observe pressure and temperatures to see that they remain normal.
- 17. When underway, *close recirculating valve and turbine drains*. Precaution. *Proper warming up* of the turbine is extremely important.

#### Q. Explain how you would secure your turbine installation after your voyage?

Steps to secure turbine installation after voyage:

- a. Start auxiliary condensate system and transfer auxiliary exhaust and make up feed to the auxiliary condenser.
- b. Use hand tripping device to shutt steam off main turbine then close throttle and bulkhead stop valve.
- c. Secure the main air ejector and main condensate pump.
- d. Shutt off gland seal steam and open turbine drain.
- e. Rotate main turbine with turning gear until it cool off and then secure turning gear and the main lubricating pump.
- f. When main condenser has cool off, secure main circulating pump.

### Q. What is meant, function of the following mountings, fittings on steam turbine unit?

*Turbine rotor* –consist of shaft, spindle rings or wheels and blading. The shaft is a steel forging with integral thrust collar. Wheels are secured to the shaft and blades dovetailed into the wheels. Fitted also dummy piston and gland sealing secure on high and low pressure end of the shaft.

**Turbine casing** – made in two halves housing that encloses the rotor; for low pressure made of cast iron, and steel for high temperature. It has a space for receiving steam sealing glands and extraction connection. The two halves of the casing are bolted together with a metal to metal contact but required graphite before assembly.

*Throttle valves* – provide hand control throttling of steam to increase speed and trip quick closing valve either by hand or emergency governor.

Steam strainer – fitted between main turbine stop valve and entrance of admission valve to prevent scale or rust that cause erosion or breaking of turbine blade from steam lines.

Gland Steam Seals – to prevent escaping of steam from high pressure end and also eliminating air leakage into the low pressure end while on standstill.

**Reduction gears** – it reduce the high speed turning of a turbine to the low efficient speed of a propeller. It consist of thrust bearing collar, main reduction gear, and pinion gears secured to the shaft. Double reduction gears mostly use in cross – compound turbine either nested, articulated type.

Steam extraction – consist of flanged connection from turbine casing, used for external purposes for feed water heating, evaporator steam supply, ships heating, thereby increasing over all plant efficiency by reducing the amount of cooling surface need to the condenser, also act as reducing valve to lower pressure and temperature used in auxiliary heatings.

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**Diaphragms** – found in impulse turbine used to hold the nozzle blocks and prevent steam leakage between the stages.

*Turning gear* – used to warm up the turbine, provide slow rotation, thereby permitting inspection of clearances and condition of reduction gear teeth.

*Turbine bearings* – fitted at the end of the turbine to carry the weight of the rotor assembly and absorb end thrust in reaction turbine.

Flexible coupling – used to connect turbine and driven shaft for the following reasons: It provide inequality in bearing wear, permit axial adjustment of turbine rotor, and allow differences in expansion. Types are: rubber bushing, pin and gear type.

**Squealer ring** – fitted on older type turbine device warn the engineer of less than adequate axial turbine clearances later type turbine, now fitted with micro meter gauges by which axial clearance may be checked.

**Dummy or balance piston** – used to counter act pressure difference across the bladings in reaction turbine, which move the rotor axially toward the exhaust end, and fitted on inlet end of the rotor.

**Nozzles** – are fitted in impulse turbine, to change thermal energy(velocity). Also to direct jet of steam from nozzles against blades mounted on a wheel which is converted into work.

Stage – is a part of the turbine unit in which a single pressure or velocity drop take place.

**Pressure stage** – combination of nozzles with one or more rows of blades, which single pressure drop occur between inlet to the nozzle and exit from the last row of blades.

**Velocity stage** – speed of the steam flows through one set of vanes is reduced without reduction of pressure.

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Stationary blades – fitted on reaction turbine for the purpose of directing steam flow to the next of moving blades.

**Shrouding** – is a strip metal secured to the ends section of blading, which adds strength, lessen vibration, prevents steam leakage over blade tips.

Tip clearance - the distance between the tip of the blade and the casing.

Static balance – the part to be balanced is place on knife edges has been leveled and remove low and high spot which determine by force of gravity, certain amount of metal. **Dynamic balance** – the unbalance force is determine while the rotor in motion until angle correction has been made, by means of dynamic balancing machine, after it can be rotated at any speed within a safety factor of the material without apparent vibrations.

*Critical Speed* – At critical speed all the vibrations are in harmony, their sum producing a total vibration which would cause the metal of the part to become fatigued, the tensile strength to be lowered.

Sentinel value – fitted or exhaust casing of a steam turbine, to warn or indicate excess steam pressure.

Bridge gage - an instrument used to find radial position of a crankshaft or rotor shaft.

Dummy micrometer - instrument used to measure the axial clearance of a turbine rotor.

Torsion meter - an instrument used to determine the shaft horsepower of an engine.

*Scoring* – in reduction gear is the result of scratches or gauges caused by foreign materials in the oil.

**Galling** – caused by chafing of metal from one gear tooth and depositing it to the mating tooth of another gear.

# **Q.** What is the difference between isothermal expansion and adiabatic expansion of gases?

Isothermal expansion is expansion of gas where its volume increase but its temperature remain constant. To maintain the temperature ousted the gas air expand must be heated.

Adiabatic expansion is expansion gas where in its volume increases and its temperature decreases.

### Q. What are the advantages and disadvantages of steam turbine

#### Advantages

- 1. Better utilization high vacuum
- 2. Permits use of higher pressure and temperature
- 3. Lesser weight per horse power
- 4. There are fewer wearing parts
- 5. Less vibration due to elimination of reciprocating parts
- 6. Can handle extreme overload capacity
- 7. Automatic oiling in turbine saves labor and consumption
- 8. Exhaust steam free from oil
- 9. Require less engine space per horsepower
- 10. Reliability

#### **Disadvantages**

- 1. Breakdown are usually serious and requires shore expert and special equipment.
- 2. Reduce power astern.

#### Q. Give the different types of Steam and define each.

- 1. Saturated Steam kind of steam produce by boiling water in a closed vessel where steam is the same condition temperature and pressure as the water. Mostly produce by low pressure fire tube boiler for heating purposes.
- 2. Wet Steam it is a saturated steam but is usually considered as containing more entrained moisture by volume than is natural to its saturation pressure, and temperature which sometime called wet saturated steam.
- 3. Dry Steam condition is between wet and dry saturated steam, which contains little or no moisture due to arrangement of their drypipes or heating component parts.
- 4. Superheated Steam type of steam required in steam turbine plant or engine, where steam is being heated to a higher temperature above that due to its pressure. It consist of first and second stage of superheated tubes, where saturated steam from boiler passes through stages and heated by the boiler exhaust from furnace, thereby increasing its temperature by eliminating moisture entrained to saturated steam but the pressure remain the same. Superheated steam used to main turbine to avoid damage of blades and other parts.

#### Types of superheater:

- 1. Radiant superheater located in the furnace of a boiler, heat transfer by radiation directly from the flame of the fire.
- 2. Convection superheater fitted in the boiler so that it receives all of its heat from the hot combustion gases by connection. Protect by 2 or more rows of screen tubes to avoid direct contact on burned hot gases from furnace. Usually installed on marine boilers nowadays.
- 5. Desuperheater a coils of piping device installed in the steam drum of a boiler, submerged to water, connected from outlet of superheater and the outlet piping end connected to auxiliaries which cannot use superheated steam, by reducing steam superheat to saturated or mildly superheated steam called *internal desuperheated steam* used for sootblowers, atomizing steam, feed water pumps. Another method is external desuperheated steam directly contact of superheated steam and condensate water, thereby producing saturated or wet steam at low pressure and temperature for cargo oil pump and ballast pumps. Another term for desuperheater is attemperator.

# Q. What are the various devices for controlling speeds of turbines? Explain each one.

- 1. *Throttle Valve* Used in maneuvering or for minor changes in speed. Varies the steam chest presssure.
- 2. Nozzle Control Valves Used to control speed and power requirements without throttling loss.
- 3. By-Pass Used only for excessive power or speed requirements. With throttle and all nozzle control valves wide open, a point is reached where no more steam can pass through the turbine, the flow being limited to the cross-sectional area of the first stage nozzles. In order to increase the flow, valves are installed which by-pass most of the steam around the first stage admitting it to later stage or stages where the nozzle openings and blade areas are larger, thus developing more power.
- 4. Speed Regulating Governor To maintain revolutions constant, either mechanical, mechanical hydraulic relay or direct hydraulic.
- 5. Overspeed Trip Prevents high damaging speeds, generally spring loaded plunger built into turbine shaft. Centrifugal force causes plunger to fly out and trip a trigger, releasing spring which closes throttle.
- 6. Hand Trip Used in conjunction with overspeed trip.
- 7. Low Oil Trip When lube oil pressure is reduced to a predetermined point, a hydraulic relay causes throttle to close.
- 8. Back Pressure Trip Some units fitted with diaphragm relay to trip throttle when vacuum is reduced generally not installed on main propulsion units.

### Q. What are the probable causes of Low Vacuum?

- 1. Insufficient circulating water. The circulator may have slowed down or stopped, or the pump may require speeding up owing to the vessel having entered a stream of warmer water. The sea suction may have become clogged with ice or seaweed.
- 2. Improper flow through the condenser. Steam side of the condenser may be fouled with grease (from reciprocating auxiliaries), the water side may be coated with mud, or the division plate in the (two-pass) condenser may be cracked.
- 3. Air leaks into the condenser due to poorly functioning low-pressure steam seals or to a leak at the connection between turbine and condenser.
- 4. Air ejector may not be operating properly. Steam pressure may be too low or may be fluctuating. Ejector nozzles or strainer may be clogged up.
- 5. Condensate-pump speed may be so low that insufficient cooling water is supplied to air-ejector condenser. Water may have been blown out from the loop seal connecting the intercondenser to the main condenser.

#### Q. What are the methods of gland sealings on turbine?

Usually in steam turbine sealing gland are used on high pressure end-to prevent leakage of steam to the atmosphere, at low pressure end-to prevent air leakage into the exhaust end of the turbine. Also at nozzle and diaphragm blocks fitted in impulse turbine to prevent steam leakage along the shaft. Types of gland seals are:

- 1. Metallic labyrinth packing 3. Water seal type
- 2. Carbon ring packed gland 4. Stuffing box type

#### Q. What are the two major adjustments of the main propelling turbine.

The two methods of adjustment for fixing the rotor in its proper radial and axial position. Radial position of the rotor is maintained by the main bearings and axial position by the thrust bearing. Instrument used to detect if any change in the height of the turbine rotor. The axial clearance between rotating and stationary parts of turbine is controlled by the adjusting of thrust blocks, by using finger plate and clearance indicator methods.

#### Q. What are the different types of reduction gear?

1. Single reduction gear – consist of small pinion gear, driven directly from the turbine shaft, engages a larger main gear attached to the propeller shaft.

2. Double reduction gear – consist of two types, the nested and articulated type. Have the same principle in operation, only fitted a second or intermediate set of gears installed between the main turbine shaft and propeller shaft thus giving a double reduction unit. It is mostly installed on cross – compound steam turbine.

#### Q. What is the purpose and types of flexible coupling in a turbines?

*Flexible coupling*—are used to connect turbine and driven shafts to allows any differences in expansion within limit, permit axial adjustment of turbine rotor and provide clearances to main bearing wear.

Three types of flexible coupling usually used:

- 1. rubber bushing
- 2. pin type
- 3. claw or gear type

### Q. Name different types of losses which prevent a steam turbine from being 100% efficient.

- 1. Throttling loss, or pressure drop at throttling and governor valves.
- 2. Leaving loss, or exit velocity after steam leaves last row of blade and can do no further useful work.
- 3. Exhaust loss, or turbulence in exhaust which does no useful work.
- 4. Gland leakage; loss of steam by leakage through gland packing and dummy piston.
- 5. Mechanical; friction loss, friction at the bearing.
- 6. Radiation loss; loss due to heat radiation from casing.
- 7. Nozzle and blade loss; losses due to steam friction and windage.
- 8. Interstage leakage loss; loss from one stage to another, over blade tips or through diaphragm packing.

As engineer on board, the immediate action should be done is to slow-down the turbine and make necessary inspection or observation what is the cause. If the cause is mechanical defect, that cannot be rectify on board especially the turbine side, proceed if possible or bring the vessel in port for repair which is duly authorized repairman of the maker.

## Q. How can you detect the turbine output is reducing to normal standard base on trial record?

- 1. Unusual noise of vibration
- 2. Increased in steam consumption
- 3. Changes in speed required
- 4. Unstable vacuum reading
- 5. Pressure and temperature reading shows abnormal limit than standard point.

Q. What is the procedure, with respect to a geared turbine vessel, when coming to a stop and the orders are to stand by for an indefinite period, being ready to get under way within 15 minutes.

- 1. Open the circulating valve from the deaerating feed tank to the condenser. It may also be necessary to open the circulating valve from the main air ejector to the condenser.
- 2. Secure the first stage of the air ejector and maintain vacuum as obtained from the second stage.
- 3. Maintain lubricating oil at the required temperature.
- 4. Crack turbine and throttle drains.
- 5. Slowdown main circulating pump to supply a flow of water just sufficient to maintain desired vacuum.
- 6. Engage turning engine and keep turbine rotor turning continuously. The above can be accomplished in any sequence.

## Q. What are the requirements in operation and maintenance in order to have a good vacuum in steam turbine.

- 1. It must have a good condition of gland packing.
- 2. Sealing steam or water gland on both ends of turbine at low required pressure at all times.
- 3. It must free from air leaks on exhaust trunks, condensers, joints, valves.
- 4. Keep air pump and ejector in working condition.
- 5. Main condensers must free from scales, dirt and mud.
- 6. Keep the temperature overboard discharge lower then vacuum temperature.
- 7. Avoid back pressure due to higher vacuum that require more heat energy to the pumps and ejector.

#### Q. What are the advantages of the turbo-electric drive?

- 1. Better maneuverability.
- 2. Elimination of the astern turbine.

- 3. Increased economy at reduced powers, especially when two or more generators are provided.
- 4. If the motor is located in the after end of the ship, there is a considerable reduction of shafting.
- 5. Full astern power available.

#### Q. What is a Reciprocating Steam Engines.

Reciprocating Steam Engine – consist of piston enclosed inside the cylinder, connected to crosshead, thus reciprocating, motion transmitted through a connecting rod to a crank which drive the rotary crankshaft which produced a rotary motion of the propeller shaft. Steam valve gear actuated by the crankshaft, allows steam to enter the engine cylinder and permits exhaust steam to leave the cylinder.

#### Q. What are the advantages and disadvantages of Reciprocating engine?

#### Advantages:

- 1. Simple in construction, can repair if any breakdown
- 2. Heavy duty construction stands up under terrific treatment.
- 3. Full power astern.

#### **Disadvantages:**

- 1. Restricted to lower pressure and temperature
- 2. Lower efficiency than turbine
- 3. Not reliable with superheated steam
- 4. Reduce heat transfer caused by re-evaporation and initial condensation

#### Q. What are the advantages in construction of multistage steam engine and types?

- 1. It prevent or reduce initial condensation and re-evaporation.
- 2. Higher mechanical efficiency due to ratio of maximum pressure to mean effective pressure is reduced each cylinder.
- 3. No flywheel is necessary to get the piston over dead center position.
- 4. Weight of moving parts is less per cylinder.
- 5. Enough power developed each cylinder.

#### Multistage engines are generally consist of:

- 1. Compound engine –used on small craft; like tugboat or ferries which expansion taking place in two successive cylinders.
- 2. Triple expansion engine consist of a high, intermediate and low pressure cylinder, where expansion of steam is taking place.

**3.** Quadruple expansion engine – is a four cylinder engine consists of one high–, two intermediate–, and one low pressure cylinder, which steam expansion take place at different stage pressure.

### Q. What are the purpose of the steam lap and exhaust lap in the slide value a reciprocating steam engine?

STEAMLAP – is that part of the valve which ovelaps the admission edge of the port when the valve is in mid-position. The purpose of steam lap is to permit cut off to occur so that steam within the cylinder may expand.

EXHAUST LAP – is the part of the valve which overlaps the exhaust edge port when the valve is in mid-position. The purpose of exhaust lap is to stop the exhausting of steam at predetermined point and to trap a certain volume of steam within the cylinder, thus permit the formation of a steam cushion which prevent pounding when piston reaches the end of its stroke.

#### Q. What are the factors that may prevent engine from starting?

- 1. No vacuum
- 2. Low pressure steam of the boiler
- 3. Engaged turning gear
- 4. Condensate and other foreign material in cylinder
- 5. Stuck-up or frozen bearings
- 6. The high pressure piston stopped at dead center
- 7. Crosshead strongback still in place
- 8. Loose mechanical parts

#### Q. What is the purpose of stephenson linkage in reciprocating engine?

Stephenson linkage has two prime important functions:

- 1. It permits reversal of the engine.
- 2. Allows distribution of work between the various cylinder of the engine.

### Q. Give reasons for the use of reduction gears with turbines rather than direct drive.

In order to preserve the steam speed-blade speed ratio, turbines should operate at high speeds. Propellers are efficient only at low speeds due to churning, eddies, and cavitation. With direct drive, the turbine shaft is joined directly to the propeller shaft through a flexible coupling. The rotor must turn very slowly, making the same revolutions per minute as the propeller. In order that the blade peripheral speed ratio, the corresponding turbine diameter must be enormous. To accommodate the high speed of the turbine to the low speed of the propeller, mechanical reducing gears are employed. Since direct drive has no outstanding advantage over the geared turbine but does have many disadvantages such as weight, space, and low economy, it has become obsolete.

#### Q. What are the rotational losses in a steam turbine?

- 1. Blade loss caused by friction as the steam passes over the blades.
- 2. Tip leakage loss the loss of steam over the tips of both fixed and moving blades.
- 3. Leaving loss- the residual velocity of the steam passing through exhaust to the condenser.
- 4. Mechanical friction loss result of friction through the bearings, and reduction gears.
- 5. Windage loss caused by fluid friction as the turbine blades rotate in the surrounding steam.

### Q. What are the methods of determining the quantity of steam consumed by a turbine?

- 1. By a steam flowmeter
- 2. By measuring the feed water
- 3. By measuring the condensate usually best method to check the quantity of steam for greater accuracy use on board.

#### Q. How can you determine the output of a turbine?

- 1. By mechanical means such as a pony brake or water brake, torsion meter
- 2. By measuring the output electrically through a dynamometer.
- 3. By a thrust meter.

#### Q. What are the causes of noise and vibration in turbines?

- 1. Misalignment
- 2. Loose couplings
- 3. Operating the critical speed range
- 4. Excessive bearing clearances
- 5. Insufficient thrust bearing clearances
- 6. Unbalance dues to loss blade, deposit of dirt, corrosion loose parts
- 7. Loose foundation bolts and nuts
- 8. Changes of load pressure and temperature
- 9. Bending of shaft or distortion due to rubbing of blades glands.
- 10. Insufficient lubrication on reduction gear.

### Q. What are the effect of too much vibration and what action should be done as engineer on board?

#### Effect of vibration are the following:

- 1. Breakage of rotor shaft, blades piping and linkages
- 2. Severe stress and cracked formation
- 3. Loosening of fitting joints
- 4. Damage to casing and foundation
- 5. Damage to instruments or gauges

### **BOARD QUESTIONS**

### STEAM BOILERS, ENGINES, TURBINES, INTERNAL COMBUSTION AND MACHINE SHOP

- 1. The result of a low alkaline boiler water, the presence of free oxygen or both may result in:
  - A. scale C. foaming
  - B. corrosion D. priming
- 2. Nozzle block bolted to the steam chest, which in turn is bolted to base of the turbine casing is called:
  - A. turbine cylinder C. wheel casing
  - B. diaphragm D. dovetail roots
- 3. The "scleroscope" is used to determine the:
  - A. "hardness" of the metal
  - B. "thickness" of the metal
- C. "brittleness" of the metal
- D. crack on the metal
- 4. Flash point of oil is the temperature at which:
  - A. fuel oil will ignite in the cylinder
  - B. fuel temperature above 150°F
  - C. 150<sup>0</sup>F
  - D. fuel must be heated to allow flammable vapors to form on its surface
- 5. To determine the discharge capacity of the safety valve on boilers is known as
  - A. accumulation test C. steam stop test
  - D. safety adjustment test B. pop test
- 6. The inner sides of a combustion chamber of scotch boilers are stayed by direct stays called:
  - A. girder stays
  - B. sling stays
  - C. diagonal stays
  - D. stay bolts
- 7. Rupture disk are installed for emergency purposes on the
  - A. steam turbines

- C. steam condenser
- D. boilers B. air ejector

- 8. The lap of a steam valve of reciprocating steam engine is measured when the valve is in the
  - A. central position

- C. steam condenser
- B. air ejector D. boilers
- 9. Kinetic energy is the energy of the body has due to its
  - A. position

C. motion

D. horsepower

- B. temperature
- 10. Work is conveniently expressed in:

  - B. kilograms per minute
- C. kilogram meter
  - D. foot-pounds per minute
- 11. Power is the work done as
  - C. per unit of time A. 33,000 ft. pounds D. work times distance
  - B. 2450 kilograms
- 12. Which of the significant combustible elements of fuel oil is a major source of boiler corrosion?
  - A. oxygen C. hydrogen **B.** sulphur D. carbon
- 13. What pumps are normally used for fuel oil service?
  - A. positive displacement rotary
     B. two-stage centrifugal C. explosion proof gear
  - D. non-vented plunger
- 14. Phenolphthalein is used to test boiler water for:
  - A. hardness
  - **B.** alkalinity
  - C. hydrazine
  - D. chloride content
- 15. A waste heat boiler would produce maximum steam when used with which type of diesel engine?
  - A. supercharged, four stroke
  - B. supercharged, loop scavenged
  - C. turbo-charged, cross-flows scavenged
  - D. turbo-charged return flow
- 16. Waste heat boilers maybe equipped with vents on water heaters to
  - A. remove sedimentB. release excess pressure
- C. allow for feedwater treatment
- D. prevent air locks

17. A hydrazine test is conducted on boiler water to check for:

A. sulfatesC. phosphatesB. excess oxygenD. nitrates

18. How would you plug a leaky tube in a scotch boiler?

- A. by welding
- B. by metal lock
- C. by two tapered plugs connected by a rod
- D. cannot be repaired

19. What is the purpose of stationary blades in a reaction turbine?

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- A. to direct steam flow to the next set of moving blades
- B. to improve steam flow inside the turbine
- C. to give more steam power
- D. to give more flexibility on steam flow

20. Maximum pressure developed by a waste heat boiler is determined by engine exhaust

A. gas composition

C. timing

B. pressure

- D. gas temperature
- 21. Which of the significant combustible elements of fuel oil is a major source of air pollution?
  - A. sulphur
  - B. nitrogen
  - C. carbon
  - D. hydrogen
- 22. What always results in dissolved oxygen carry over from the main condenser?
  - A. taking on make up feed
  - B. priming in the boiler
  - C. dumping auxilliary steam exhaust to the main condenser
  - D. excessive temperature
- 23. A desirable property of boiler fuel is
  - A. low residual acid after combustion
  - B. low carbon content per pound of fuel
  - C. high sulphur content for complete combustion
  - D. high BTU content per pound of fuel
- 24. Nozzle diaphragms are installed in pressure compounded pressure turbines to
  - A. support moving blades
  - B. support shrouding
  - C. hold the nozzles of the stage
  - D. eliminate blade and nozzle losses

25.	<ol> <li>Superheated steam is used in the main propulsion turbine instead of satur steam, because superheated steam has</li> </ol>			
	<ul> <li>A. greater heat energy per pound of steam</li> <li>B. less specific gravity per pound of steam</li> <li>C. higher pressure than saturated</li> <li>D. less specific volume than saturated</li> </ul>			
26.	When heated, brickwork in a boiler is kept from buckling by installing			
	A. anchor boltsC. expansion jointsB. sliding saddlesD. insulating blocks			
27.	What refractory material can be used in an area directly expose to the highest heat in the furnace?			
	A. firebrickC. baffle mixB. insulating brickD. insulating block			
28.	How can the proper speed of the propeller be reduced against the speed of the turbine?			
	A. by reduction gearC. by installation of intermB. by modified turbine bladesD. by reducing steam inlet opening			
<b>29</b> .	What do you call the instrument that measure the radial position of the crankshaft or rotor shaft?			
	A. shafting gaugeC. spirit level gaugeB. bridge gaugeD. dial gauge			
30.	Steam produced by a boiler should be separated from moisture			
	A. before leaving boilerC. through the dry pipeB. by way of the superheaterD. in the turbine steam trap			
31.	Vacuum refers to pressures			
	A. 34 inches of mercuryC. below atmosphericB. 31 inches of mercuryD. zero gauge			
32.	Specific heat of a substance is defined as the heat required to raise the temperature of			
	A. 1 ib. of it to 1°C       C. 1 ib of it to 1°F         B. 1 kg. of it to 1°F       D. 10 ibs of it to 1°F			
33.	Too high alkalinity of boiler water may cause			
	A. scaleC. caustic embrittlementB. corrosionD. acidity			

æ. "

	34.	. The number of cubic feet of fresh water that will weigh one ton is			
		A. 62 cu. ft.C. 24.5 cu. ft.B. 35.84 cu. ft.D. 30.4 cu. ft.			
	35.	The pressure due to a column of H <sub>2</sub> 0 one foot high is			
		A491 lbs/sq. inC5 lbs/sq. inB434 lbs/sq. inD625 lbs/sq. in			
	36.	Specific heat of water is:			
		A. 1 B. 10 <sup>0</sup> F C. 100 <sup>0</sup> C D. 212 <sup>0</sup> F			
	37.	Latent heat of evaporization of water is			
		A. 100 BTU per lbC. 100 calories perB. 212 BTU per lbD. 970 BTU per lb.			
	38.	23°C reads in absolute degrees Centigrade as			
		A. 123° AC       C. 276 AC         B. 146° AC       D. 296° AC			
	39.	Air starting valve-overlap in a 4-cylinder 2 cycle air starting diesel engine			
		A. 25 <sup>0</sup> B. 40 <sup>0</sup> C. no overlap <b>D.</b> 10 <sup>0</sup>			
	40.	Flash point of oil is the temperature at which			
		<ul> <li>A. fuel will ignite in the cylinder</li> <li>B. fuel must be heated to allow flammable vapors to form on its surface</li> <li>C. fuel temperature above 150°F</li> <li>D. 150°F temperature</li> </ul>			
	41.	In a 4 cycle engine the intake valve begins to open while the piston is on its			
•		A. exhaust strokeC. compression strokeB. power strokeD. suction stroke			
	42.	In a 4 cycle engine the exhaust valve opens while the piston is on its			
		A. suction strokeC. power strokeB. exhaust strokeD. compression stroke			
	44.	In a natural aspirated 4 cycle diesel engine the exhaust valve is open in the cycle for a period of			
		A. 180 <sup>0</sup> B. 200 <sup>0</sup> C. 250 <sup>0</sup> D. 190 <sup>0</sup>			

- 45. In a modern turbine installation lube-oil system strainers are usually located in the line:

  - A. pump suctionB. gravity tank overflow

C. bearing supply

D. gravity tank discharged

- 46. A unit of measure used to express the chloride content of boil water is
  - A. PPM
  - B. salinometer
  - C. pH
  - D. micro-ohm
- 47. Temperature measurement is an indication of the:
  - A. total heat contained in any closed energy system
  - B. rate of heat transfer from one substance to another
  - C. total heat of a substance
  - D. level of heat intensity
- The most likely effect of water slugs in the steam supply of a ship service turbo-48. generator is:
  - A. excessive shaft seal wear
  - B. contamination of the lube-oil
  - C. damage to the turbine blades
  - D. rapid erosion of labyrinth packing
- 49. What type of fuel pump is usually used with a unit type auxilliary boiler?
  - C. reciprocating A. centrifugal
  - B. propeller **D.** rotary
- 50. In a turbine installation, the condensate pump discharges to:
  - A. air ejector condenser C. overboard
  - B. the hot well D. the feed water heater
- 51. What constituent of the fuel oil determines the specific heat

A.	hydrocarbons	С.	nitrogen	
_				

- D. sulphur B. oxygen
- 52. A corbel in the furnace of a water tube boiler is:
  - A. preformed burner arch section
  - B. formation of soot on furnace floor
  - C. type of refractory anchor bolt
  - D. fillet of plastic refractory

53. Serious tube leakage in the air ejector condenser assembly will cause:

- A. loss of vacuum
- B. fouled nozzles
- C. clogged steam strainers
- D. faulty steam pressure
- 54. A pressure reading of 00.0 psig is theoretically equal to
  - A.14.7 psiaC.30.0 inches of vacuumB.30.0 inches of waterD.00.0 psia

#### 55. A corbel is used in the boiler furnace to

- A. reduce gas turbulence B. protect the expansion joints C. direct the flow of gases D. contain the furnace heat

#### 56. What is the purpose of counterbore in a cylinder?

- A. to facilitate piston overhaul
- B. to have good and effective combustion
- C. to prevent the piston ring from wearing a shoulder in the cylinder
- D. to maintain effective and good lubrication system inside the cylinder

#### 57. Thermal efficiency refers to heat engines and is the ratio of

- A. input to the output B. output over input
- C. horsepower over BTU
- D. output over BTU

#### 58. Vacuum refers to pressures as

- A. 34 inches of mercuryC. zero gaugeB. 32 inches of mercuryD. below atmospheric
- 59. How would you cut a boiler out of service
  - I. Secure main oil valve
  - II. Secure steam stop
  - III. Close all steam line
  - IV. Secure feed line

#### A I. II and III

B. II. III and IV

### C. I, II and IV D. I. III and IV

- D. I. III and IV
- 60. It is a measure through which a definite quantity of oil will flow out and the duration of the flow can be timed
  - A. flow meter
  - B. saybolt viscosimeter
  - C. flash point
  - D. densimeter

61. This indicates that the piston in a cylinder may be excessively heated or needs lubrication

- A. pounding
- B. binding

C. injection

- D. seizing
- 62. The main condensate pump discharge FIRST to the
  - A. DC heater vent-condenser
  - B. main condenser hot well
  - C. air ejector aftercondenser
  - D. air ejector inter condenser
- 63. When turbine rotor shafts extend through the casing, sealing steam is used in conjunction with labyrinth packing to
  - A. maintain the rotor journal temperature
  - B. provide a constant flow to the gland leak-off condenser
  - C. seal the casing during periods of high casing pressure
  - D. seal the casing during periods of low casing pressure
- 64. Fresh water accumulating in the reduction gear pump may be directly attributed to a/an
  - A. faulty turbine casing drain valve
  - B. inefficient gland sealing system
  - C. wire drawn nozzle control valve
  - D. fractured main condenser support sheet
- 65. What do you call the valve that prevent steam pressure from exceeding the allowable working pressure?
  - A. safety valve

- C. steam valve
- B. steam regulator valve

A. explosion proof gear

- D. moin valvo
- D. main valve
- 66. A major difference between two-element and three-element feedwater regulator control systems is that a three-element system will additionally measure and transmit
  - A. steam flow to the regulating valve in the feedline
  - B. drum waterlevel to the regulating valve in the feedline
  - C. fuel oil flow to the regulating valve in the feedline
  - D. feedwater flow to the regulating valve in the feedline
- 67. Pumps normally used for fuel oil service are pumps.
  - C. two-stage centrifugal
  - B. non-vented plunger
- D. positive displacement rotary

- 68. The volume swept through by the piston in moving between the TDC and BDC is called:
  - A. stroke

C. piston

B. piston displacement D. clearance volume

- 69. This occurs because of the lag in action of the control mechanism which may be caused by insufficient sensitivity or lack of power
  - A. hunting C. surging B. stability D. all of these
- 70. What is the name of the valve fitted in the bottom of a scotch boiler used for circulating the water while raising steam?
  - C. bottom blow valve A. feeder valve D. circulating valve B. hydrokineter valve
- 71. A unit of measure used to express the chloride content of boiler water is the
  - C. PPM A. pH B. Micro ohm D. Salinometer
- 72. What is meant by water hammer?
  - A. condenser moisture in a steam line
  - B. pressure flow inside steam pipe
  - C. all of these
  - D. uneven flow of steam
- 73. It is the external combustion engine utilizing the beat given to a working medium by an external source
  - A. boiler
  - B. heater

- C. reciprocating steam engine
- D. turbine

#### 74. What type of strainer is used in a turbine lube-oil system to remove metallic particles?

- A. Simplex filter A. Simplex filterC. Metal edge strainerB. Magnetic basket strainerD. Fullers earth filter C. Metal edge strainer
- 75. The third stroke of four-stroke cycle diesel engine is called:

Α.	compression stroke	C. air	stroke	
-	- · ·	_		

**B.** power stroke D. expansion stroke

- A sample of boiler water can be chemically tested by adding a few drops of a 76. specific color indicator and then slowly titrating a standard solution into the water sample until the:
  - A. desired pH has been attained in the sample
  - B. desired amount of standard solution has been added
  - C. color indicator reveals a definite visual change in the sample
  - D. burette reading is zero and the sample color changes
- 77. The last stroke of two-stroke cycle diesel engine is also called:
  - A. power stroke

C. ignition stroke

B. air stroke

- D. compression stroke
- 78. Parts of a boiler where a high temperature gas is produced by burning mixture of atomized fuel and air
  - A. firebox
  - B. steam operator
- C. burner
- D. air preheater
- 79. Design characteristics of a velocity compounded impulse turbine include utilization of
  - A. two or more simple impluse stages
  - B. a single pressure stage with two or more velocity stages
  - C. a low velocity steam jet
  - D. one or more nozzles with one row of rotating blades
- 80. In solving the IHP developed in the cylinder the indicator card is used to determine
  - A. compression pressureB. firing pressure
    - C. mean effective pressure

- D. mean height of diagram
- In an engine cylinder there exist a certain average pressure throughout a stroke 81. which is called:
  - A. atmospheric pressure
  - B. mean pressure
  - C. absolute pressure
  - D. mean effective pressure
- 82. It is a device for determining engine horsepower by the mechanical method of measuring it directly at the shaft.
  - A. bridge gauge
  - B. piston area

- C. length of stroke
- D. prony brake

83. When you are operating with the auxiliary feed line feedwater flow is controlled

- A. manually by adjustment of the auxiliary feedwater regulator spring setting
- B. manually by throttling the auxiliary feed stop-check valve
- C. automatically by the economizer bypass
- D. automatically by the main feedwater regulator

84. Prior to lighting off, which system should you test by filling an idle boiler?

<b>A.</b>	Auxiliary fuel oil system	C. Auxiliary Feed
B.	all of these	D. Chemical feed

85. The ash content of a fuel oil is significant to the operating engineer because it:

A. indicates the quantity of energy released by burning a unit amount of the fuel

and the state

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1.5 av 1.5 1.5 1.5

- B. is useful for determining proper atomization temperatures
- C. reflects the overall thermal efficiency of the fuel oil service system
- D. is an indication of the amount of non combustible material present in the oil.
- 86. The steam plant component that transforms the plant's heat energy into mechanical energy is
  - A. turbine C. deaerator
  - B. pumps D. condensed

87. What type of fuel pump is usually used with a unit type auxiliary boiler

A.	Reciprocation		:	C.	Propeller
B.	Centrifugal	ŝ		D.	Rotary

- 88. With the steam control valve wide open during normal operation, the rate of steam flow from the auxiliary exhaust steam line into the DC heater is actually controlled by
  - A. rate of condensation in the DC heater
  - B. spring pressure of the spray valves
  - C. rate of evaporation in the DC heater
  - D. water level in the DC heater reservoir

89. The function of a feed booster pump is to

- A. increase the net positive suction head of the main feed pump
- B. increase the main feed pump discharge pressure to above the superheater outlet pressure
- C. increase the main feed pump discharge pressure to above the steam drum pressure
- D. maintain the by-pass pressure return

- 90. The fuel pump delivers a constant amount of fuel, slightly in excess of the maximum requirement and the surplus is disharged back to the fuel tank through a spring loaded valve called
  - A. non-return valve

C. fuel rack

B. pressure regulator

D. plunger

- 91. It is essentially a record of the pressures existing in the cylinder at vacuum positions of piston throughout the engine cycle:
  - A. timing diagram

C. temperature diagram

B. indicator diagram

- D. cycle diagram
- 92. Clearing a cylinder of exhaust gases by forcing into a current of air which provides clean air for the next compression stroke is also called:
  - 184 A 1 B. compression A. expansion

C. scavenging D. cvcle

- 93. What is the "driving force" behind heat transfer by conduction
  - A. The size of the heat sink for absorbing heat

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- B. The amount of heat available in the heat source
- C. The temperature difference between hot and cold regions
- D. The conductivity of the heat transfer mechanism
- 94. It is a series of events which are repeated in regular order in the operation of an engine
  - A. cycle

C. four-stroke engine

1 1 2

- B. two-stroke engine
- D. all of these
- 95. It is the actual horsepower delivered by the engine to the drive shaft.
  - power strokeB. brake horsepower C. number of cylinder D. mean effective pressure
- 96. Row of tubes installed along the walls floor and roof of the furnace are called
  - A. downcomers C. water headers B. screen tubes D. water walls
- 97. Peculiar property of Babbit metal which makes it the best lining metal for crankpin and main bearings is 1. 1. 1. 1. 5
  - A. its soft and can be cast easily
  - B. it does not expand when heated
  - C. it can be scraped for easy fit
  - D. good conductivity for heat

98. What should you do to re-establish the air ejector loop seal?

- A. Momentarily close the valve in the loop seal line re-open slowly
- B. Shut off the steam to the second-stage air ejector
- C. Decrease the steam pressure to the air ejector jets
- D. increase the condensate flow through the air ejector
- 99. An intermediate chamber is used in conjunction with labyrinth packing on a compound turbine for sealing steam
  - A. leak-off during periods of internal vacuum
  - B. propulsion of peripheral water seals
  - C. supply during periods of low internal pressure
  - D. supply during periods of high internal pressures
- 100. The adjustment of the valves to open and close at the proper time to smooth and efficient operation of the engine is called
  - A. rocker arm C. valve timing
  - B. none of these

- D. tappet clearance
- 101. In a modern turbine installation, lube oil system strainers are usually located in the line.
  - A. bearing supply C. gravity tank discharge
  - B. pump suction D. gravity tank overflow
- 102. A test being used for boilers to detect leaks and to check water tightness after certain repairs:
  - A. efficiency testC. temperature testB. hydrostatic testD. conductivity test
- 103. The water in a steaming auxiliary boller should be tested daily for

Α.	dissolved	oxygen	С.	chloride
В.	dissolved	nitrogen	D.	sludge

#### 104. The astern guardian valve must be open when a vessel is

- A. loading cargoC. maneuvering into portB. at full speedD. running with a warm bearing
- 105. While preparing to get underway, you have steam downstream of the bulkhead stops. You want to roll the turbines. What valve do you open next?

Α.	Sentinel valve	C. Guard	ding valve	1
В.	Main steam stop	D. Nozzl	e valve	

### SECOND-CHIEF ENGINEERS

- 1. The primary function of a waste heat boiler is to
  - A. recover heat which otherwise would be lost
  - B. reduce engine back pressure
  - C. reduce engine exhaust noise
  - D. increase turbocharges efficiency
- 2. Relief valves in the fuel oil service system discharge to either the service pump suction or the

- A. recirculating lineC. settling tanksB. simplex fuel oil strainerD. slop retention tanks
- 3. Testing boiler water for chloride content will indicate the amount of
  - A. solids in the water from sea contamination
  - B. phosphate present in the water
  - C. total dissolved solids in the water
  - D. methyl orange that should be added
- 4. One advantage of installing water walls in a boiler furnace
  - A. reduced furnace temperatureC. increased furnace sizeB. decreased refractory maintenanceD. proper combustion

- To maintain design discharge pressure from a centrifugal pump, the design clearance 5. must be maintained between the
  - A. shaft and impeller
  - B. shaft and shaft sleeve
  - C. casing and impeller wearing rings
  - D. mounth ring and impeller
- 6. Fine adjustments to a boiler combustion control system to bring about near perfect combustion should be made by manually adjusting the

  - A. fuel oil back pressureB. air volume regulatorsC. fuel-air ratio knobD. forced draft fan dampers
- The purpose of the air chamber on the discharge of an emergency boiler feedsteam 7. reciprocating pump is to
  - A. reduce pulsation in the feed lineC. adjust the speed of the pumpB. facilitate draining of the cylinderD. provide for easy suction
- 8. Which of the following safety devices should be installed on turbines?
  - A. lubrication low pressure stop mechanism C. rupture disk

B. atmosphere relief valve

- D. vacuum breaker
- 9. Which of the following is the correct answer concerning the lubrication system for a high power turbine flexible coupling
  - Α. lube oil is directed from the bearings
  - B. oil flowing into an internal groove at the periphery of the coupling is directed via axial passages to the coupling teeth
  - C. they are greased with solid grease
  - D. lubrication oil is maintained in its central zone
- 10. Turbo alternators turbine speed governors include a device to change speed droop. What is the purpose of this device when
  - A. keep the alternator voltage constant
  - B. keep the alternator electrical load constant
  - C. divide the electrical load among alternators
  - D. eliminate the alternators variable speeds
- 11. Under normal conditions, how is the superheated steam outlet temperature regulated?
  - A. by diverting part of the flow thru the desuperheater
  - B. by varying the combustion air
  - C. by regulating the water supply temperature
  - D. by replacing the burners nozzles
- 12. When a boiler pressure tube fails, the following should be done:
  - A. keep burners at the minimal flow possible
  - B. if water level is low open feed valve
  - C. open the superheater purger
  - D. close forced draft blower
- 13. What is the purpose of jacketing steam cylinder?
  - A. standard operation procedure
  - B. to reduce condensation by keeping them hot at all types
  - C. for easy engine starting
  - D. to facilitate engine manuevers, especially astern rotation
- 14. Largest factor in preventing steam engine from attaining ideal engine performance is
  - C. leakage past rings A. radiation
  - B. friction D. cylinder condensation

- 15. The term applied to the reduction of steam pressure which occurs when steam passes through a partially closed valve is
  - A. wire drawing of steam B. incomplete expansion
- C. leakage

D. condensation

- 16. The weakening of boiler steel as the result of inner crystalline cracks is known 88
  - C. alkaline stress A. exposure stress
  - B. caustic embrittlement D. corrosion
- 17. Unequal distribution of combustion in the furnace is known as
  - A. flame impingementC. temperature failureB. furnace overloadD. unequal firing
- 18. The purpose of the steam lap in a reciprocating steam engine is
  - A. permit expansion of steam
  - B. permit cut off exhausting steam
  - C. permit exhaust steam to pass
  - D. permit cut off to occur so steam can expand in the cylinder

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- 19. The purpose of the exhaust lap in a reciprocating steam engine is
  - A. permit the formation of a volume as steam cushion to prevent pounding
  - B. permit cut off of exhausting steam only
  - C. cut-off coming in of the power steam
  - D. allowing exhaust steam to pass
- 20. The steam turbine auxilliary for emergency purposes in case the turbine overspeeds is the

- A. rupture disk C. atmospheric relief valve D. vacuum breaker **B.** overspeed trip
- 21. Enthalpy is the number of heat energy a substance contains above
  - A. 100°C **B.** 32°F C. 0°F D. 212°F
- 22. What is the standard SI units for fuel oil viscosity now in use?

the second

- A. SSU
- B. SSF
- C. cSt
- D. Redwood I or II

- 23. The basic type of reversing air starting system that can be used only on two-stroke ported direct propulsion marine engines is the
  - A. rotating camshaft
- C. sliding camshaft

B. reversing latch

- D. distributor type
- 24. Auxilliary boilers can be classified as:
  - A. fire tube boilers
  - B. water tube forced circulation
  - C. water tube natural circulation boilers
  - D. any of the above
- 25. In addition to a nozzle, a fuel oil atomizer has which part?
  - A. ignition electrode C. orifice plate
  - D. air cone B. burner cone
- 26. Air leakage into the packing gland of a condensate pump is prevented by:
  - A. water seal line to the packing gland
  - B. special packing in the stuffing box
  - C. an air seal line from the compressed airline
  - D. the vacuum in the pump suction
- 27. In steam turbine and reduction gear units, lube oil coolers in the lubricating system are located between the
  - A. lube oil pump and lube oil pump
  - B. gravity tanks and main unit
  - C. gravity tanks and lube oil pump
  - D. lube oil pump and gravity tanks
- 28. The flash point of a residual fuel oil should be used to describe the highest temperature to which the oil maybe heated
  - A. for atomizingC. in a storage-tankB. for centrifugingD. in the recirculating line
- 29. In a segmentall pivoted shoe thrust bearing, the load among the shoes is equalized by the

Α.	leveling plates	С.	base ring
Β.	oil wedge	D.	thrust collar

- 30. Carbon ring packing is secured in a turbo-generator gland by means of
  - C. steam proceed D. labyrinth rings A. garter springsB. centering rings C. steam pressure
- 250

- 31. Most auxialliary turbines do not require an external source of gland sealing steam because they
  - A. operate at relatively low pressure
  - B. exhaust to pressures above atmospheric
  - C. utilizes carbon packing rings at the low pressure end
  - D. operate with only a small amount of axial thrust
- 32. There is a fusible plug installed on a scotch boiler?
  - A. at or near the center of the crown sheet of the combustion chamber
  - B. at the shell approximately 1" below the normal water line
  - C. in the furnace approximately 1 inch below the normal water line
  - D. in the furnace not more than 1 inch below the lowest permissible water level
- 33. Hydrostatic test on new boiler or on those which have extensive replacement of pressure parts should be
  - A. twice the working pressure
  - **B.** 1 1/2 times the working pressure
  - C. 2 1/2 times the working pressure
  - D. 3 times the working pressure
- 34. A device used in power plant work to determine the calorific value of a fuel is known as
  - A. tachometer C. throttling calorimeter
  - B. bomb calorimeter D. pneumercator
- 35. A boiler forced draft pressure gauge reads 6 inches of water.
  - A. .216 B. .288 C. .312 D. .405
- 36. Additives commonly found in turbine lubricating oil include
  - A. oxidation inhibitorsC. extreme pressure additivesB. antifoaming agentsD. all of the above
- 37. The element of a Kingsbury thrust bearing which transmits the thrust from the shaft to the oil film and shoes is the
  - A. collarC. upper leveling plateB. lower leveling plateD. base ring
- 38. When starting some types of turbogenerators, you must provide lube oil pressure
  - to the unit by means of
    - A. a line from the other generatorB. a line from the gravity tankC. hand operated pumpD. the main lube oil pump

- 39. What part of the main feed and/water cycle separates the condensate system from the feed water system?
  - A. deaerating feed tank
- C. boiler drum
- B. main condenser
- D. atmospheric drain tank
- 40. For use in boilers the flash point of fuel oil may be exceeded which
  - A. firing under maximum load
  - B. required for proper atomization
  - C. smokeless operation is required
  - D. necessary to transfer fuel
- 41. Reduction gears on main propulsion turbines are lubricated by:
  - A. grease cups and gravity feed lines
  - B. oil flinger rings mounted on the shaft
  - C. leak-off lines from the lube-oil cooler
  - D. spray nozzles at the gear meshing points
- 42. What part of a Kingsbury thrust bearing tilts to permit the formation of a wedge shaped film of oil?
  - A. shoesC. dowel diskB. lower leveling platesD. tilting plates
- 43. Which type of main propulsion turbine is most likely to require a dummy piston or cylinder arrangement to counter balance axial thrust?
  - A. double flow impulse turbine C. multi-stage impulse turbine
  - B. double-flow reaction turbine D. single flow reaction turbine
- 44. When a waste heat boiler is installed in the exhaust from a main propulsion diesel engine, the exhaust gas bypass would be used
  - A. at high loads to prevent overheating
  - B. at low loads to prevent corrosion in the boiler
  - C. during periods of high steam demands
  - D. when the turbo-charge is in use
- 45. The basic types of reversing air starting that can be used in both 4 and 2 cycle direct propulsion marine engines are: I reversing latch, II rotating camshaft, II sliding camshaft IV-distributor type, are

Α.	I and II	С.	II and III
В.	I and III	D.	II and IV

- 46. A rhythmic variation of speed that can be eliminated by blocking the energy medium supply manually or with a load limit control, but which re-appears when the engine returns to governor control is known as
  - A. compensation C. sensitivity
  - D. hunting B. non-stability
- 47. The ability of the engine governor to correct speed disturbance with a minimum of false motions is known as
  - A. stabilityC. speed droopB. sensitivityD
    - D. compensation
- 48. The steam turbine auxilliary for emergency purposes in case the turbine overspeed is the

  - A. vacuum breakerC. overspeed tripB. rupture diskD. atmospheric relief valve
- 49. The weakening of boiler steel as the result of inner crystalline cracks is known as
  - C. alkaline stress D. corrosion. A. exposure stress
  - B caustic embrittlement
- 50. Unequal distribution of combustion in the furnace is known as
  - C. temperature failure A. flame impingement
  - B. furnace overload D. unequal firing
- 51. A mechanical and or hydraulic action that prevents over correction of the energy medium supply in a governor which produces transient speed droop during a speed correction is known as
  - A. stability C. dead band A. stabilityC. dead bandB. compensationD. sensitivity
- 52. In a diesel engine which uses a continuous pressure pump, the fuel is introduced into the combustion chamber of the cylinder
  - C. pneumatically A. hydraulically
  - D. unit injector B. mechanically
- 53. To increase the firing pressure or maximum pressure in the cylinder of a diesel engine using a constant stroke fuel pump, the fuel pump timing is adjusted for an
  - A. early injection B. early suction C. late delivery D. adjustment of plunger travel

- 54. The part of the mechanical governor that is manipulated by the servo-motor to increase or decrease engine speed
  - A. linkage to fuel rackC. compensating springB. sensitive bandD. dashpot
- 55. A narrow-band of speed variation through which the governor makes no correction of the energy medium and refers to the sensitivity of the governor is known as
  - A. speed droop C. dead band D. isochronous B. sensitive band

flow of fuel to the engine is the

- 56. The part of the hydraulic governor which actuates the fuel racks controlling the
  - A. speed sensitive sectionC. compensating sectionB. power sectionD. dashpot
- 57. In solving for the I.H.P. developed in the cylinder the indicator card is used to determine the

  - A. compression pressureC. mean effective pressureB. firing pressureD. mean height of the diagram
- 58. In a 4 cycle supercharge diesel engine the exhaust valve is open in the cycle for a period of
  - A. 200° B. 280° C. 220° D. 230°
- 59. For maximum efficiency the speed of impulse blades of steam turbine varies
  - A. directly as the steam speed **C.** one half of the steam speed
  - B. one-fourth the steam speed D. as twice the steam speed
- 60. The steam trap which operates on the principle that hot water under pressure tends to flash when the pressure is reduced is
  - A. float actuated trapB. inverted bucket type trapC. live steam separatorD. impulse steam trap
- 61. What pressure is usually carried on a gland sealing system?
  - A. 6 to 8 LBS gauge pressure
  - B. 4 to 5 LBS gauge pressure
  - C. 8 to 10 LBS gauge pressure
  - **D.** 2 to 3 LBS gauge pressure

62. Low compression in one or more diesel engine pistons can be caused by:

I Gas leakage thru admission or exhaust valves

II. Gas leakage due to ring's corrosion

III. Bad quality fuel

IV. Oil contamination

- A. I. II and IV C. I. II and IV A. I, II and IV B. I, II and III D. II. III and IV
- 63. When a new cylinder liner is installed into a 2-stroke engine which of the following steps should be taken
  - I. Increase the cylinder oil flow
  - II. Reduce the cylinder load

II. Reduce the oil flow

A. I. II C. 11, 111 B. I. II. III D. I. III

64. What is the purpose of a converging-diverging nozzle

- C. to control turbulence A. all of these
- B. to lessen the critical pressure **D.** to expand steam
- 65. What is apparent slip?
  - A. the difference between the speed of the propeller and speed of the ship
  - B. the difference between the developed engine RPM and speed
  - C. none of these
  - D. the difference between the speed of the shaft and the reduction gear

66. The temperature at which a vapor liquifies is called

- A. dew pointC. vaporation pointB. condensation pointD. moisture point

67. What is the main function of additives in an engine cooling circuit?

- A. to prevent scaling
- B. to improve cooling fluid evaporation
- C. to improve heat extraction
- D. to increase circulation speed
- 68. As applied to diesel engine operation, it is the disturbance or agitation of the sprayed fuel oil and the air within the combustion chamber or cylinder

Α.	drooping	С.	turbulence
В.	surging	D.	knocking

69. What is called "Neutral" when its PH is equal to:

A. 8 B. 7 C. 9 D. 7.5

- 70. It is an energy function of a constant pressure in which the sum of the internal energy and the work done:
  - A. enthalpy C
    - C. entropy
  - B. adiabatic D. isometric
- 71. It is the process of passing the steam through a restricting orifice or a partially opened valve which causes a wire drawing effect and reduce the pressure
  - A. throttling C. heating
  - B. evaporating D. condensing
- 72. A back pressure trip on an auxillary turbine functions to secure the turbine if the
  - A. gland seal leak off pressure is too high
  - B. oil pressure is too low
  - C. turbine exhaust pressure is above a preset limit
  - D. discharge pressure of a turbine driven pump is excessive
- 73. Under normal conditions of a steam engine plant, the engines consumes steam at the same rate at which it is generated in the boiler therefore the steam is generated at:
  - A. constant volume
  - B. constant pressure
  - C. constant temperature
  - D. constant temperature and volume
- 74. A reversible adiabatic process is also called:
  - A. isobaric C. isentropic
  - B. isometric D. isothermal
- 75. What is the advantage of steam turbine compared with reciprocating engine?

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- I. Less space per horsepower
- II. Low fuel oil consumption
- III. Less vibration
- IV. Lower lube oil consumption
- A. I, III and IV
- B. I, II and III
- C. I, II and IV
- D. II, III and IV

77. The noises of exhaust gases of a diesel engine on a gasoline engine can be reduced by:

A. all of these

- C. silencers
- B. ear mufflers D. head mufflers
- 78. What do you call the instrument that measure the radial position of the crankshaft or rotor shaft?
  - A. bridge gauge C. shafting gauge
  - B. spirit level gauge
- D. dial gauge
- 79. What method is employed in the design of waste heat boilers to obtain maximum heat transfer while maintaining low overall weight?
  - A. steel fins are installed on generating tubes to increase the effective surface area
  - B. an unfired exhaust gas preheater is added to increase the heat transfer rate
  - C. an external superheated unit is located above the boiler to the gas passages
  - D. Feedwater is preheated in a separately fired economizer
- 80. It is the amount of heat released by a substance during complete combustion of unit of mass of that said substance

Α.	enthalpy value	C.	calorific value
B.	thermal value	D.	entropy value

81. A 200 PSI new boiler should be subjected to a hydrostatic pressure of

A. 400 PSI B. 300 PSI C. 500 PSI D. 250 PSI

82. Steam which is in physical contact with the boiling water from which it has been generated is termed:

A. unsaturated steam	С.	wet steam	
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- B. pure steam D. saturated steam
- 83. What are the indications of excessive cylinder clearance in a small diesel engine?
  - I. loss of power
  - II Misfiring
  - III. White exhaust smoke
  - IV. Excessive consumption of lube oil
  - A. II, III and IV
  - B. I, III and IV
  - C. I, II and III
  - D. I, II and IV

84. What are the advantages of the turbo-electric drive?

- I. Better manueverability
- II. Elimination of the astern turbine
- III. Increased economy at reduce power
- IV. Less fuel consumption

A.	I, II and III	C. I, II and IV
B.	I, III and IV	D. II, III and IV

85. It serves as the heat exchanger of the cooling system of the cylinder in which the water is cooled by the forced flow of the atmospheric air around the pipes or tubes carrying the water:

A.	thermostat	С.	pump
Β.	water jacket	D.	radiator

86. The fusible plugs used in fire-tube auxiliary boilers are installed in the

A.	end bell	C.	stay tube
B.	furnace	D.	crown sheet

- 87. Which automatic boiler control should you test prior to lighting off an auxiliary boiler?
  - A. voltage output of the ignition transformer
  - B. automatic bottom blow valve
  - C. insulation resistance readings in the ignition system high tension leads
  - D. low water level cutoff switch
- 88. What is the advantage of steam turbine compared with reciprocating engine?
  - I. Less space per horsepower
  - II. Low fuel oil consumption
  - III. Less vibration
  - IV. Lower lube oil consumption

Α.	II, III and IV	C.	١,	III and IV
B.	I, II and IV	D.	١,	II and III

- 89. In a four stroke cycle diesel engine, a four stroke of the piston is required to complete one cycle which must take place in regular order, and the second stroke indicates:
  - A. expels the burned gases
  - B. drawing of air in the cylinder
  - C. compression of air
  - D. power stroke

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- 90. Labyrinth seals, used to reduce lea of
  - A. staged rubber composition seal stripping
  - B. spring bound carbon segments
  - C. machine packing strips or fins
  - D. braided asbestos covered core segments
- 91. Fractures on boiler refractory are normally due to:
  - I. Lack of expansion joints
  - II. Deposits of chemical agents
  - II. Sudden temperature changes
  - A. I and III C. II and III B. I and II D. I. II and III
- 92. In which lube oil line should you expect to find an illuminated sight glass (bull's eve)?
  - A. Lube oil pump dischargeB. Gravity tank overflowC. Lube oil pump suctionD. Gravity tank discharge
- 93. This tank is a small chamber located at the bottom of the fuel tank which has a drain cock to allow sediment and water to collect and be drained
  - C. settling tank D. Sediment tar A. septic tank
  - B. service tank D. Sediment tank
- 94. Saturated steam is steam that
  - A. has temperature at boiling point
  - **B.** contains moisture
  - C. has temperature above boiling point
  - D. contains no moisture
- 95. Torque is a force which tend to produce
  - A. compressive power C. rotation B. work D. stress
- 96. Boiler horsepower is equivalent to
  - C. 30,000 BTU per hour A. 33.000 ft. lb. B. 33,475 BTUper hour D. 30,000 ft. lbs. per minute

97. A device used in power plant work to measure the moisture content of steam is known as A. bomb calorimeter C. pneumercator B. throttling calorimeter D. tachometer 98. What is the theoretical lift of a pump handling fresh water at atmospheric pressure **A.** 33.9 ft. B. 40 ft. C. 24 ft. D. 26 ft. 99. The temperature at which air begin to liquifies is called B. moisture point C. vaporation point D. melting point 100. Absolute pressure is accurately indicated by C. manometer A. Bourdon gauge B. mechanical gauge D. barometer 101. The overspeed trip device installed on a auxilliary turbine is actuated by: A. spring force C. centrifugal force B. back pressure D. hydraulic force 102. Which of the following fuel injection pump are used for constant speed machines such as electrical generators? A. common rail

- C. variable stroke pump B. constant stroke pump D. mechanical system
- 103. The logical firing sequence for a 6-cylinder 4-cycle right hand rotation

Α.	1-4-2-5-3-6	С.	1-6-2-5-3-4
B.	1-5-3-6-2-4	D.	1-2-3-6-5-4

104. Two results of supercharging are that

- A. exhaust temperature is not significantly raised and brake specific fuel consumption drop
- B. power increased and brake specific fuel increased
- C. temperature is raised and fuel consumption increased
- D. exhaust temperature is raised and power increased
- An instrument used to measure the contents of a tank in which it is not convenient 105. to use a glass gauge or sounding rod is

Α.	balance chamber	C. depth gauge
В.	tank gauge	D. pneumercator

**D.** pneumercator



#### PART IV

#### **REFRIGERATION AND AIRCONDITIONING MACHINERY**

#### What is Refrigeration?

**REFRIGERATION** is a process that involves the removal of heat from an area which is desired to be kept cool and the rejection of that heat to an area whose temperature remains practically constant.

Therefore in Marine Refrigerating plant, the area need to be kept cool like ice box where the ship provision are stored, or cargo hold in which perishable good is transported, thus, refrigeration able to preserve the food product by delaying the ripening process of fruits (live product), preventing the development of micro-organisms and retarding the oxidation of fats like dead product.

AIR CONDITIONING is the method of controlling the temperature, humidity, air movement and cleaning of air in a confined space like office, building etc and refrigeration unit is the heart of the system.

#### What is a Refrigerant?

**Refrigerant** is a chemical substance used for heat transfer in a refrigerating system. It absorbs heat in evaporator by change of state from liquid to a gas, and gives up this heat by condensing at a higher temperature and pressure from gas to liquid state.

### CHARACTERISTIC OF A GOOD REFRIGERANT

- 1. Latent heat of vaporization must be higher, lesser the mass required per unit capacity.
- 2. It must be volatile, capable of being evaporated, low boiling point.
- 3. Safety in operating condition, non explosive.
- 4. Non-toxic and easy to detect by simple test.
- 5. It must have reasonable evaporating and condensing pressure.
- 6. Compression ratio must lower thus low power consumption required and high volume efficiency.
- 7. Critical temperature should be well above condensing temperature.

#### DIFFERENT KINDS OF REFRIGERANT

	CHEMIC	AL SYMBOL	BP at Atmospheric	Freezing Point
1.	Ammonia	NH3	-28.0 °F	-107.9 ⁰F
2.	Carbon Dioxide	CO2	-109.3 °F	-69.9 ⁰F
3.	ETHYL CHLORIDE	C2H5CL	+54.5 °F	-218.0 ⁰F
4.	FREON 12	CCL2F2	-21.6 ⁰F	-252.0 ºF
5.	FREON 22	CHCLF2	-41.4 ⁰F	-256. °F
6.	ISOBUTANE	(CH <sub>3</sub> ) <sub>3</sub> CH	+10.3 °F	-229.0 °F
7.	METHYL CHLORIDE	CH3CL	-10.8 ⁰F	-144.0 °F
8.	SULFUR DIOXIDE	S02	+14.0 °F	-104.0 °F

## A. Characteristic of Freon 12 (CCL<sub>2</sub>F<sub>2</sub>)

- a. colorless, odorless
- b. non flammable, non explosive
- c. non irritating, non poisonous
- d. non corossive to metal, excellent solvent
- e. boiling point 21.6 °F at atmospheric pressure
- f. always available in the market
- g. low power consumption at higher efficiency
- h. soluble when mixed with oil at lower viscosity & pourpoint.

### B. Characteristic of Ammonia (NH<sub>a</sub>)

- a. colorless, corrosive
- b. pungent odor
- c. very soluble in water
- d. combustible or explosive when mixed with air
- e. health hazard due to exposure affect of lung tissues
- f. Boiling pt. at atmospheric pressure -28°F
- g. required high power consumption which gas need to condensed.
- h. solubility is fairly low when mixed with oil.

# C. Characteristic of Carbon Dioxide (CO<sub>2</sub>)

- a. colorless, odorless
- b. non corrosive, non poisonous
- c. non explosive and very safe to health
- d. boiling point at atmospheric pressure 109.3 0F
- e. high specific gravity

### What is the principle of Mechanical Refrigeration? Types?

Mechanical Refrigeration - is the process of absorbing heat under temperature, compression, pressure and expansion and the working fluid known as refrigerant

### **Types:**

1. Absorption system of refrigeration – ability of one substance (the absorbent) to absorb large volume amount of vapor of another substance usually the liquid refrigerant. The essential parts are absorber and a generator, expansion valve, evaporator coil, and include also analyzers or bubble column, rectifier, heat exchangers, liquid pre coolers for better efficiency performance factor. This type is usually used on domestic household refrigerator.

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### Advantages of Absorption System over Compression System

- 1. saving in operating cost using low pressure steam
- 2. less heavy electrical load
- 3. automatic start/stop procedure
- 4. simple in operation and maintenance
- 5. less space required for large tonnage.
- 6. less fewer moving parts
- 7. more efficiency at all ranges of reduced load
- 8. best application where waste heat or low pressure steam available
- 2. Compression System of Refrigeration usually used three refrigerants on merchant ship like Freon, ammonia and carbon dioxide, and the method of expansion system can be divided in two category either direct or indirect. The system where the refrigerant, at low pressure and temperature, enters the suction side of the compressor through a scale trap, compression take place and refrigerant leaves the compressor, at high pressure and temperature, passes through oil separation which remove oil from it. Then flows through suitable piping of condenser where sea water is circulated and remove heat from the gas refrigerant, change into liquid form collected by liquid receiver and passes out through king valve or liquid valve leading to expansion valve, then absorbs heat and become gas or vapor, led back again to the compressor and repeat the cycle.

**Direct expansion system** - the evaporation is in direct contact with the material or space refrigerated or the refrigerant itself extracts the heat from the space to be cooled.

**Indirect expansion system** - the refrigerant is evaporated into the coils of the evaporator, which are in a brine tank, thus the brine secondary refrigerant is circulated to the coil of the cold storage chamber to do the cooling instead the coil with the refrigerant inside.



# DIRECT SYSTEM OF REFRIGERATION

- A. Compressor
- B. Condenser
- C. Expansion Valve
- D. Evaporator coils

- E. Suction Valve
- F. Discharge Valve
- G. Liquid Receiver
- Note: Temperature produced in a refrigeration vapor-compression cycle indicated

5.9



### **INDIRECT SYSTEM OF REFRIGERATION**

- A. Compressor
- B. Discharge valve
- C. Condenser
- D. Liquid Receiver
- E. Expansion valve
- K. Cold storage room

- F. Evaporator coils
- G. Suction valve
- H. Brine cooler
- I Brine Pump
- J. Cooling coils

#### What are the four processes of Mechanical Refrigeration Cycle?

- 1. COMPRESSION PROCESS:
  - a. The cold gas is withdrawn from the evaporator and compressed to a higher temperature and discharged to the condenser.
  - b. The low pressure gas is changed into high pressure hot gas.
- 2. CONDENSATION PROCESS:
  - a. In this process, latent heat of the hot gas is removed by passing it through the heat exchanger condenser cooled by sea or fresh water.
  - b. The hot gas is changed its physical state into high pressure warm liquid.

### 3. EXPANSION PROCESS

- a. In this process, the pressure of the refrigerant is reduced changing its state into low pressure cold liquid particles.
- b. Refrigerant changes its state into gas picking up its latent of evaporation thus lowering the temperature to freezing cold temperature after it passes to the expansion control valve.
- 4. EVAPORATION PROCESS:

In this process, the liquid refrigerant absorbs its latent of evaporation from the refrigerated space, change its state to a low-pressure gas leading to the compressor.

#### Major Parts of Mechanical Refrigerations

### I. COMPRESSOR

- a) FUNCTION:
  - 1. It acts as a pump, circulate the refrigerant through the system.
  - 2. It maintain low pressure at the evaporating unit during operation
  - 3. It compresses the low pressure gas to higher pressure and temperature thereby raising the boiling point.
- b) TYPES:
  - 1. RECIPROCATING COMPRESSOR consist of one or more piston and cylinder combinations. The piston moves in reciprocating motion to draw the suction gas into the cylinder on one stroke and to compress and discharge it to the condenser on the return stroke.
  - 2. CENTRIFUGAL COMPRESSOR has a single or multistage high speed impeller to set up enough centrifugal force within a circular causing to raise the pressure of the refrigerant gas to condensing level.
  - 3. ROTARY SLIDING VANE COMPRESSOR is a positive-displacement unit which trap a given volume of gas, compresses it, and ejects it from the machine. It usually has a rotor revolving off-center in a cylinder with sliding vanes forced against the cylinder wall, thus produces higher pressure from cylinder discharge line.
  - 4. HELICAL ROTARY SCREW COMPRESSOR another positive displacement unit which was used for refrigeration in the late 1950's, but because of its simplicity it rapidly gain favor. It consist of two mating helically grooved rotors, a male lobes and female grooves in a stationary housing with suction and discharge ports.

# c) TYPICAL MOUNTING PARTS OF RECIPROCATING COMPRESSOR

- 1. CYLINDER HEAD is divided up into a suction and pressure chamber equipped with a built-in safety valve and open at prescribed set pressure. The valves are tongue valve's and consist of an intermediate plate on which suction and discharge valve plate are fitted.
- 2. CRANKSHAFT is made of drop-forged special steel with excellent tensile and wear resistant qualities where the piston connected in the journal drilled for proper lubrication.
- 3. PISTON AND CONNECTING ROD The piston are made of an aluminum alloy and fitted with a piston ring and a scraper ring. The connecting rod are drop-forged fitted with supporting cups for the journals.
- 4. MAIN BEARING consist of rear and main bearing where the crankshaft resting firmly and cannot dismount without use of draw tools. When mounting use press-tools or heating in oil both that sustain heat up to 250 °C.
- 5. SHAFT SEAL of the slide ring type or mechanical seal and its duty is to seal between the rotating crank shaft and the shaft seal cover. It divided into two units, the stationary part with lapped surface contact and the dynamic part rotating with the crankshaft respectively.
- 6. OIL PUMP is a gear wheel pump with high effect and driven by the crankshaft, suck oil from the crankcase, through oil filter, and deliver the oil under pressure to various bearings and to the shaft seal through channel in the crankshaft, while cylinder wall and piston pins are splash lubricated.
- 7. SUCTION STRAINER mounted between suction stop valve and compressor, to prevent the impurities from the plant are carried with the gas flow into the compressor.

# II. CONDENSERS:

- a. FUNCTION:
  - 1. Act as heat exchanger between the hot gas refrigerant and the cooling medium
  - 2. Remove the heat of compression and also the latent heat of condensation.
- b. TYPES:
  - 1. SHELL AND TUBE CONDENSER consist of a shell, tube sheets and tubes, water boxes and refrigerant connection. The refrigerant gas flows into the shell and around the tubes while water flows through the tubes. It has two types—vertical and horizontal shell and tube condenser.

- 2. DOUBLE PIPE CONDENSER has the condensing water tube inside the refrigerant tube. The refrigerant flows into space between the tubes while water is pumped through the inner tube. Water flows in the opposite direction to the refrigerant with the coolest water in contact with coolest refrigerant and the warmest water in the warmest refrigerant.
- 3. EVAPORATIVE CONDENSER combine the functions of a cooling tower and a condenser. It consist of a cooling tower and a condenser. It consist of a casing enclosing a fan or blower section, water eliminators, refrigerant condensing coil, water pan, float valve and spray pump outside the casing.
- 4. AIR COOLED CONDENSER almost all fractional horsepower unit are equipped with air cooled condensers. It is commonly used in radiators of automobiles consisting a bundle of finned tubes rolled or welded into header. Advantages that air is always available, while water is not, less cost of space require for cooling tower, pumps, piping chemicals etc.

# III. EVAPORATORS:

- a. FUNCTION:
  - 1. Part of the system where the liquid refrigerant is evaporated.
  - 2. It also function of transferring heat from the substance being cooled like food, liquid in the icebox.
- b. TYPES;
  - 1. FLOODED EVAPORATOR types are classified according to the type of liquid feed. Consist of tank or a surge drum located above the coil so that the inside of evaporator is full or flooded with refrigerant.
  - 2. DRY EVAPORATOR has a refrigerant control devices that admits only enough liquid refrigerant to be completely evaporated by the time it leaves the coil in a dry state.

# IV. EXPANSION VALVES

- a. FUNCTION
  - 1. To regulate the flow of refrigerant to the evaporator from high side to the low side of the system.
  - 2. To reduce the pressure of the liquid refrigerant, and adjustment by means of thermostatic or by hand settling control.
- b. TYPES:
  - 1. CAPILLARY TYPES consist of coil or length of fine tubing with small orifice, high pressure is being force the liquid and determine the amount of liquid at a reduce pressure allow to flow to the evaporator. In operation absolute cleanliness of the refrigerant is necessary in order to avoid clogging of foreign materials to the system.

- 2. HAND EXPANSION VALVES a globe type valve with a needle seat in the smaller sizes and a plug-type tapered seat in the larger sizes. The prime advantage are its simplicity and low initial cost.
- 3. AUTOMATIC EXPANSION VALVES- is a pressure reducing device, beliew operated valve, that open and closed when compressor run, reducing the gas pressure in the evaporator adjusting spring pressure pushes the diaphragm down allow more refrigerant to flow in the evaporator, when liquid pressure increases forcing the diaphragm upward and allowing the valve to close.
- 4. THERMOSTATIC EXPANSION VALVES also automatic expansion valve with added device to correct the feed rate of the valve correspond to the load on the evaporator. It is sometime known superheat valve - a force needed to operate the valve is obtained from the superheat of the refrigerant gas in the evaporator coil, and primary function is to meter the flow of refrigerant to the evaporator.

POINTS IN SELECTING A THERMOSTATIC EXPANSION VALVE:

- 1. load or tons of refrigeration.
- 2. pressure differential across the valve at operating condition.
- 3. size and type of inlet and outlet connection.
- 4. possible need for an external equalizer.
- 5. refrigerant type used in the system.
- 5. LOW SIDE FLOAT made of hollow ball, pan, or inverted bucket connected through linkages and pivot to open or close a needle valve. It maintain a predetermined liquid level in an evaporator where linkage open the valve to admit more refrigerant, then closes the valve reaches required setting point. Advantages of low-side float, it gives very good control by maintaining the proper refrigerant level regardless of load changes, compressor off cycles and other operating variables.
- 6. HIGH-SIDE FLOAT has the same element of low-side float but it differ location, it is on the high pressure side of the system and that a rising liquid level open the valve, mounted below the condenser and passes the liquid refrigerant to the evaporation as rapidly as it is condensed. It has a purge valve fitting for noncondensable gases present in the system and usually use this type in domestic and small commercial system with a single compressor, evaporator and condenser.

a. LIQUID RECEIVER

FUNCTION:

- 1. Stores unused or excess refrigerant returning from the condenser.
- 2. Provide a place to store refrigerant when pumping out the evaporator during maintenance operation.
- 3. Stores refrigerant to be evaporated by the expansion valve.

FITTINGS AND LOCATION: Liquid Receiver must have a return line from the condenser, a relief valve, a gage glass to show the liquid level, an equalizing line to the top of the condenser; located between condenser and king valve or liquid stop valve.

## **b. DEHYDRATOR**

FUNCTION:

- 1. It absorbs moisture that usually present in the refrigerant circulating to the entire system.
- 2. It used for filtering and collecting foreign materials during charging refrigerant.

LOCATION: – Between the liquid line and the service valve which is the outlet from the condenser or liquid receiver, also sometime connected between the suction line and suction service valve at compressor during charging gas refrigerant side.

**DEHYDRATING AGENTS:** 

ACTIVATED ALUMINA – is a granular aluminum oxide that removes mois ture by absorption method.

- SILICA GEL is a glasslike silicon dioxide which also removes moisture and foreign material by absorption.
- **DRIERITE** is an anhydrous calcium sulphate made by a granular white solid; which remove moisture by chemical action.

CALCIUM OXIDE AND CALCIUM CHLORIDE - remove water and acid present in the system by chemi cal action too.

# C. CHARGING CONNECTION

# FUNCTION

- 1. It is used to add or charged refrigerant into the system.
- 2. Also used for removing excess or transfer refrigerant in a cylinder bottle. LOCATION: Before drier which is liquid refrigerant valve to be used in the cylinder, at high pressure side of the system.
- 3. Suction line before suction valve of the compressor, and gas refrigerant valve should be open at low pressure side of the system.

## D. SIGHT GLASS

FUNCTION:

- 1. It shows the amount of refrigerant, or oil in the system
- 2. Indicates the presence of gas bubbles in the liquid line.

### E. PRESSURE GAUGE:

- 1. Used to measure or indicate the working pressure exerted into the system.
- 2. Type and Location
  - a. Suction pressure gauge also called compound gauge consist of two dials or graduations which represent the pressure and temperature. The scale indicate vacuum from 0-30 inches of mercury and from zero to the capacity of the gauge in PSI clockwise direction.
  - b. Discharge pressure gauge fitted in the compressor should be the pressure which corresponds to a temperature from 5-15 °F higher than the condenser pressure. It shows the pressure carried on the condenser and liquid receiver and give warning when reaches a dangerous point.
  - c. Inlet-outlet pressure gauge used to indicate the flow of cooling water medium into the condenser either seawater or fresh water.

### F. THERMOMETER

- 1. Used to indicate normal and abnormal temperature of the entire system, also shows the heat refrigerant leaving the refrigerant to the condenser.
- 2. Fitted at the suction and discharge side of compressor, liquid lines, chamber box, and cooling water system, and the unit expressed in degrees fahrenheit or centigrade scales.

LOCATION: At the liquid line between receiver and the expansion valve, made of glass tube or glass window in the refrigerating mechanism

### G. CIRCULATING FAN

- 1. Used in the refrigerating chamber to circulate air evenly cooling while in operation in order to absorbs heat.
- 2. Fitted mostly overhead the space to be cooled or near the evaporating coils for defrosting method.
- H. COOLING WATER PUMP
  - 1. Classified as nonpositive, fairly low pressure pump unit used to supply cooling water into the condenser directly and into the brine system indirectly like ammonia system.
  - 2. Fitted on the cooling water piping system after the sea chest or in the brine system. Usually used a centrifugal pump because they are simple, cannot build up dangerous moistures, smooth, constant, non pulsating discharge.
  - 3. Fitted with strainer used to separate foreign materials from the sea suction to prevent clogging and reduce the efficiency of the pump.

# CONTROL MECHANISM OF REFRIGERANT INTO THE SYSTEM

- 1. HAND EXPANSION VALVES manually control the refrigerant liquid flowing to the evaporator in the event of failure of the thermal expansion valve.
- 2. SUCTION-LINE REGULATORS used to control the flow of refrigerant gas from the evaporator coil
- 3. SOLENOID VALVES usually fitted in liquid suction or discharge lines to interrupt the flow on demand from any one of the types of temperature or pressure-sensing devices.
- 4. CHECK VALVES used to prevent the flow of gas from the condenser back to the compressor during off cycles. Also fitted in suction lines to avoid the flow of high pressure gas from the other evaporator on the same circuit.
- 5. HOLD-BACK VALVES used to limit the flow of gas to the compressor to prevent surge or excessive loads from overloading compressor motor.
- 6. REVERSING VALVES used in defrosting cycle or heat pump system to divert the flow of refrigerant
- 7. HOT GAS DEFROST VALVES fitted in modern multiplex system for method of defrosting the entire system before the suction side of evaporator coil.

# **ELECTRIC CONTROL DEVICES:**

- 1. **PRESSURE CONTROLLERS** control the flow in some portion of the sytem, provide automatic defrosting and transfer of liquid from the system. Three basic types of pressure controllers:
  - a. BELLOWS consist of a flexible bellows connected to the pressure line to be controlled, pressure in the line tend to expand the bellows but is opposed by a spring with an adjusting screw and the motion of the bellows transmitted through linkage to open or close electrical contacts.
  - b. DIAPHRAGM employs a flexible diaphgram that has the same function as the bellows. Since the movement is limited, large lever is needed to give enough movement to actuate the switching mechanism.
  - c. BOURDON TYPE made of curved oval tube anchored at one end and free to move toward or away from the switching mechanism at the other end, linkage are neededd to open or closed electrical contact.
- 2. TEMPERATURE CONTROLLERS control variable temperature have similar designed with basic power elements bellows, diaphragm and bourdon tube that are used in pressure control.
  - a. BIMETAL THERMOSTAT a temperature sensitive device made up of a thin duplex strip of two dissimilar metals with different thermal expansion coefficients. As temperature changes the difference in expansion create a bending action that open or closes electrical contacts.
  - b. REMOTE-BULB THERMOSTAT has sensitive bulb connected to the control with a length of capillary tubing at some distance from substance to be controlled outside the room being refrigerated. Types according to bulb fill are fade-out or limited fill, high temperature fill and cross-ambient fill.

# SAFETY CUT-OUTS DEVICES:

- a. HIGH-PRESSURE CUTOUT SWITCH used as a safety control on the discharge line of compressor. Any abnormal rise of discharge pressure caused by condenser failure, rise above a set point, the high-pressure cutout open the circuit stop the compressor.
- b. LOW-PRESSURE CUTOUT SWITCH fitted on suction side of compressor, opened the contact when the pressure fall below a set point also prevent the suction prevent from falling to a point where damage occur due to low temperature such as freezing. It also a device to stop the compressor when pressure & temperature condition have not been normal satisfied.

- c. LOW OIL-PRESSURE SWITCH contacts are fitted into the compressor drive motor circuit, when oil pressure falls below the preset point, open the circuit to stop the compressor to prevent damage due to lack of lubrication.
- d. WATER FAILURE SWITCH it opened the contact and stop the compressor in case failure of the cooling water system in the condenser.
- e. FLOAT SWITCH an electric control device designed to open or close the circuit in response to the rise and fall of the liquid level in a vessel which uses in modern refrigeration systems.
  - 1. It operate liquid solenoid valves to maintain liquid level in suction accumulator for a coil.
  - 2. It control some pumps and actuate alarm lights or signal devices.



**AUTOMATIC CONTROL FREON REFRIGERATION SYSTEM** 

## PARTS:

- A. Compressor
- B. Condenser
- C. Liquid Receiver
- D. Expansion valve-manual
- E. Evaporator
- F. Suction valve
- G. Discharge valve
- H. Oil trap
- I. Liquid/King valve
- J. Charging valve
- K. Dehydrator
- L. Sight glass

- M. Solenoid valve
- N. Thermo-expansion valve
- O. S.W. outlet valve
- P. S.W. inlet valve
- Q. Purging valve
- R. Compound (suction) gauge
- S. LP cut-out switch
- T. HP cut-out switch
- U. Discharge press, gauge
- V. Low oil press switch
- W. Water failure switch
- X. S.W. in-out pressure

# DEFINITIONS OF TECHNICAL TERMS:

ABSOLUTE PRESSURE - is the pressure in pound per square inch above a complete vacuum, sum of gauge pressure and atmosphere pressure.

AMBIENT TEMPERATURE - the temperature of air in space, room temperature

- ANALYZER is a pressure vessel mounted above the generator through which the vapors leaving the generator in absorption system, also called bubble column which contains a number of baffles or plates.
- BAROMETER instrument for measuring atmospheric pressure, expressed in pounds per square inch or inches of mercury in column.
- BTU the amount of heat energy required to raise the temperature of one gram of water, one degree Fahrenheit.
- CALORIE the quantity of heat required to raise the temperature of one gram of water one degree celcius.
- CALORIMETER a device used to measure quantities of heat or determine specific heats of a substance.

- CHILLER a heat exchanger in which low-pressure refrigerant boils or vaporizes thus absorbing the heat that was remove from the refrigerated area by the cooling medium which is water.
- COMPRESSION RATIO ratio of the volume of the clearance space to the total volume of the cylinder. In refrigeration used as the ratio of the absolute low-side pressure to the absolute high-side pressure.
- COOLER is a heat exchanger which removes heat from a substance.
- CRITICAL PRESSURE compressed condition of the refrigerant which gives liquid and gas the same properties.
- CRITICAL TEMPERATURE temperature at which vapor and liquid have same properties regardless of pressure.
- CRYOGENIC is a field of engineering deals with the development, production and use of equipment in the range of lowest temperature, liquifaction of gases in bulk process.
- DEHUMIDIFIER a device found on airconditioning system used to remove moisture from air.
- DENSITY The weight of a substance per unit volume
- DEW POINT temperature at which the water vapor at 100 percent humidity begins to condense and deposit as liquid.
- DYNAMETER a device for measuring power output or power input of a mechanism.
- ENTHALPHY total amount of heat in one pound of a substance calculated from accepted temperature range.
- EQUALIZER is a part or connection on thermostatic expansion valves to transmit evaporator pressure to the underside of the diaphragm and classified in two types: internal and external equalizer.
- HEAT is a form of energy, the quantity of heat depends on the quantity type of the substance involved expressed in BTU.
- HEAT EXCHANGER device used to transfer heat from a warm or hot surface to a cold or cooler surface like evaporator and condensers are heat exchangers. The cooling medium either seawater or fresh water.
- HYDROMETER floating instrument used to measure specific gravity of a liquid such as refrigerants, oil, lube oil.

HYGROMETER - instrument used to measure degree of moisture in the atmosphere.

- LATENT HEAT heat added or removed from a substance to cause a change of state without a change of temperature such as solid, liquid and vapor states.
- LATENT HEAT OF CONDENSATION the amount of heat that must be removed from a vapor to change it to a liquid state.
- LATENT HEAT OF FUSION the amount of heat needed to change a substance from solid to liquid state, expressed in BTU per pound.
- LATENT HEAT OF VAPORIZATION the amount of heat required to change a substance from liquid to the vapor state expressed in BTU per pound.
- MANOMETER instrument for measuring pressure of gases and vapors.
- PSYCHROMETER also called wet bulb hygrometer used for measuring the relative humidity of atmospheric air.
- PYROMETER instrument used for measuring higher temperatures.
- RELATIVE HUMIDITY ratio or difference between the amount of water vapor present in air to greatest amount possible at same temperature.
- SENSIBLE HEAT The heat added or removed from a substance, measured by a change in the temperature.
- SPECIFIC GRAVITY is the weight of a liquid compared to water which is assigned value of 1.0.
- SPECIFIC HEAT the amount of heat needed of a substance to raise the temperature of one pound of that substance one degree Fahrenheit.
- SUBLIMATION condition of a substance changes from a solid to a gas without passing the liquid state.
- SUPERHEAT the temperature of vapor above its boiling temperature as a liquid at that pressure. Also the difference between the temperature at the evaporator outlet and the lower temperature of the refrigerant evaporating in the evaporator.
- TON OF REFRIGERATION the cooling effect of one ton or 2000 lbs of ice melting in 24 hours. This is equal to 2000 lbs multiplied by 144 BTU, result 288,000 BTU/ day; 12000 BTU/hour; 200 BTU/min.
- WET BULB a device used to measure the relative humidity of air in space.

FIRST LAW OF THERMODYNAMICS - state that heat and work are mutually convertible to each other.

SECOND LAW OF THERMODYNAMICS - state that heat will flow from a body at higher temperature to a body of lower temperature.

State - P

### **OPERATION AND MAINTENANCE**

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#### I. STARTING PROCEDURES OF AMMONIA SYSTEM

- 1. Open the valves and start the cooling water pump.
- 2. Open the compressor discharge valve.
- 3. Start the compressor.
- 4. Open the suction value of the compressor slightly until evaporator pressure is pumped down to about 20 PSI, then open it full.
- 5. Open the liquid value and adjust the expansion value to give the desired suction pressure.

#### STOPPING

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- 1. Close the liquid valve or king valve.
- 2. Close the suction valve.
- 3. Shut down the compressor motor.
- 4. Close the compressor discharge valve.
- 5. Shut off the cooling water system.

### CHARGING AMMONIA SYSTEM:

- 1. First, raise the bottom end of the cylinder, dipper pipe points down, weighed before and after charging.
- 2. Connect charging pipe between king valve and expansion valve loosely, cracked open slightly until ammonia is smelled, which allow air to escape, then tight.
- 3. Closed king valve, open cylinder valve and charging valve.
- 4. Charging ammonia pressure between king valve and expansion valve will drop to suction pressure allow liquid ammonia to flow into the system.
- 5. When receiver gauge glass shows half full, stop charging. close charging valve and open the king valve.

# PURGING PROCEDURE AMMONIA SYSTEM:

- 1. Close the liquid value or king value and allow cooling water to circulate through condenser.
- 2. Keep the compressor running until suction gauge, is nearly zero.
- 3. Stop the compressor for about 12 hours with circulating water cooling system
- 4. Attach hose to the purging valve and end of the hose into a bucket of water.
- 5. Open the purge valve which indicate bubble means expulsion of air.
- 6. Ammonia can be heard by crackling noise and by smell, then close the purge valve
- 7. After system purged, open the king valve, start compressor for normal operation.

## Sources of noncondensable gas or air in the refrigeration system

- a. corrosion
- b. breakdown of oil
- c. decomposition of the refrigerant in contact with impurities
- d. entering of air under vacuum operation or during maintenance work.

### CHARGING OIL TO CRANKCASE OF AN AMMONIA MACHINE:

- 1. Close the liquid valve.
- 2. Run the compressor until pressure shows 5 inches vacuum.
- 3. Close suction valve and stop the unit.
- 4. Close discharge valve and open purge cock slowly.
- 5. Connect hose pipe with funnel to charging valve and pour in with oil closed after normal level.
- 6. Start machine for purging to eliminate air in the system.
- 7. Open discharge valve and start to normal operation.

### METHOD OF DETECTING LEAKS IN AMMONIA SYSTEM

- 1. Sulfur Candle Test produced white smoke when fumes come in contact with escaping ammonia.
- 2. Litmus Paper Test place around the piping joints, valve stem, etc., ammonia leak will turn litmus paper to blue color.
- 3. A Soapy Lather spread over joints or pipes will produce bubble when leak.

## **II. STARTING PROCEDURES OF FREON SYSTEM:**

- 1. Check level of lubricating oil in the compressor, add oil if necessary and must be visible in the sight glass.
- 2. Start the condenser cooling system and compressor cooling if applicable.
- 3. Open compressor discharge stop valve.
- 4. Set the capacity regulator to minimum, and to avoid excessive pressure reduction in the compressor when starting-up, the suction stop valve must be opened a couple of turns to prevent the oil foaming.
- 5. Open the king valve or liquid valve.
- 6. Start the compressor motor check suction and oil pressure.
- 7. Adjust the expansion valve until the suction pressure correspond to the temperature desired for the icebox.
- 8. Check to ensure that level of oil is normal, while operation and oil return flow from the oil separator is functioning.
- 9. Do not leave the compressor during first 15 minutes of operation until its condition is normal.

#### STOPPING PROCEDURES:

- 1. Close the liquid supply to the evaporators a few minutes before stopping the plant.
- 2. Stop the compressor.
- 3. Close the suction and discharge stop valves but leave expansion valve open.
- 4. Allow to circulate cooling water through condenser and compressor jacket till they are cool then shut off the supply cooling.

CHARGING METHOD OF FREON SYSTEM

- 1. First ensure air is evacuated. Rectify leak in the system.
- 2. Weigh the bottle refrigerant, hang it on a scale, slightly inclined.
- 3. Connect charging pipe to the charging valve either in two location points.
  - a. HIGH PRESSURE SIDE LIQUID METHOD: before drier
  - b. LOW PRESSURE SIDE GAS METHOD: suction line before valve
- 4. Remove, purge air from charging pipe by cracked open slightly until refrigerant blow the air, then tight.
- 5. Open the compressor discharge and suction valves.

- 6. Close liquid valve, then circulate cooling water in the condenser.
- 7. Run the compressor intermittently until the system is fully charged, can be checked on gauge glass at normal level.

SOME INDICATION POINTS IF THE SYSTEM IS:

- a. FULLY CHARGED:
  - 1. Liquid level should be 1/3 or 1/2 while running on full load.
  - 2. Sight glass full of bubbles
  - 3. Suction and discharge pressure normal
  - 4. Able to maintain required room temperature.
- b. UNDER CHARGED:
  - 1. Lower liquid level
  - 2. Bubble in sight glass
  - 3. Low suction and discharge pressure
  - 4. Difficulty in maintaining room temperature.

ADDING OIL TO CRANKCASE OF FREON SYSTEM

Two Method of Charging oil to the system by means of pumping it or allowing compressor suction to pull it in.

- 1. Using an oil charging hand pump proceeds as follows.
- 2. Oil pump suction is placed in the oil can and discharge hose is loosely connected to the oil charging valve on the crank case.
- 3. Purge and eliminate air to hose and tight to prevent entrance of air into the crank case.
- 4. Used hand pump to charge it until about 3/4 of the sight glass is filled after oil charging valve is closed and disconnect hose discharged.

METHOD OF DETECTING LEAK ON FREON SYSTEM:

- 1. HALIDE TORCH TEST used only for finding leaks of hydrocarbon refrigerants, a normal blue flame will turn green in the presence of freon gas.
- 2. SOLUTION of SOAPSUDS METHOD in case of large leaks applied to joints, pipings etc if there is a leak bubble produced.

# CORRECTION RUNNING CONDITIONS OF REFRIGERATION

In order to have optimum good performance of the system. It must have the following conditions:

- 1. Correct level of refrigerant in the system.
- 2. Correct level of lubricating oil in the crank case sump.
- 3. System circuit should be free of lubricating oil, air and moisture
- 4. Good performance of thermostatic valve and other control mechanism.
- 5. Free from foreign materials.
- 6. Proper quantity and flow of cooling water
- 7. Periodical defrosting.
- 8. Periodical overhauling of compressor.
- 9. Periodic check up of electrical controls.

## WHAT ARE THE TWO PRESSURE AREAS IN THE REFRIGERATION SYSTEM?

- A. FREON SYSTEM
  - 1. **High pressure sides** it starts from the discharge of the compressor, through the condenser and liquid receiver, until the inlet side of the expansion valve.

- 2. Low pressure sides absorbs the heat and starts from the discharge of the expansion valve through the evaporator until the suction side of the compressor.
- B. AMMONIA SYSTEM:
  - 1. High pressure sides generator, condenser, expansion valve, liquid receiver, heat exchanger and analyzer.
  - 2. Low pressure sides evaporator, absorber.
  - NOTE: In ammonia absorption system replace the compressor in vapor compression system to absorber and generator.
    - The absorber take place the suction stroke of the compressor by drawing the low pressure gas from the evaporator.
    - The generator takes the place of the compression stroke discharging ammonia gas at high pressure and temperature leading to condenser and expansion valve of the evaporating coil same as compression system.
- A. METHODS OF DEFROSTING COIL IN REFRIGERATION SYSTEM
  - 1. Electric Resistance Heating a modern electric defrost cooler, designed for low temperature commercial coolers or freezers in the medium & size range, consist of heater fin slot or tubular heater fitted at the lower part of the coils to improve heat transfer, thus reduce defrost time and kilowatts required. Dip trays also provided with electric heating elements.
  - 2. Hot Gas Method built in piping unit used to divert gas from the compressor directly to the evaporator so therefore, hot gas defrost the coils and heat remove prevent from freezing and turn to condense gas back to the system.
  - 3. Use of Warm Air done in natural method which cool and isolate temporarily from space or to the system at room temperature. Sometime use blow-torch for emergency cases.
  - 4. Water Method defrosting the system by means of flooding the outside of the coil either warm or cold water until the frost is melted.

#### PROCEDURES TO DEFROST FREON OR AMMONIA SYSTEM WITH

- A. HOT GAS METHOD
  - 1. First hot gas line is connected from the discharge side of the compressor to a point beyond expansion valve into the evaporating coils.
  - 2. Close the liquid line stop valve ahead of the expansion valve.
  - 3. Close the compressor discharge valve and liquid stop valve.
  - 4. Open the valves in the hot gas line and start the compressor.
  - 5. Open the hot gas valve slowly to prevent damage to the evaporator and compressor.
- B. ELECTRIC HEATING METHOD

Defrosting sequence will be as follows in automatic control.

- 1. The compressor stop and all solenoid valves in the system close.
- 2. The fan in the freezing room stop working, but the fan in the chilled rooms continue circulation of the hot room air over the coolers to keep full of ice.
- 3. Then electric heating elements in the freezing room coolers are on.
- 4. As the temperature reaches the set point approx. + 10oC, the heating elements are switched by defrosting thermostat.
- 5. The compressor starts, and coil temperature reach below freezing point, the fan start. The system is now back on the cycle again. Automatic defrosting should be done at least once a day cycle, depend on set point time interval.

#### LUBRICATION SYSTEM :

Oil for lubricating refrigerating machinery must be always in fluid at the lowest temperatures of system in operation in order to prevent or reduce efficiency and method of lubrication are classified in two methods.

- SPLASH SYSTEM the lubricating oil is splashed by reciprocating motion of the compressor, to all bearings by cranks and connecting rod, dip into oil and thrown into pockets that supply oil to main bearings piston pin, bearing and shaft seal. The method must have a normal level on the sight glass, and if the level is too high there will be excessive churning of oil, high oil temperature, leakage and high oil consumption due to large oil can escape into the high side of the system.
- FORCED-FEED SYSTEM A shaft driven-gear pump supplies oil under pressure to the crankpin and piston pin bearings into the shaft seal, thus give good distribution to all moving parts preventing foaming taking place on initial starting cycle.

#### Method of draining oil from Reciprocating Compressor.

- 1. Close the suction valve.
- 2. Start the compressor, then open the valve in the crankcase pump-out line to create vacuum causes the refrigerant to boil out of the oil for several minutes then stop the compressor.
- 3. Close the discharge valve, open bypass valve to equalize the pressure above and below the piston.
- 4. Open the oil drain valve and drain the oil. Draining should be done at least once a year or depending base on your routine observation that might be oil is contaminated in a short running period of time.
- 5. Cleaned the crankcase and fitters thoroughly then take the procedure of proper step in adding oil to the system.

#### **BRINE SYSTEM OF REFRIGERATION:**

Usually used in marine refrigeration system on a reefer vessel where a large cold storage room or cargo hold to transport perishable cargoes. Also often installed in commercial purposes like ice-skating rinks, and large power output of airconditioning in building factory etc.

Indirect Absorption system of refrigeration which evaporator cool the brine, then circulated by a pump to the cold spaces, lower the thermal efficiency of the brine, which you can easily controlled.

#### Advantages:

- 1. Require less expensive refrigeration
- 2. Can easily control the temperature.
- 3. No danger of leakage of poisonous in cold storage
- 4. Remain liquid, not freezing at lowest temperature
- 5. Corrosive effect to metals is minimum.
- 6. Have specific heat, enough high to permit economical operation.

#### TYPES OF BRINE:

- 1. Calcium Chloride used more frequently on the system because it has lower freezing point.
- 2. Sodium Chloride is used for ice making storage
- 3. **Magnesium Chloride** is unstable when concentration is high and temperature low, not usually used for large capacity system.

#### **GENERAL PRECAUTIONS IN USE OF THE AIR CONDITIONER**

- In order to enjoy comfortable cooling effect, please check the following conditions.
  - 1. Is the suction gas pressure in the normal condition?
    - 2. Is the discharge gas pressure in the normal condition?
    - 3. Are the oil pressure and temperature normal?
    - 4. Is the air outlet of each room almost fully open?
    - 5. Are the air filter and refrigerating machine oil not dirty?
    - 6. Are the V-belts (used for the fan and compressor) adjusted properly?
    - 7. Cleaning of the condenser tube and replacement of protective zinc at least twice a year.
    - 8. Oil level of the compressor approx. 1/2 2/3 of level gauge (during operation)
    - 9. Liquid level of the condenser or receiver approx. 1/3 1/2 of oil gauge (during operation)
    - 10. Greasing into the fan bearing section at least one two months
    - 11. Insulation resistance of the electric apparatus, 1 mil or higher
    - 12. Adjustment of super heat degree of the expansion valve Evaporation temperature + (5 7 °C)
    - 13. Power source voltage Rated voltage ± 10%

- 14. Is there no uncondensed gas (air etc.) mixed inside the equipment?
- 15. Is there no air remaining unpurged in the cooling water piping line?
- 16. Do the fan and compressor operate without abnormal vibration?
- 17. Is the fresh/return air ratio satisfactory?
- 18. Are the doors and windows of each room including the engine room closed? Curtains of glass windows should preferably be closed.
- 19. Is there no gas leaking from each section? Check once every week.

Factors that affect the air conditioning load.

While in operations.

- 1. Heat transmission
- 2. Solar radiation or sun effect
- 3. People
- 4. Light and power equipment
- 5. Ventilation air or infiltration
- 6. Product load and miscellaneous

#### **PROCEDURE FOR STARTING THE SYSTEM**

#### A. Preparation for Drive

- 1) Start cooling sea water through the condenser
- 2) Check opening and closing conditions of the following valves.
  - a. Valves opened during operation are:

Compressor suction & discharge valve

Strainer inlet & outlet valve

Valve for each gauge

Cooling water inlet & outlet valve for condenser.

- inlet & outlet valve of expansion valve (for central unit system)
- b. Valves closed during operation are:

Refrigerant supply valve

Refrigerating machine oil supply valve

Condenser air purge valve

3) Switch the crank case heater "ON" (about 2 hours before starting).

#### **B.** Starting and Driving

- 1) Start the fan.
- 2) Start the compressor.
- 3) Change the liquid line solenoid valve to the automatic position. Refrigerant flows, pressure increased from low and the compressor starts. (When the low pressure is higher than specified, it may occur that the compressor starts before the solenoid valve is open.)

To restart the compressor after a long period of suspension or after stopping abnormally or stopping without returning the coolant to the condenser, open the compressor suction valve, by degrees so as not to allow liquid turn back.

#### c. Stopping

- 1) Close the liquid line solenoid valve. (In the case of central unit system, close the condenser's or receiver's outlet valve.)
- 2) After a while, coolant in the piping and cooler is returned to the condenser, pressure decreases and the DPS (low-pressure side) operates so that the compressor stops automatically. After stop, it may happen that residual coolant evaporates, pressure increases, the DPS (low-pressure side) operates and the compressor restarts.

As the above process is repeated, coolant in the cooler and piping is returned to the condenser.

- 3) Close the suction valve and discharge valve of the compressor.
- 4) Stop the fan.
- 5) Switch the crank case heater "OFF"
- 6) Stop the cooling water to the condenser.

#### METHOD OF AIR PURGE IN EQUIPMENT

## A. Air purge in the system from the strainer inlet value to the refrigerating machine discharge value.

- 1) Close the strainer inlet valve and return the coolant in the system into the condenser or receiver.
- 2) Electrically stop the compressor.
- 3) Close the compressor discharge valve.
- 4) Open the purge valve of the compressor and make pressure inside the refrigerating machine and system equal to atmosphere pressure.
- 5) Operate the compressor while keeping the low pressure side of the DPS from working. Air and gas are removed from the purge valve.
- 6) After driving until the low pressure is nearly vacuum, stop the compressor and close the purge valve simultaneously.

#### B. Air purge in the condenser

- 1) Stop the compressor. Keep on running the cooling water for 20-30 minutes.
- 2) Open the purge valve provided in upper part of the condenser, and remove air and gas until the high pressure gets saturated equivalent to the cooling water temperature.

#### STEAM HEATER'S HEATING OPERATION

- 1. Drive the fan
- 2. Effect complete draining of the system. Absolutely avoid using a water hammer.
- 3. Make sure of the steam pressure.
- 4. There are two methods of automatic steam flow control, the electric valve control system by thermostat and the automatic control system by automatic temperature regulating valve. For manual control, the opening degree of the needle valve is adjusted.
- 3. Humidification is effected by spraying through the spray nozzle. It is controlled by either manual operation or humidistat operation.
- 6. For stopping, close the steam valve.
- 7. After stopping steam supply, drive the fan continuously for more than 20 minutes to cool down the heater.
- 8. Open the drain cock of the drain valve panel.
- 9. In a frigid area, great care should be taken to drain the heat coil completely when stopping heating, because congelation may break the coil.

PRECAUTIONS:

- 1. When steam pressure lowers during operation, the heating efficiency also decreases. The strainer should be cleaned at times.
- 2. Clean the air filter, feed grease for the fan bearing, motor bearing sections and adjust the V-belt

					Misc.			Ç	2			Temperature				Pressire					Compressor						Trou for r
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					Low reingerant level in the receiver	Bubbles in the liquid sight glass	Sweating or frozen crankcase	Insufficient oil pressure	Oil in the crankcase foaming intensely	Oil level in the crankcase falls	Oil temperature too high	Discharge pipe temperature too low	Excessive discharge pipe temperature	Insufficient suction pressure	Excessive suction pressure	Insufficient discharge pressure	Excessive discharge pressure	Liquid hammer (slug) in the compressor during operation	Liquid hammer (slug) in the compressor during start-up	Insufficient compressor capacity	Abnormally noisy compressor	Compressor runs continuously	Compressor starts, but stops immediately afterwards	Compressor starts and stops frequently	Compressor will not start	Observed fault	ig compressors Fault due to:
Electrical				3   K	3		10	18	17	6	15	14	13	12	11	10	9	8	7	<b>6</b>	5	4	3	N	- <b>*</b> :	1	No current main switch not coupled in
supply			F			╪	╞													-			*		***	2 3 4	Fuses burnt out - loose electrical connection Electrical voltage too low No pilot current
Electrical connections	Check-points when starting																					*	**		***	5 6 7 8	Over current relay open- reset Pilot current circuit open Pumps/fans not started Welded contacts in the motor protection
Automatic controls	dn-f s			×	×			*					*	* *	*		*			*			****	** *	** *	9 10 11 12 13	High-pressure pressure switch cut-out reset Low-pressure pressure switch cut-out reset Low-pressure pressure switch differential too small Oil pressure pressure switch cut-out reset Capacity regulator incorrectly set
OII		4		<u>x x x</u>		*	*	* **	*	* *					*				*	*	**		** **		*	14 15 16 17 18	Defrost timer causes power cut-out Insufficient oil charge Excessive compressor capacity during start-up Insufficient oil pressure – adjust oil pressure regulating valve Oil in the crankcase foaming
			+	╁	╈			F		*			¥	**				*		¥	*	: *		*		19 20 21	Excessive oil charge Poor oil return - oil in the evaporators I mited evaporate
Refrigerant		IJ			7	***	*	*	*	*		*			*	*	*	~ * *	*	~***	*	~* *		<b>***</b>		21 22 23 24 25 26	Limited supply of reirigerant Insufficient refrigerant charge Refrigerant vapour in the liquid line Leaky refrigeration plant Excessive refrigerant charge Liquid in the suction line
Condenser		5										*	****	*		*	****			*				*		27 28 29 30 31 32 33	The degree of filling in the evaporator rises at low operating temperature Insufficient cooling water/air to the condenser Temperature of the cooling water/air too high Non-condensable gases in the condenser Condenser should be cleaned Too much cooling water/air in the condenser Water value out of operation
Expansion valve		7					*		*		****	*	****	***	*			*	***	****				****		34 35 36 37 38 39	Expansion valve external equalizing closed Expansion valve is partially blocked by ice, dirt or wax Expansion valve has lost its charge Expansion valve sensor incorrectly placed Leaky expansion valve Expansion valve gives insufficient superheat
Miscellaneous				>	k	*					*		**	*** **					*	** ***		*	**	** **		40 41 42. 43 44 45 46	Expansion valve gives excessive superheat Filters in liquid/suction line clogged Solenoid valve in liquid/suction line closed Leaky solenoid valve Evaporator frozen or clogged Cooling air recirculates (shorted) Plant load too high
					>	ĸ															*				B	47 48	Refrigerant collects in cold condenser (close by-pass) Coupling misaligned or loose
Compressor				x x x x x x x x x x x x x x x x x x x	xxx			**	*	*	*		*	*	***	** *			**	****	*****	** *	** *	** *		49 50 51 52 53 54 55 55 56 57	Defective oil pumps         Bearings worn or defective         Defective piston rings or worn cylinder         Discharge valves defective or leaky         Suction valves defective or leaky         Compressor by-pass open – leaky safety valve         Compressor oil filter clogged         Defective capacity regulator         Excessive compressor capacity during start-up
				>	k	*			*	**				*	*	*			*	*	*	*	*	*		58 59 60 61 62	Solenoid valve in oil return clogged/faulty Filter in oil return clogged Compressor capacity too large Compressor capacity too small Heating element in crankcase defective

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### TROUBLESHOOTER'S GUIDE TO REFRIGERATION PROBLEMS

	Symptoms	<b>R</b> robable Cause	<b>Recommended</b> Action
		Trouble: Compressor "Short-Cycl	les"
1.	Normal operation ex- cept too frequent stop- ping and starting	1. Intermittent contact in electrical control circuit	1. Repair or replace faulty electrical control
2.	Normal operation ex- cept too frequent stop- ping and starting	2. Low-pressure control- ler differential set too close	2. Reset differential in accordance with proper job conditions
3.	Valve may hiss when closed. Also tempera- ture change in refrige- rant line through valve	<ol> <li>Leaky liquid line sole- noid valve</li> </ol>	3. Repair or replace
4.	<ul> <li>Reduced airflow</li> <li>a. Dirty air filters</li> <li>b. Broken fan belt</li> <li>c. Fan belt tension improperly adjusted</li> </ul>	4. Dirty or iced evapora- tor	4. Clean or defrost eva- porator. Check filters and fan drive
5.	Excessively high discharge pressure	5. Faulty condensing	5. Check for water failure or evaporative conden- ser trouble
6.	High discharge pressure	6. Overcharge of refrige- rant or nonconden- sable gas	6. Remove excess refri- gerant or purge non- condensable gas
7.	Normal operation except too frequent stopping and starting on low-pressure con- trol switch	7. Lack of refrigerant	7. Repair refrigerant leak and recharge
<b>8.</b>	High discharge pressure	8. Water-regulating valve inoperative or restricted by dirt, or water tempe- rature too high	8. Clean or repair water valve
<b>9</b> .	High discharge pressure	9. Water piping restricted or supply water pres- sure too low	9. Determine cause and correct
10.	Suction pressure too low and frosting at strainer	10. Restricted liquid line strainer	10. Clean strainer
11.	Motor starts and stops	11. Faulty motor	11. Repair or replace
12.	Compressor cuts off on high pressure cutout	12. Fouled shell-and-tube	12. Clean condenser tubes
13.	Compressor cuts off on high pressure cutout	13. Faulty operation of evaporative condenser	13. Determine cause and correct
	a. No water b. Spray nozzles	ı.	a. Fill with water b. Clean spray

	clogged c. Water pump not operating d. Coil surface dirty e. Air inlet or outlet obstructed f. Fan not operating <b>Tro</b>	uble: Compressor Runs Contin	nozzles c. Repair faulty pump d. Clean coil e. Remove obstruc- tion f. Repair uously
1.	High temperature in conditioned area	1. Excessive load	1. Check for excessive fresh air or infiltration. Check for inadequate
2.	Low temperature in conditioned area	2. Thermostat controlling at too low a tempera- ture	2. Reset or repair thermostat
3.	Low temperature in conditioned space	3. "Welded" contacts on electrical controls in motor short circuit	3. Repair or replace faulty control
4. 5.	Bubbles in sightglass High discharge	<ol> <li>Lack of refrigerant</li> <li>Overcharge of refri- gerant</li> </ol>	<ol> <li>Repair leak and charge</li> <li>Purge or remove</li> <li>excess</li> </ol>
6.	Compressor noisy or operating at abnor- mally low discharge pressure or abnormal- ly high suction pressure	6. Leaky valves in compressor	6. Overhaul compressor
7.	Air-conditioned space too cold	<ol> <li>Solenoid stop valve stuck open or held open by manual lift stern</li> </ol>	<ol> <li>Repair valve or restore to automatic operation</li> </ol>
		Trouble: Compressor Loses C	Dil
1.	Oil level too low	1. Insufficient oil charge	1. Add sufficient amount of proper compressor oil
2.	Oil level gradually drops	2. Clogged strainers or valves	2. Clean or repair and replace
3.	Excessively cold suction	3. Loose expansion valve or remote bulb	3. Provide good contact between remote bulb and suction line
4.	Excessively cold suc- tion. Noisy compressor	4. Liquid flooding back to compressor	4. Readjust superheat setting or check
5.	Too frequent starting and stopping of compressor	5. Short cycling	<ol> <li>Defrost; check pres- sure cutout</li> </ol>
<b>6.</b>	Oil around compressor base and low crank- case oil level	6. Crankcase fittings leak oil	6. Repair oil leak and add proper refrigerant oil

	Trouble: Compressor is Noisy								
1.	Coupling bolts loose	1.	Loose compressor drive coupling	1.	Tighten coupling and check alignment				
2.	Compressor cuts out on oil failure contact	2.	Lack of oil	2.	Add oil				
3.	Squeak or squeal when compressor runs	3.	Dry or scored seal	3.	Check oil level				
4.	Compressor knocks	4.	Internal parts of com- pressor broken	4.	Overhaul compressor				
5.	Abnormally cold suc- tion line. Compressor knocks	5.	Liquid "flood back"	5.	Check and adjust superheat. Valve may be too large or remote bulb loose on suction line. Air entering eva- porator too cold for complete evaporation of liquid				
6.	Water valve chatters or hammers	6.	Dirty water regulating valve, too high water pressure or intermittent water pressure	6.	Clean water regulating valve. Install air cham- ber ahead of valve				
7.	Abnormally cold suc- tion line. Compressor knocks	7.	Expansion valve stuck in open position	7.	Repair or replace				
8.	Compressor or motor jumps on base	8.	Compressor or motor loose on base	8.	Tighten motor or com- pressor hold-down bolts				
		Trou	ble: System Short of Cap	acity					
1.	Expansion valve hisses	1.	Flash gas in liquid line	1.	Add refrigerant				
2.	Temperature change in refrigerant line	2.	Clogged strainer or solenoid stop valve	2.	Clean or replace				

	through strainer or solenoid stop valve				
3.	Reduced airflow	3.	Ice or dirt on evapo-	3.	Clean coil or defrost
4.	Short-cycling or con- tinuous running	4.	Expansion valve stuck or obstructed	4.	Repair or replace expansion valve
5.	Superheat too high	5.	Excess pressure drop in evaporator	5.	Check superheat and reset thermostatic expansion valve
6.	Short-cycling or continuous running	6.	Improper superheat adjustment	6.	Adjust expansion valve. Check super- heat and reset ther- mostatic expansion valve
7.	Short-cycling or con- tinuous running	7.	Expansion valve im- properly sized	7.	Replace with correct valve

Trouble: Disharge Pressure Too High

1.	Excessively warm water leaving condenser	1.	Too little or too warm condenser water	1.	Provide adequate cool water, adjust water- regulalting valve
2.	Excessively cool water leaving condenser	2.	Fouled tubes in shell- and-tube condenser	2.	Clean tubes
3.	Low air or spray water volume. Scaled surface	3.	Improper operation of evaporative condenser	3.	Correct air or water flow. Clean coil surface
4.	Exceptionally hot condenser and exces- sive discharge pressure	4.	Air or non-condensa- ble gas in system	4.	Purge
5.	Exceptionally hot con- denser and excessive discharge pressure	5.	Overcharge of refrigerant	5.	Remove excess or purge

1.	Excessively cold water leaving condenser	1.	Too much condenser water	1.	Adjust water-regulating valve
2.	Bubbles in sightglass	2.	Lack of refrigerant	2.	Repair leak and charge
3.	Suction pressure rises faster after pressure shutdown than 5 lb/min	3.	Broken or leaky com- pressor discharge valves	3.	Remove head, examine valves, replace faulty ones
4.	Low discharge pres- sure and high suction pressure	4.	Leaky relief bypass valve	4.	Inspect valve to deter- mine if replacement is necessary

#### Trouble: Suction Pressure Too High

1.	Compressor runs continuously	1.	Excessive load on evaporator	1.	Check for excessive fresh air or infiltration, poor insulation of spaces
2.	Abnormally cold suc- tion line. Liquid flood- ing to compressor	2.	Overfeeding of expan- sion valve	2.	Regulate superheat setting expansion valve, see remote bulb OK on suction line
3.	Abnormally cold suc- tion line. Liquid flood- ing to compressor	3.	Expansion valve stuck open	3.	Repair or replace valve
4.	Abnormally cold suc- tion line. Liquid flood- ing to compressor	4.	Expansion valve too large	4.	Check valve rating, replace if necessary
5.	Noisy compressor	5.	Broken suction valves in compressor	5.	Remove head, examine valves, repair faulty ones

Trouble: Suction Pressure Too Low

1.	Bubbles in sightglass	1. Lack of refrigerant	1.	Repair leak, then
			1	

	<i>,</i>				charge system
2.	Compressor short- cycles	2.	Light load on evapo- rator	2.	Not enough refrigerant
3.	Temp. change in refri- gerant line through strainer or solenoid stop valve	3.	Clogged liquid-line strainer	3.	Clean strainer
4.	No flow of refrigerant through valve	4.	Expansion-valve power assembly has lost charge	4.	Replace expansion valve power assembly
5.	Loss of capacity	5.	Obstructed expansion valve	5.	Clean valve or replace if necessary
6.	Conditioned space too cold	6.	Contacts on control thermostat stuck on closed position	6.	Repair thermostat or replace if necessary
7.	Compressor short- cycles	7.	Compressor capacity control range set too low	7.	Reset compressor capacity control range
8.	Lack of capacity	8.	Expansion valve too small	8.	Check valve rating table for correct sizing and replace if necessary
9.	Too high superheat	9.	Too much pressure drop through evapo- tor	9.	Check for plugged external equalizer

#### **AIRCONDITIONING SYSTEM:**

Factors affecting both physical and chemical conditions of the atmosphere within a structure can be controlled by air-conditioning systems. They are temperature, humidity, motion of air, air distribution, air pressure, dust, bacteria, odors, toxic gases, and ionization. These are known under the acronym of HVAC (heating, ventilating, air conditioning).

#### Q. What factors affect the conditioning load?

A. A group of complex factors affect the conditioning load. They are (1) heat transmission, (2) solar radiation or sun effect, (3) people, (4) light and power equipment, (5) ventilation air or infiltration, (6) product load, and (7) miscellaneous.

#### Q. What is meant by heat transmission?

A. Heat transmission is the heat flow through walls, floors, windows, ceilings, and roof. It comes about from a temperature difference between the inside air-conditioned space and the outside atmosphere. Heat flows in when the temperature is higher outside. This unwanted heat must be removed by cool air.

#### Q. What should be known about outside temperatures?

A. Weather conditions make up most of the heat transmission load in conditioned spaces. Local weather bureaus forecast valuable information on this subject. An operating engineer can use forecasts to plan operations ahead. Insulating spaces or buildings against transmission loads reduces the load on air-conditioning equipment.

#### Q. What effect does sunlight have on air-conditioned spaces?

A. Windows exposed to sunlight transmit most of the solar radiation. This in turn is absorbed by furniture, fixtures, and flooring. Solar radiation can be reduced with blinds, awnings, or light-colored paint on the outside of building walls. Painting roofs aluminum or spraying them with water during sun periods reduces radiation.

#### STARTING AIR-CONDITIONING CENTRIFUGAL COMPRESSOR SYSTEMS

#### **BASIC STEPS FOR STARTING CENTRIFUGAL SYSTEMS**

- A. There are various types of systems and controls, but here are basic steps for starting:
  - 1. Check oil levels in the compressor, drive, gear, and coupling to make sure they are all right.
  - 2. Start condenser-water flow. Be sure to avoid water hammer in the system.
  - 3. Start brine circulating through the brine cooler. Again, avoid water hammer.
  - 4. Check the air pressure of air-operated controls, if any.
  - 5. Run the purge unit to rid the machine of air. Always do this before starting.
  - 6. Close the suction damper only as far as necessary on synchronous-motor drives.
  - 7. Warm the turbine on turbine-driven machines. Be sure to drain the system thoroughly before starting the turbine.
  - 8. Close the holding circuit for safety controls, if necessary for starting.
  - 9. Bring the machine to full speed and be sure the seal-oil gages have the right oil pressure.
  - 10. Open the air supply to the controller on automatically controlled machines.
  - 11. Open the supply value in the water line to the oil cooler on the unit for drive and reduction gears.
  - 12. Run at high speed if machine surges. This accelerates purging. Centrifugal compressor is usually installed for hotel and passenger ships.

	Symptom 3 Sympto	Probable Cause
Β.	Pump does not deliver rated capacity	<ol> <li>Wrong direction of rotation.</li> <li>Suction line not filled with liquid.</li> <li>Air or vapor in suction line.</li> <li>Air leaks in suction line or through stuffing boxes.</li> <li>Suction-line intake not submerged enough.</li> <li>Available NPSH not sufficient.</li> <li>Height from liquid level to centerline of pump too great.</li> <li>Distance from suction-well liquid level to centerline of pump too small.</li> <li>Difference between suction pressure and vapor pressure too small.</li> <li>Pump not up to rated r/min.</li> <li>Total head greater than head for which pump was designed.</li> </ol>

#### TROUBLESHOOTER'S GUIDE TO CENTRIFUGAL PUMP PROBLEMS

		<ol> <li>Foot valve too small.</li> <li>Foot valve clogged with trash.</li> <li>Viscosity of liquid greater than that for which pump was designed.</li> <li>Mechanical defects such as wearing rings worn, impeller damaged, or internal leaks caused by defective gaskets.</li> </ol>
C.	Pump's discharge pressure low	<ol> <li>Gas or vapor in liquid.</li> <li>Pump not up to rated r/min.</li> <li>Greater discharge pressure needed than that for which pump was designed.</li> <li>Liquid thicker than that for which pump was designed.</li> <li>Wrong rotation.</li> <li>Mechanical defects such as wearing rings worn, impel- ler damaged, or internal leaks caused by defective gaskets.</li> </ol>
D.	Stuffing boxes overheat	<ol> <li>Packing too tight.</li> <li>Packing not lubricated.</li> <li>Wrong grade of packing.</li> <li>Not enough cooling water to jackets.</li> <li>Stuffing box improperly packed.</li> </ol>
E.	Pump loses prime after starting	<ol> <li>Suction line not filled with liquid.</li> <li>Air leaks in suction line or through stuffing boxes.</li> <li>Gas or vapor in liquid.</li> <li>Air or vapor pockets in suction line.</li> <li>Available NPSH not high enough.</li> <li>Inlet to suction line not submerged far enough.</li> <li>Height from liquid level to centerline of pump too great.</li> <li>Distance from suction-well liquid level to centerline of pump too small.</li> <li>Difference between suction and vapor pressure too small.</li> <li>Liquid seal piping to lantern ring plugged.</li> <li>Lantern ring not properly placed in stuffing box.</li> </ol>
F.	Pump overloads drive	<ol> <li>R/min too great.</li> <li>Total head lower than rated head.</li> <li>Either the specific gravity or viscosity of liquid or both different from that for which pump is rated.</li> <li>Mechanical defects such as misalignment, shaft bent, rotating element dragging, or packing too tight.</li> </ol>
G.	Vibration	<ol> <li>Starved suction, because of gas or vapor in liquid, available NPSH not high enough, inlet to suction line not submerged far enough, or gas or vapor pockets in suction line.</li> <li>Misalignment.</li> </ol>

		<ol> <li>Worn or loose bearings.</li> <li>Rotor out of balance, because of the impeller being plugged or damaged.</li> <li>Shaft bent.</li> <li>Control valve in discharge line improperly placed.</li> <li>Foundation not rigid.</li> </ol>
H.	Bearings overheat	<ol> <li>Oil level too low.</li> <li>Improper or poor grade of oil.</li> <li>Dirt in bearings.</li> <li>Dirt in oil.</li> <li>Moisture in oil.</li> <li>Oil cooler clogged or scaled.</li> <li>Various failures of oiling system.</li> <li>Not enough cooling water.</li> <li>Bearings too tight.</li> <li>Oil seals fitted too closely on shaft.</li> <li>Misalignment.</li> </ol>
i.	Bearings wear rapidly	<ol> <li>Misalignment.</li> <li>Shaft bent.</li> <li>Vibration.</li> <li>Excessive thrust resulting from mechanical failure inside the pump.</li> <li>Lack of lubrication.</li> <li>Bearings improperly installed.</li> <li>Dirt in bearings.</li> <li>Moisture in oil.</li> <li>Excessive cooling of bearings.</li> </ol>

#### MAINTENANCE

#### Common caution for dismantling compressors for repair.

Keep the following caution for dismantling and reassembling the compressors.

- 1. Be careful not to impair or scratch the parts when they are dismantled or reassembled. Special care should be taken to the shaft seal when it is handled.
- 2. Use a clean tool.
- 3. Arrange the parts in order as they are dismantled on a clean place. If it takes time to repair the compressor, apply the refrigeration oil to them for storage.
- 4. Use absolute alcohol of normal temperature to clean the parts. After cleaning, wipe off alcohol completely.
- 5. Use sponge (morutoplane) which has no fibre to wipe off alcohol so as not to leave strings on those parts.
- 6. Take special care with parts having similar form or forming a pair not to mix them up with others.
- 7. Take special care that parts having insertion parts have predesigned clearance.

- 8. Besure to remove rust, dust, water or foreign objects from the parts before being reassembled.
- 9. If packing adhere firmly to metal surface, carefully remove them without impairing packings and metal surface. If they are heard to peeled off, tear them into pieces, but do not make any scares on metal surface.
- 10. Before placing a packing, apply clean refrigeration oil to machined surface.
- 11. Remember where the clamp bolts are used when they are removed, as they have similar form and measurements. However, they are made of different materials and have different screw thread. In addition, do not forget to attach the washers if they were attached.

#### **CONVERSION FACTORS**

Atmosphere (standard) = 29.92 inches of mercury

- Atmosphere (standard) = 14.7 pounds per square inch
- 1 horsepower = 746 watts
- 1 horsepower = 33,000 foot-pounds of work per minute
- 1 British thermal unit = 778 foot-pounds
- 1 cubic foot = 7.48 gallons
- 1 gallon = 231 cubic inches
- 1 cubic foot of fresh water = 62.5 pounds
- 1 cubic foot of salt water = 64 pounds
- 1 foot of head of water = 0.434 pound per square inch
- 1 inch of head of mercury = 0.491 pound per square inch
- 1 gallon of fresh water = 8.33 pounds
- 1 barrel (oz) = 42 gallons
- 1 long ton of fresh water = 36 cubic feet
- 1 long ton of salt water = 35 cubic feet
- 1 ounce (avoirdupois) = 437.5 grains

#### Liquid

2 pints = 1 quart 4 quarts = 1 gallon = 231 cubic inches 1 gallon (U.S.) = 0.83267 British Imperial gallon 1 gallon (British Imperial) = 1.20095 U.S. gallons 42 gallons = 1 barrel (of oil)

#### **THERM-HOUR CONVERSION FACTORS**

1 therm-hour = 100,000 Btu per hour				
1 brake horsepower = 2	2544 Btu per hour			
1 brake horsepower	= <u>2544</u> =	0.02544 therm-hour		
-	100,000			
1 therm-hour	= <u>100.000</u> =	39.3082 brake horsepower		
	2544	(40 hp is close enough)		
1 therm-hour	= <u>100.000</u> =	2.9873 boiler horsepower		
	33,475	(3 hp is close enough)		
Example: How many th	erm-hours in a 10	00-hp engine?		

#### **PROBLEMS (PUMPS)**

# Q. How much heat is needed to raise the temperature of 200 lb. of butter from 40 to 82°F and specific heat is 0.64?

FORMULA: H =

- = WS  $(t_2 t_1)$ 
  - = 200 x 0.64 x (82 40)
  - = 200 x 0.64 x 42
  - = 5376 BTU of heat required.

# Q. What horsepower is needed to raise 3000 gallon of water to a height of 100 ft? SOLUTION:

3000 gal. x 8.33	<u>lb.</u> = gal.	24,9	90 lbs.		
Pumping for 1 hour	24,990 416.5	+ X	60 100 ft.	=	416.5 lb/min. 41,650 ft. lb./min.
Therefore:	<u>41,650</u> 33,000	=	1.26 hp.		

Q. Calculate the horsepower needed to drive a centrifugal pump to deliver 250 gal./ min. of water against a 70 ft. head if the pump efficiency is 65 percent.

FORMULA:

- $hp = \underline{gal./min. x S.G. x head}$  3960 x Eff.
  - = <u>250 x 1 x 70</u> 3960 x 0.65

= 6.8 HP

Q. Calculate the Kilowatt needed by the electric motor driving a centrifugal pump used for pumping 250 gal./min. of water against a 1000-ft. head, efficiency of pump is only 50 percent, efficiency of motor is 80 percent. Data: 5308 constant, SG = 1  $H_2O$ .

FORMULA:

- Kw = <u>gal./min. x Sp. gr. x head</u> 5308 x Ep x Em
  - = <u>250 x 1 x 100</u> 5308 x 0.50 x 0.80
  - = <u>25000</u> 2123.2
  - = 11.775 Kw.

Q. Find the refrigeration needed to cool 30,000 lbs. of lean beef from a temperature of 95°F to 35°F in 24 hours. Specific heat of beef above freezing = 0.77 BTU/LBS.

- Q = mass x specific heat x temp. change
  - = (30,000 lb.) (0.77 BTU/lb.) (95 35)
  - = 1,386,000 BUT in 24 hours
  - = <u>1,386000 BIU/day</u>
    - 288,000 BTU/day/tons
  - = 4.81 tons

**Q.** A compressor chills 100 gal./min. of water through a temperature range of 20°F. What is the compressor capacity in this load?

- C = 0.042 x gal./min. x temperature
  - $= 0.042 \times 100 \times 20$
  - = 84 tons

Q. Calculate the piston displacement of a two cylinder compressor rotating at 1,500 RPM. If the diameter of the cylinder is 5 cm. and the length of stroke is 5 cm.

SOLUTIONS:

cyl. dia. 
$$5 \text{ cm} = 1.97 \text{ inch} 1728 \text{ cu. in.} = 1 \text{ cu. ft.}$$
  
stroke  $5 \text{ cm} = 1.97 \text{ inch} = 1 \text{ cu. ft.}$   
Vd = Area x L x N x Xn  
1728  
=  $0.7854 \times (1.97)^2 \times 1.97 \times 1500 \times 2$   
1728  
= 10.44 cu. in.

**Q.** Determine the shaft power required by the compressor if the theoretical power required to drive the compressor is 1.327 Kw and overall efficiency of the compressor is 80%.

Given:	efficiency	=	80% or .8
	theo. power	=	1.327 Kw

FORMULA:

Efficiency	=	<u>output</u> input	
output	-	input x efficiency	
shaft power	=	theo. power x efficiency	
	=	1.327 Kw x .8	
	=	1.0616 Kw	

Q. If the volumetric efficiency of the compressor is 76% and the theoretical refrigerating capacity is 8.376 Kw. What is the actual refrigerating capacity?

Efficiency	=	<u>output</u>
		input
Output	=	input x Efficiency
·	=	8.376 x 0.76
	=	6.366 Kw.

## **BOARD QUESTIONS**

## FOURTH ENGINEER Refrigeration and Airconditioning Machinery

1. The process of changing a solid to a liquid is called the latent heat of

	A. B.	Vaporization Evaporation	<b>C</b> . D.	Fusion Condensation
2.	The	purpose of the evaporator is to	):	
	A. B.	Transmit latent heat of fusion Transmit latent heat of evapora	ation	C. Absorb latent heat of fusion D. Absorb latent heat of evaporation
3. \	Vhic	h of the following would give the n	nost	trouble when operating with hot condenser:
	A.	Freon - 12	C.	CO2
	В.	Ammonia	D.	Methyl Chloride
4.	A I	iquid receiver is used to:		
	<b>A</b> . B.	Separate the oil from the refrig Cool the hot gases	jerar	nt C. Store the refrigerant D. Receive the refrigerant on charging
5.	The	heat used to change a liquid t	o a	gas is called latent heat of:
	A.	Fusion B. Vaporization		C. Absorption D. Liquid
6.	A re	efrigerant gives up heat when it		r
	Α.	Evaporates B. Condenses		C. Vaporizes D. Boils
7.	Whe	en securing a system, the first s	step	would be to:
	<b>A.</b> B.	Close king valve C. Open Solenoid Valve D.	Cio Opi	se compressor high pressure valve en by pass valve
8.	The	lowest temperature of the syst	em i	refrigerant is at the
	А. В.	Evaporator Condenser	C. D.	Receiver Expansion valve outlet
9.	Mois	sture in a vapor compression sy	rsten	n will cause:
	А. В.	High suction temperature High suction pressure	<b>C.</b> D.	Faulty Expansion valve Low discharge temperature
10.	A t	hermostat expansion valve can	be t	ested by:
	А. В.	Holding its buib in ones hand Immersing its tube in hot wate	r	C. Immersing its bulb in ice water D. Shorting out the cut-out switch

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- 11. Primary reason for use of compressor in a vapor compression system:
  - A. To compress refriderant das
  - B. To save the expanded liquid so that it can be reused many times
  - C. Raise the temperature of the cas
  - D. As principal part of the system
- 12. Ambient temperature means
  - A. Temperature of the body C. Temperature of machinery
  - B. Temperature of air in a space D. Temperature of compressed gas
- 13. Quantity of heat required to raise the temperature of one gram of water one degree celsius is
  - A. BTU B. Calorie C. Specific heat D. Latent Heat
- 14. The actual refrigerating or cooling effect is produced by:
  - A. Pressure change of refrigerant
  - B. The boiling refrigerant changing to a vapor
  - C. Increasing pressure of refrigerant
  - D. Lowering pressure of refrigerant
- 15. To handle a 288,000 BTU load of cooling, if the cooling is to be done in 12 hours you will need a:
  - A. 1 ton compressorB. 2 tons compressor C. 1 1/2 tons compressor
  - C. 1 1/2 tons compressor D. 3 tons compressor

16. Necessary property of all compression system refrigerant

- A. Non-toxic B. Volatile C. Low-boiling pressure D. Non-acidic
- 17. The two main types of evaporators are:
  - C. Finned and tube A. Wet and dry A. Wet and dry B. Dry and flooded
  - D. Short and extended
- 18. The most practical material used as evaporator of ammonia system is:
  - B. Copper alloy C. Steel D. Brass A. Copper
- 19. Test for leak for system containing methyl chloride:
  - A. Ammonia swab test C. Halide torch
  - B. Soap and water test D. Sulphur candle test
- 20. Primary function of the thermostatic expansion valve:
  - A. Control the superheat
  - B. meter the flow of refrigerant
  - C. Control the temperature in the evaporator
  - D. Control gas suction of compressor

- 21. Unloader works on the compressor by:
  - A. Bypassing compressed gas
  - B. By preventing suction valves from closing
  - C. By controlling the temperature
  - D. Controlling pressure
- 22. The direction of flow of the refrigerant gas in a system using horizontal shell and tube condenser is

m in

- A. Bottom to top C. Bottom to bottom
- B. Top to bettom D. Top to top
- 23. The temperature at which the water vapor in the air begins to condense is:
  - A. Saturation point B. Dew point C. Flash point D. Cooling point
- 24. Latent heat is:
  - A. Heat add to change temperature of a substance
  - B. Heat removed to melt ice
  - C. Heat removed to change temperature of a substance
  - D. Heat removed to change state of substance
- 25. Solenoid valve controls the:
  - A. Amount of refrigerant entering the evaporator
  - B. Flow of refrigerant to the expansion valve
  - C. Pressure in the evaporator coils
  - D. Amount of circulating water to the condenser.
- 26. The greatest decrease in the temperature of the refrigerant is at the
  - A. expansion valve B. evaporator C. condenser D. receiver
- 27. When there is freon leaking from the system, halide torch flame will turn

A. blue B. yellow C. green D. orange

- 28. Tubing joints are:
  - A. brazed B. screwed C. welded D. silver welded
- 29. Closing of solenoid valve will stop compressor through the:
  - A. low pressure cut out switch C. high pressure cut out switch
  - B. bypass relief valve D. low water-pressure cut out switch
- 30. A receiver is used to:
  - A. Separate to oil from the refrigerant
  - B. Store the refrigerant
  - C. Cool the hot gases
  - D. Condense the refrigerant

#### 31. The evaporator coils:

- A. are placed in the top of the compartment
- B. are secured to the slides of the compartment
- C. have air completely surrounding them
- D. are placed in front of circulating fans
- 32. Ambient temperature means
  - A. Temperature of the body C. Temperature of compressed gas
  - B. Temperature of air in a space D. Temperature of machinery
- 33. The temperature of the refrigerant is highest just before it enters the:
- A. Receiver **B.** Condenser C. Evaporator D. king valve 34. Moisture in a system will cause a:
- - A. low discharge temperature
  - B. high suction pressure
- 35. Zinc rods are found in the:
  - A. salt water side of the condenser
  - B. evaporator area

#### THIRD ENGINEER

- 1. What effect does ammonia have on lubricants?
  - A. Will cause sludging
  - B. Will lower the efficiency of the oil
  - C. Will not have any effect
  - D. Will form emulsion in the compressor crank case
- 2. Quantity of heat required to raise the temperature of the pound of water to 1oF:
  - A. Calorie B. Specific heat C. Sensible heat D. BTU
- 3. What is the freezing point of water at atmospheric pressure?
  - A. 40 °F B. 36 °F C. 32 °F D. 28 °F
- 4. To handle 288,000 BTU load of cooling, if the cooling is to be done in 4 hours, you will need:
  - A. 3-ton compressor C. 4-ton compressor
  - B. 2-ton compressor D. 6 ton compressor
- 5. The actual refrigerating or cooling effect is produced by:
  - A. Lowering pressure of refrigerant
  - B. Increasing pressure of refrigerant
  - C. The boiling refrigerant changing to a vapor
  - D. Pressure change of refrigerant

- C. compressor crankcase
- D. gas side of the condenser

- C. high suction temperature
- D. faulty expansion valve

- 6. To handle 144,000 BTU load of cooling, if the cooling is to be done in 12 hours, vou will need:
  - A. 2-ton compressorC. 3-ton compressorB. 1-ton compressorD. 4-ton compressor
- 7. What part of the ammonia compression system must the charge connection be hooked up?
  - A. Between the evaporator and compressor
  - B. Between the king valve and the expansion valve
  - C. Between the compressor discharge and the condenser
  - D. Between the solenoid valve and the expansion valve
- 8. Test for leak for system containing sulphur dioxide
  - A. Halide torch
  - A. Halide torchC. Ammonia swab testB. Leak tracing eyeD. Sulphur candle test C. Ammonia swab test
- 9. General type of solenoid valves
  - A. Vertical and horizontal
  - B. Liquid and vapor
- C. Direct-acting & pilot operated
- D. electric and manual
- 10. Main types of evaporators
  - A. Plain and pipe
- C. Prime surface and extended
- B. Dry and flooded D. Plain or corrogated
- 11. Purpose of starting bypass on compressors:
  - A. equalize pressure between discharge and suction side on starting
  - B. to unload discharge pressure to liquid line
  - C. equalize pressure to the crankcase
  - D. protect compressor from overload
- 12. If an ammonia compressor trip-out on cut-out, the solenoid valve is closed by:
  - A. an electric release C. Bellows control
  - B. pressure and bellows control D. temperature & spring control
- 13. Excess refrigerant is removed from the:
  - A. discharge side of compressor C. condenser vent
  - B. suction side of the system D. charging side of the system
- 14. Another name for the liquid valve is the:
  - A. Freon valve B. Master valve C. king valve D. Main shut off valve
- 15. The elements of a thermostat controller switch are usually of the:
  - A. Diaphragm type B. Bellows type C. Bi-metal type D. Bourdon type

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- **16.** Excess frost on the evaporator colls
  - A. Keep ice box cooler C. Lessen load on compressor
  - **B.** does not affect the system **D.** reduce efficiency of the plant
- 17. The suction pressure switch is operated by
  - A. Electric current C. Cut-out relay
  - B. Pressure on a bellow D. Thermocouple
- 18. If frost forms on the cylinders, the cause would be:
  - A. leaky compressor discharge valve C. expansion valve open too wide
  - B. leaky compressor suction valve D. dehydrator-drier clogged
- 19. How is the CO2 system purged?
  - A. The same as the ammonia system C. with a vacuum pump

D. temperature of compressed gas

B. The same as the freon system

#### 20. Ambient temperature means

- A. temperature of the bodyB. temperature of air in spaceC. temperature of machineryD. temperature of compressed gas
- 21. If a change of enthalphy can be sensed as a change of temperature, it is also called as:
  - A. latent heat B. sensible heat C. heat of vaporization D. specific heat
- 22. Trouble of system: Discharge pressure too high Symptom: Exceptionally hot condenser and excessive discharge pressure Cause:
  - A. Air or non-condensable gas in system
  - B. Fouled tubes in shell and tube condenser
  - C. Too little or too warm condenser water
  - D. Overfeeding of expansion valve

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- 23. The most widely used refrigerant control because of its high efficiency and its ready adaptability to any type of refrigeration application
  - A. Hand expansion valve C. Thermostatic Expansion valve
  - B. Automatic expansion valve D. Simple valve
- 24. The most widely used refrigerant, it is completely safe non-toxic, non-flammable and non-explosive.
  - B. Carbon dioxide C. Ammonia D. Freon 12 A. Sulfur dioxide
- 25. Name of the two methods of exercising the proper control of temperature in the refrigeration and which are well known.
  - A. thermostat control C. electronic control
  - B. low pressure control D. both A and B

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- 26. The low-water cutout switch:
  - A. recirculates the cooling water when there is too much refrigerant in the condenser
  - B. stops the compressor when there is no refrigerant running to the evaporator
  - C. stops the flow of refrigerant when the condenser temperature is too low
  - D. stops the compressor when there is insufficient cooling water
- 27. What effect does ammonia have on lubricants?
  - A. Will lower the efficiency of the oil
  - B. Will form emulsion in the compressor crank case
  - C. Will cause sludging
  - D. Will not have any effect
- 28. It is the production and maintenance in space of temperature lower than that of the surroundings:
  - A. refrigerant B. refrigeration C. humidification D. absorption
- 29. The agent used in an indirect reefer system is

Α.	sodium chloride	C. calcium chloride
Β.	potassium chloride	D. A or C

- 30. Purpose of starting bypass on compressor:
  - A. to unload discharge presssure to liquid line
  - B. equalize pressure between discharge and suction side on starting
  - C. protect compressor from overload
  - D. equalize pressure to the crankcase
- 31. Chemical formula of Freon 12

A. CCIF3 B. CF4 C. CCL2F2 D. CCL3F

- 32. One of the disadvantage of carbon dioxide as refrigerant is that
  - A. it is toxic
  - B. it is poisonous
  - C. its critical temperature is 31°C, which falls within the range of sea water temperature
  - D. it is corrosive
- 33. The boiling point of Freon 12.
  - A. -21.6 °F B. 28.9 °F C. 26.8 °F D. 29.8 °F
- 34. The elements of a thermostat controller switch are usually of the:
  - A. Bi-metal type C. Bourdon type
  - B. Diaphragm type D. Bellows type

- 35. What is the absorption system of refrigeration?
  - A. It is system which uses heat surgery to make a change in the condition required in the ref. system
  - B. It is the absorption within the system
  - C. It is the system which uses mechanical energy to make a change in condition req. in the ref. cycle
  - D. both A and B
- 36. Zinc rods are found in the:
  - A. compressor crankcase
  - B. salt water side of the condenser D. evaporator area
- C. gas side of the condenser
- 37. It expands the high pressure liquid to a mixture of low pressure liquid and gas particles.
  - A. condenser

C. expansion valve

B. evaporator

D. compressor

- 38. The indications of faulty freon compressor valve are:
  - A. low head pressure-high suction pressure
  - B. any of these
  - C. compression runs continously
  - D. gradual or sudden decrease in capacity
- 39. How is the CO2 system purged?
  - A. The same as the freon system
  - B. back to CO2 tank
  - C. The same as the ammonia system
  - D. with a vacuum pump
- 40. It dispenses the heat absorbed from the low pressure side. It starts from the discharge of the compressor through the condenser and receiver to the liquid until the inlet side of the expansion valve

- C. low pressure area
- A. compressorC. low pressure aB. high pressure areaD. solenoid valve
- 41. A heat carrying mediums that absorb heat during their cycle in the refrigeration system
  - A. refrigerant
  - B. heat exchanger
  - C. analyzer
  - D. heater

## SECOND/CHIEF ENGINEER

- 1. What takes the place of the suction stroke of the compressor in an absorption system of refrigeration?
  - A. Absorber

- C. Liquefier
- B. Generator D. Refrigerant pump
- 2. What is the absorber in the aqua-ammonia absorption system of refrigeration?
  - A. Water

- C. Ammonia
- B. Bromide D. Lithium
- 3. High latent heat is desirable in a refrigerant so that:
  - A. smaller compressors can be used
  - B. will allow smaller pipings
  - C. will boil at low temperature
  - D. small amount of refrigerant will absorb large amount of heat
- 4. Two main types of evaporator calls are:

Α.	wet and dry	С.	short and extended
B.	finned and tube	D.	dry and flooded

5. Temperature ranges used in the preservation and storage of perishable foods for consumption:

Α	+28°F to +40°F	C20°F to 30°F
Β.	-10°F to -15°F	D. 0°F to +15°F

- 6. System trouble: Compressor "Short Cycles" Symptom: Normal operation, except too frequent stopping and starting Causes:
  - A. low pressure controller differential set too close
  - B. leaky liquid line solenoid valve
  - C. Faulty condensing
  - D. dirty or iced evaporator
- 7. Trouble of system: Discharged pressure too low Symptom: Bubbles in sight glass Cause:
  - A. Leaky relief bypass valve C. Lack of condenser
  - B. Lack of refrigeration D. Dirty expansion valve

8.	Trouble of system: Suction pressure too low Symptom: Too high superheat Cause:			
	A. B. <b>C.</b> D.	Clogged liquid line strainer Expansion valve too small Too much pressure drop throug Light load on evaporator	h ev	aporator
9.	What read	at is the maximum theoretical sucti ds 28 inches?	on lif	t of a pump when the mercury barometer
	A.	33 feet B. 32.5 feet	C.	28 feet D. 31.6 feet
10.	Tes	t for leak for system containing s	sulph	ur dioxide:
	А. В.	Halide torch Leak tracing dye	<b>C.</b> D.	ammonia swab test sulphur candle test
11.	Cyli	inder water jacket cooling is used	d on	
	<b>A</b> . B.	Ammonia compressors Methyl chloride compressors	C. D.	Propane compressors Butane compressors
12.	Gei	neral types of solenoid valves:		
	А. В.	Vertical and horizontal Liquid and vapor	<b>C.</b> D.	Direct-acting and pilot operated Electric and pressure
13.	Wh sys	at takes the place of the compress tem?	ion s	troke of the compressor in an absorption
	А. В.	evaporator pump absorber	<b>C.</b> D.	generator condenser pump
14.	Wh mu:	en removing reusable refrigerant st:	from	a system, the line to the storage drum
	А. В.	be made of copper have no bends in it	<b>C.</b> D.	contain a strainer-dryer be above the level of the compressor
15.	Doe	es ammonia have any effect on I	ubric	ants?
	<b>A</b> . B.	will not have any effect will cause sludging	C. D.	will lower efficiently of the oil will cause emulsion

- 16. To handle a 288,000 BTU load of cooling, if the cooling is to be done in 4 hours, you will need:
  - A. 3-ton compressor C. 2-ton compressor
  - B. 4-ton compressor D. 6-ton compressor
- 17. What part of the ammonia system must the charge-connection be hooked up?
  - A. between the evaporator and the compressor
  - B. between the king valve and expansion valve
  - C. between the compressor and discharge and condenser
  - D. between the dehyrator and expansion valve
- 18. Vacuum pump and indicator for removing moisture in the new vapor compression is hooked up between:
  - A. evaporator and compressor C. condenser and receiver
  - B. compressor and condenser D. receiver and expansion valve
- 19. When adjusting compressor V-belts:
  - A. Make as tight as possible
  - B. Allow 1/2" slack
  - C. Make belt just tight enough to turn pulley
  - D. Align pulleys
- 20. If brine has a high specific gravity:
  - A. it will freeze C. nothing will happen
  - B. it will crystallize D. it will solidify
- 21. A precooler is sometimes installed between the:
  - A. compressor and condenser
  - B. condenser and expansion valve
  - C. expansion valve and evaporator
  - D. evaporator and compressor
- 22. The boiling point of Freon-12 is:
  - A. -26°F
  - B. -32°F
  - C. -60⁰F
  - **D.** 21.6°F

- 23. Many pressure gauges on a Freon system have two dials or graduation on one gauge. The two dials represent:
  - A. Pressure and temperature
  - B. Liquid pressure and gas pressure
  - C. Suction and discharge pressure
  - D. Cooling water inlet and outlet temperature
- 24. Calcium chloride is sometimes used in refrigeration systems as a
  - A. refrigerant D. secondary coolant
  - D. lubricant C. primary coolant
- 25. A refrigerating unit of one ton capacity can remove
  - A. 500 BTU per minuteC. 200 BTU can removeB. 288 BTU per minuteD. 100 BTU per minute
- 26. Frost in the high pressure side of a thermostatic expansion valve would probably be caused by:
  - A. refrigerator box too coldB. dirty expansion valveC. condenser too coldD. High head pressure
  - D. High head pressure
- 27. High temperature of cylinder heads and crankcase is caused by:
  - A. noncondensable gasesC. insufficient refrigerantB. high head pressureD. too much refrigerant
- 28. In every refrigeration installation, the cooling effect is produce in the
  - A. compressor C. condenser
    - D. liquid reservoir
- 29. If the thermal bulb becomes loose on the evaporator coils, it will cause:
  - A. an electrical short

**B.** evaporator

- B. flooding back of the refrigerant
- C. improper operation of expansion valve
- D. any of the above
- 30. External frost on inlet of expansion valve indicates:
  - A. expansion valve plugged or dirty C. refrigerating compartment too cold
  - B. head pressure too high D. air in system
- 31. The temperature of the refrigerant is highest just before it enters the:

A. receiver	B. evaporator	C. king valve	D. condenser
-------------	---------------	---------------	--------------

- 32. Subcooling of the refrigerant results in:
  - C. A. less circulating water needed liquid less likely to vaporize
  - B. effect of refrigerant increased D. B and C
- 33. Absolute zero on Fahrenheit scale is:
  - A. 460° below zero C. any of these B. -273.15°C D. +460°F
- 34. Name the methods of exercising the proper control of temperature in the refrigeration and which are well known.
  - A. low pressure control C. thermostatic control B. electronic control both A and B D.
- 35. What is the compression system of refrigeration?
  - it is the system which uses heat energy to make a change in the cond. req. in the Α. ref. cycle
  - B. both a and b
  - C. it is the absorption of heat under temp. compression, pressure and expansion
  - D. it is the system which uses mechanical energy to make a change in the cond. req. in the ref. cycle
- 36. When securing a system the first step would be to:
  - C. cut compressor on high pressure A. open bypass valve
  - B. open solenoid valve D. close receiver (king valve)
- 37. The purpose of providing hot-gas defrosting facilitates:
  - A. defrosting without raising compartment temperature above 32oF.
  - B. thawing frozen coils
  - C. defrosting automatically
  - D. B or C
- 38. Trouble of system: Discharge pressure too low Symptom: Bubbles in sight glass Cause:
  - A. Lack of condenser water C. Lack of refrigerant
  - B. Leaky relief bypass valve
- D. dirty expansion valve
- 39. It is the amount of heat absorbed by a pound of substance in changing from the liquid to vapor form.
  - A. heat of evaporation B. latent heat of evaporation
- C. sensible heat
- D. boiling point

40. Ammonia leaks in the condenser can be detected by:

- A. adding oil of peppermint to the system and tracking the smell
- B. smelling the discharge water
- C. applying a soapy solution to the condenser heads and looking for bubbles.
- D. applying litmus paper to the circulating water discharge
- 41. An automatically controlled Freon-1/2 compressor will stop when the:
  - A. Expansion valve closes C. Solenoid valve closes
  - B. Expansion valve opens D. Solenoid valve opens
- 42. The thickness of the head gasket is important because it may cause:
  - A. re-expansion
  - B. the piston to strike the head
  - C. decreased efficiency due to increased clearance
  - D. all of these
- 43. It is used to absorb moisture that may be present with the refrigerant.
  - A. evaporator coils B. charging valve C. oil separator D. dehydrator
- 44. If the compressor discharge becomes frosted, the probable cause would be.
  - A. expansion valve improperly set
  - B. refrigerant flooding back
  - C. cuts out the compressor to maintain proper flow
  - D. regulates the king valve
- 45. A scale trap in a Freen system will be found on the:
  - A. receiver B. discharge side C. suction side D. condenser
- 46. The compressor will run continuously if there is:
  - A. too heavy a loadC. air in the systemB. any of theseD. insufficient refrigerant
- 47. A hot suction line may be caused by:
  - A. excess refrigeration
  - B. insufficient condensing cooling water
  - c. B or C
  - D. lack of refrigerant

48. In the refrigeration cycle, the low pressure side in the system is located from

- A. the outlet of the expansion valve to the suction of the compressor
- B. the discharge of the compressor to the inlet of the expansion valve
- C. the outlet of the condenser to the inlet of the expansion valve
- D. the outlet of the condenser to the outlet of the expansion valve

49.	. Humidity is a measure of:		
	A. temperature B. BTU	C. latent heat D. water vapor content	
50.	What is the other name of the brine-circulating system of refrigeration?		
	A. both A and B B. none of these	C. Indirect system D. direct system	
51.	What is the refrigerant in the lithium bromide cycle absorption system?		
	A. Lithium bromide B. Ammonia	C. Bromide salt D. water	
52.	What is the absorber in the aqua ammonia absorption system of refrigeration		
	A. Ammonia B. Water	C. Bromide salts D. Lithium	
53.	<ul> <li>Why is high latent heat desirable in a refrigerant?</li> <li>A. smaller compressors can be used</li> <li>B. small amount of refrigerant will absorb a large amount of heat</li> <li>C. will boil at low temperature</li> <li>D. will allow smaller evaporators</li> </ul>		
54.	What part of the ammonia vapor compression system must the charging content be hooked up?		
	<ul> <li>A. between compressor and condenser</li> <li>B. between condenser and condenser</li> <li>C. between king valve and evaporator</li> <li>D. between solenoid vlave and drier</li> </ul>		
55.	In a refrigeration system, a fluid that serves only as a heat carrier is called		
	A. Condensing refrigerant B. Secondary refrigerant	C. Vaporizing refrigerant D. Primary refrigerant	
56.	Chemical Name of Freon 12		
	A. carbon dioxide B. dichlorodifluoromethane	C. carbon tetrachloride D. carbon tetrachloride	
57.	The cooling component of a refrigeration cycle is called:		
	A. a receiver B. an evaporator	C. a condenser D. a desiccant	
58.	8. When ordering an expansion valve which of the following information is necessar		

- A. size and pressure
- **B.** size, tonnage, temperature and pressure C. pressure and temperature

,

- D. size and tonnage



- **ENGINE INDICATOR** is a device that indicates and records simultaneous values of pressure and volume within an engine cylinder, and consists of a small piston lap-fitted inside the cylinder, a drum, clips for holding cards, coiled spiral spring, cord line and stylus writing mechanism.
- INDICATOR CARD most important use of indicator is to record and determine the mean effective pressure, compression pressure, maximum firing pressure and atmospheric line in a cylinder during combustion process, to solve the power output each cylinder.

#### Method of measuring mean effective pressure:

- 1. Use of a planimeter vernier type
- 2. By means of ordinate method
- 3. Electronic digital planimeter

#### **Procedures:**

- 1. Using planimeter is an instrument used to measure the area of irregular figures, and consist of a fixed point secured at some point attached to the planimeter arm.
  - a. Mark a starting point on the expansion line to locate start and stop position. It must be right triangle position.
  - b. Begin tracing from the starting point clockwise and circumscribe the diagram at even speed and not too slowly.
  - c. Use good illumination and if necessary use magnifying glass for accurate reading of the vernier
  - d. The difference in readings is proportional to the area of the indicator diagram.
  - e. To find MEP divide this area of working diagram by the length of the card and multiply by the number stamped on the indicator spring.

#### 2. Mean – Ordinate Method:

- a. Place an indicator card on smooth flat surface and divide its length into ten equal vertical spaces by drawing vertical lines equal distances apart.
- b. Measure the height of each center line represent the average height of the space and added together.
- c. The sum of 10 vertical lines divided by 10, represent the average height of the card.
- d. When the ave. height is multiplied by the spring scale, the figured result is mean effective pressure.



- A. Ignition
- B. Press-volume working diagram
- C. Ignition stroke
- D. Draw diagram
- E. Top dead center
- F. Bottom dead center
- G. Compression pressure
- H. Max. combustion pressure
- I. Opening Exhaust valve

#### **ENGINE INDICATOR DIAGRAM**

#### Procedures in taking the diagrams:

- 1. First, blown through by opening the indicator cock partially to release soot and oil accumulate in the indicator bore and protect cock against burning.
- 2. Before use, the indicator should be handwarm by placing it on cylinder cover for five minutes.
- 3. With the indicator valve closed, trace the atmospheric line by pressing the stylus against the paper, while the drum is turned one or two times, manually.
- 4. Connect the cord line to indicator drive and open the indicator cock valve and press the stylus against the paper to the drum at moment it moves upwards and get pressure-volume working diagram.
- 5. After, release the cord from the indicator drive, make a timing in taking both compression and maximum pressure on draw diagram, by simultaneously, pull the cord just quickly enough to draw diagram on each cylinder. NOTE:

After taking the diagram is finished, the indicator head should be cleaned and both cylinder, and piston mechanism should be well lubricated with cylinder oil.

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#### PLANIMETERING

Position the Indicator as illustrated above.

Mark a starting point on the expansion line (to exactly localize the start/stop position of the diagram circumscription).

Begin tracing from the starting point, and circumscribe the diagram at even speed, and not too slowly.

Employ good ilumination and, if necessary, use a magnifying glass for accurate reading of the vernier, before and after circumscription.

# MAIN ENGINE PERFORMANCE DATA

- Vessel : MAPLE NOS
- GRT : 78,443 MT
- ENGINE : MAN-B&W: 6S70 MC

BHP : 20,940 at 88 Rpm

TYPE : 2 CYCLE, SUPERLONG STROKE, CROSSHEAD

FIRING ORDER: 153426 Built: 1991

CYL No.	P-Comp. Kg/cm <sup>2</sup>	P.Max Kg/cm <sup>2</sup>	Fuel P. Index	Exhaust Temp.	MEP Kg/cm <sup>2</sup>	IHP
1.	103	122	87	330	16.02	3175.4
2	103	122	86	330	15.69	3110.0
3	102	122	87.	335	16.02	3175.4
4	102	122	87	340	16.12	3195.3
5	102	123	87	340	16.12	3195.3
6	104	124	87	338	16.24	3219.0
Average	102.6	122.5	86.5	3355	16.03	3178.4

#### A. To find: Mean Effective Pressure (each cylinder)

DATAS: Taken on indicator diagram: cyl. No. 1 Area of working diagram =  $3.7 \text{ cm}^2$ Length of atmospheric line = 7.7 cmSpring constant = 0.3FORMULA: MEP = Area\_x 10 Length 0.3 =  $3.7 \times 10$   $7.7 \times 0.3$ =  $16.02 \text{ kg/cm}^2$ 

#### B. Cylinder Constant - shop trial:

DATAS:	Cylinder diameter	=	700 MM
	Piston Stroke	=	2674 MM
	1 Horsepower	=	7500 KgF.cm
	1 Bar	=	1.02 kg/cm <sup>2</sup>

Formula:

Cylinder constant = 
$$.\frac{7854 (cyl. dia) (length of stroke)}{60 (7500)}$$
  
=  $.7854 (70) (70) (267.4) (1.02)$   
60 (7500)  
=  $1.049.659.7$   
450,000

Cyl. constant = 2.332

Average Rpm during test at least 1 hour.

Ave. Rpm = present reading - previous readings  

$$60 \text{ mins.}$$
  
=  $41304210 - 41299110$   
 $60$   
Rpm = 85

Indicated Horsepower each cylinder (No.1)

Formula:

IHP = MEP x Cyl. constant x Rpm = 16.02 x 2.332 x 85 = 3175.4

#### Actual Brake horsepower

BHP = Total IHP x Mech. Efficiency = 19,070 x 94.5 % = 18,021

#### Fuel consumption in Metric Tons,

- a. Flowmeter reading 1 hr = 18650590 18648160 = 2430 Liters
- b. Corrected Specific Gravity: Service F.O. tank = 85°C Sp Gr. at 15°C = .9886 Coefficient Factor per 1°C = .000654  $T_2 - T_1 = 85 - 15 = 70 \times .000654 = 0.0457$ Sp. Grav. at 85°C = .9886 - 0.0457 = 0.9429
- c. Fuel consumption in Metric Ton 2430 liters x 24 hrs. = 58,320 L 58,320 L + 1000 = 58.32 M<sup>3</sup> 58.32 x 0.9429 = 54.98 MT

#### d. Fuel consumption in Grams/BHR-HR.

54.98 MT x 1000 kgs. = 54980 kg/day = <u>54980</u> = 2,290 kg/hr. 24 hr = 2,290 x 1000 gms/kg. = 2,290,000 gms/HR. = <u>2,290,000</u> 18,021 BHP = 127.1 grms./BHP-HR

#### G. To find cylinder oil consumption: grms/bhp - hr

Time measured in cylinder lubricator pump No. 1

 $\frac{24.30}{60}$  mins/liter = 24.5 mins.

Therefore: 
$$1 \perp (1000) \times (0.92)$$
  
 $(18021) \times (24.5)$   
 $6 \qquad 60$ 

- = 0.750 grms/ bhp-hr
- = 2.449 gms/HR x 6 x 24
- = <u>352.656</u> gms/day 1000 gm/itr.
- = 352 L/day

#### H. To find BHP/day base on Consumption:

54.98 MT x 1,000,000 grms/ton

= <u>54.980.000 grms.</u> 127.1 x 24 = <u>54.980.000</u> 3050.4

BHP = 18023 approx.

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#### **FUEL - DIESEL - LUBE OIL INVENTORY**

#### **During Arrival, Departure and Bunkering Conditions:**

#### **Procedures:**

1. Check the ship's Trim condition: the differences of forward draft and aft draft in meter.

Example: (Trim by head (-) : Trim by astern (+)

MT Birch – ship trim at ballast condition

8.50 m aft.

(-) <u>5.50 m Frwd</u>.

Trim by astern 3.00 m

- 2. Take tanks sounding, which can be done either Ullage or Bottom sounding in centimeter or meter unit.
- 3. Record each tank temperature reading, bunkers specific gravity at 15°C and compute actual specific gravity at present temperature record. each tank.
- 4. Check sounding in calibration table, equivalent to actual sounding and trim into m<sup>3</sup> to metric ton by multiplying the actual S.G.
- 5. To determine the actual capacity of subject tank corresponding to the measured sounding valve by using the linear interpolation method and heeling correction.

HFO tanks:	Ullage	Temp' C	SG@15°C	Voi. m3	Cor.SG	Metric tons
#1 stbd. tk	7.98	42	.9910	1076.0	0.9733	1047.27
#2 C.pt. tk	3.54	40	.9910	743.14	0.9746	724.25
#3 port tk	5.63	38	.9850	763.70	0.9699	740.71
Sett. tk	4.08	70	.9850	75.65	0.9490	71.79
Serv. tk	3.10	86	.9850	86.35	0.9392	81.10
Total R.O.B.					·	2665.12
Diesel-Oil:	Sounding	Temp' C	SG@ 15' C	Vol. m3	Cor. SG	Metric tons
D.B. port tk	1.70	28	.8345	91.64	0.8260	75.70
D.B. stbd tk	1.30	28	.8345	67.86	0.8286	56.05
Sett. tk	4.40	32	.8345	17.44	0.8234	14.36
Serv. tk	4.35	32	.8345	17.23	0.8234	14.18
Total R.O.B.						160.20

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#### **Computation:**

#### A. HFO Service tank:

Ullage sounding = 310cm = 86.35 m<sup>3</sup> Temperature = 85 °C S.G. at 15 °C = .9850 Coefficient factor 1 °C = .000654 Trim by astern = + 3 meter

### 1. Solve the correction S.G. at 85 °C

Temp = 
$$T_2 - T_1$$
  
= 85 °C - 15 °C  
= 70 x .000654  
= .04578  
Corr. S.G = .9850 - .04578  
= .9392

2. Volume in Metric Tons

$$MT = M^3 \times Corr. S.G at 85 °C$$
  
= 86.35 M<sup>3</sup> x .9392  
MT = 81.10

3. Lubricating oil in volume metric ton

Liters +  $1000 = m^3$ m<sup>3</sup> x S.G. (.90)= MT

# INSPECTION, MEASURING OF CYLINDER LINER



Procedures: Mount the measuring rod for measuring the cylinder liner. The cylinder liner is to be measured with an inside micrometer at the positions marked on the measuring rod. Longitudinal and transverse measurements shall be taken. Note down the measuring results. Forward — Aft; Port – Stbd. points. Before starting, ensure that the micrometer gauge instrument has the same temperature as the liner, Maximum allowable wear of cylinder liner from 0.4 – 0.8% of the diameter bore.

#### Maintenance:

1. Check the condition of the cylinder liner and asses for scratches, micro-seize, wear ridge, carbon deposits.

Carefully scratch over any scores or marks on the cylinder liner running surface by means of a rough grinding stone held in the hand.

- 2. By means of a grinding tool bottom of the cylinder liner (where the piston rings turn over) so that a smooth transition is formed.
- 3. Check the lubricating points of the cylinder by manually pumping cylinder oil to each individual lubricating point. Clean any blocked lubricating duct.



1.	Nominal Height	Tolerance
Piston ring grooves	12	+0.315 +0.290
Piston ring	12	-0.110 -0.135





 Worn rings to be renewed if radial width D-2 is less than 20 mm.
 New piston ring D-1=23 mm.
 Worn piston ring D-2=20 mm.

 Effect checking of ring gap in new cylinder or at bottom of used liner. Minimum ring gap D-3=5 mm.



4. Maximum permissible burn-away of piston top D-4=20 mm.

Clearance in piston ring grooves: Measured points: Fowd. Aft. Port and Stbd. Sides.

5. Maximum clearance, new piston ring and worm ring groove D-5=0.70 mm.

Vertical clearance, new piston ring and new or reconditioned ring groove D-6=0.40-0.45 mm.

#### **CHECKING DEFLECTION-CRANKSHAFT**



#### **Procedures:**

- 1. Place a dial gauge opposite the crankpin on the port punch mark point, and set the pointer to zero.
- 2. Read the dial gauge at the following points of position drawn above x-s-t-p-y, and to get the bottom mean reading use the formula 1/2(x + y) = Z

- x = Bottom stbd exhaust side
- s = Starboard
- p = Port
- y = Bottom port crankshaft side
- 3. Record and checked crankcase temperature, ship's trim condition.
- 4. Note: closing of the crank web is considered as negative reading on the dial gauge. Deflection reading in 1/100 mm and should be taken while the ship is afloat not while in dry-dock.

#### Example of deflection reading

	Cy1.No. & deflections						
Crank position			2	3	4	5	6
Near bottom, exhaust side Exhaust side Top Camshaft side Near bottom <sub>r</sub> camshaft side	B: E T C B,	0 6 14 7 -1	0 2 3 2 2	0 5 8 5 -2	0 4 10 4 2	0 2 1 -1 -1	0งพพง
Bottom 1/2 (B <sub>1</sub> +B <sub>2</sub> )		0	1	-1	1	0	-1

## **CHECKING CLEARANCE IN MAIN BEARINGS**



#### Procedures:

- 1. Checked the clearance with kjaer feeler blade between the upper shell and the journal, forward and aft sides.
- 2. Another method for measuring, dismount the lubricating inlet pipe on top of upper bearing shell and make measurement through the hole. see above drawing.
- 3. For correct measurement of bearing wear, used bridge gauge on top of upper shell bearing by using feeler gauge. Measure the pin of the bridge gauge and the bearing journal. Result increase in measurement indicate wear of the lower shell should be taken when the ship afloat.
- 4. Checking the crankshaft deflection indicates also the actual alignment of the main bearings, should be done under nearly same temperature and load condition.

### CHECKING OF CROSSHEAD AND CRANKPIN BEARING CLEARANCES



#### **CROSSHEAD BEARING**

- 1. Turn the crosshead to be measured to BDC bottom dead center.
- 2. Measure the clearance in the crosshead bearing by means of a feeler gauge, which is to be applied at the top of the upper bearing shell
- 3. Measuring point should be forward and aft sides.

#### **CRANKPIN BEARING**

- 1. Turn the crankshaft to BDC
- 2. Check the clearance in the crankpin bearing by means of a feeler gauge.
- 3. Measure the clearance at the bottom of the bearing in both sides forward and aft.
- 4. Record the crankcase temperature.



**READINGS RELATING TO ENGINE THERMODYNAMIC CONDITIONS** 

#### PARAMETER READINGS

- A. Exhaust Temperature increasing on a single cylinder indicated:
  - a. Fuel valves need overhaul
  - b. Compression pressure too low owing to exhaust valve leakage or blow-by past piston rings.
- B. Exhaust Temperature --increasing on all cylinders indicates:
  - a. Air system fouled air filter, blower, cooler, scavenge ports
  - b. Exhaust system fouled nozzle ring, turbine wheel, exhaust gas boiler.
- C. Inlet Air Temperature -- Rising ambient temperature will give increasing exhaust temperatures.
- **D. Pressure Drop** across air filter/Increasing pressure indicates fouling. Cleaning required when pressure reach 50% greater than on test bed.
- E. Pressure Drop across air cooler.
  - a. Increasing pressure difference indicates fouling of airside.
  - b. Cleaning required when pressure difference is 50% greater than on test bed.
- F. Temperature Rise of cooling water increasing temperature difference indicates reduced water flow supply.
- G. Temperature difference air after cooler and at water inlet. Increasing temperature indicates fouled air cooler.
- H. Scavenging Air Pressure decreasing air pressure implies decreasing air quantity and indicates fouling of air or gas system.
- I. Scavenging Air Temperature rising scavenge air temperature will give increasing exhaust temperature.
- J. Pressures and Temperatures in combustion chamber will be reduced by piston ring blowby, burnt piston crown, cylinder liner wear, leaking exhaust valve, defective fuel valves. etc.
- K. Mean Indicated Pressure measured by indicator cards, which also give compression and maximum combustion pressure each working cylinder for load output of the engine.

## EMERGENCY PROCEDURES: PUTTING CYLINDERS OUT OF ACTION - B & W 6570 MC

	Case A	Case B	Case C	Case D	Case E
Nature of emergency action	Combustion to be stopped	Compression and combus- tion to be stopped	Combustion to be stopped (due to faulty exhaust valve)	All reciprocat- ing parts sus- pended or out	All reciprocat- ing parts out
Some reasons for emergency action	Blow-by at piston rings or exhaust valve. Reduction of load on bearings. Faulty injec- tion equip- ment	Leaking cylin- der cover or liner	Exhaust valve, or exhaust valve actuating gear, malfunc- tion	Quickest and safest mea- sure in the event of faults in large mov- ing parts, or cylinder cover or cylinder liner	Only of interest if spare parts not available
Fuel pump with roller guide	Lifted	Lifted	Lifted	Lifted	Lifted
Exhaust valve	Working	Held open	Closed	Closed	Closed
Air for air spring	Open	Closed	Open	Open	Open
Exh. valve actuator	Working	Out or	Out or	Out or	Out or
with roller guide		lifted	lifted	lifted	lifted
Oil Inlet for actuator	Open	Pipe dismantled and blocked	Open	Open	Open
Starting valve	Working	Blanked	Working	Bianked	Blanked
Piston with rod	Moving	Moving	Moving	Suspended	Out
Crosshead	Moving	Moving	Moving	Suspended	Out
Connecting rod	Moving	Moving	Moving	Out	Out
Crankpin bearing	Moving	Moving	Moving	Out	Out
Oil inlet to crosshead	Open	Open	Open	Blanked	Blanked
Cooling oil outlet from crosshead	Open	Open	Open		
Cylinder lubricator	Working	Working	Working	"Zero" delivery	"Zero" delivery

#### INTERPRETATION OF FAULTY INDICATOR DIAGRAMS



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#### INFORMATION FROM DRAW DIAGRAMS



Fig. 2: Fuel injection too early.

- VIT index wrong.

- Feel pump lead too large.





Fig. 3 Leakages, increased cyl. volume, or fouling.

- Piston ring blow-by.
- Exhaust valve leakage.
- Piston crown burnt.
- Low scavenge pressure, fouling of exhaust and/or air system.



Fig. 3 both pcmp and pmax are low.

#### **INSPECTION THROUGH SCAVENGE PORTS: PISTON AND LINER**



# MONTHLY REPORT RUNNING HOURS

Month:					Sh	ip:				
Main Engine										
Running hrs from last n	nonth									
Running hrs this month	)									
Running hrs end this m	onth									
Turbo Charges							<u> </u>			·····
No. 1 (AFT)					NO, 2	(FWD)				
Bunning hrs since last	Overhaul				Bunning	hrs since	e last Ove	rhaui		
Running hrs since last	Oil Change	8			Running	hra sinci	a last Oil (	Change		
CYL. No:	1	2	3	4	5	6	7	8	9	10
At last Overhaul			-							
Since last Overhaul	1				1	<u> </u>		·	1	
Max Long			$\mathbf{k}$		$\frown$	$\sim$	$\leftarrow$			$ \leftarrow  $
CYL wear Cross			$\vdash$		$\rightarrow$		$\rightarrow$		$\rightarrow$	$\vdash \rightarrow$
			Ļ				[	<u> </u>		
Others (Figures within F	aranthesis	= Standar	d hours)							
Running hrs since last	Crankcase	check			·					
Running hrs since last	Crankshaft	Deflectio	n taken			. 0	ND -			
Running hrs since main	n bearing c	learance	taken			NE				
Running hrs since big e	and bearing	g clearand	ce taken		CAN					
Running hrs since Cros	Snead Dea	uring clear	ance taker	• <u> </u>						
Hunning hrs since last	Pressure ti		njectors					-		
Running nrs since last	UII change	in Gover	nor							
Pressure cards taken d	ate									
Generator Engines										
No. 1							_			
Running hrs from last m	ionth		Running	I hrs this	month		Runni	ing hrs tot	tal	 o
Cylinders							<b>_</b>			
Running hrs since last o	complete C	<b>)verhaul</b>								
Running hrs since last o	change Cy	i. Heads							+	
Running hrs since last	exh. Vaive	s O/H	L						<u> </u>	
Running hrs since last	Crankcase	check								
Running hrs since last (	Crankshaft	Deflection	n Taken 🛶					<b>→</b>		
Running hrs since last o	check of m	aln Bearii	ngs							
Running hrs since last I	Pressure T	esting of I	Fuel Inject	ors				-		
Running hrs since last of	change of	Oil in Turi	bochargers					-		
Running hrs since last (	Overhaul o	f Turboch	argers					-		
Running hrs since last of	check of C	learance i	inlet/Exhau	ust Valve	8			-		
Running hrs since last of	change of	Oil in Gov	/ernor,					-		
Running hrs since last o	lunning hrs since last change of Bottom end bolts									

## **OIL CONSUMPTION REPORT**

Vessel	Voyage from	to
Voyage no	Voyage dates from	to
Draft fwd/aft		Chief eng.

· . .

#### **Bunker consumption summary**

	Fuel oil	Diesel oil
Main engine		
Main engine per 24 h		
Auxiliary engines		
Boiler		
Boiler cargo heating	e ONL	
Discharging cargo		
Tank cleaning Stv		8
Total consumption		
ROB at start of voyage		
Bunkered		
ROB at end of voyage		

Port of bunkering fuel/diesel oil .....

#### Lubrication oil consumption summary

	ME Cylinder oil	ME System oil	Aux.eng oil	Hydraulic oil	
ROB at start of voyage					
Bunkered					
Consumption total					
Consumption per 24 h					
ROB at end of voyage					

Port of bunkering lub.-oil

Remarks:	·.		
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# MAIN ENGINE PERFORMANCE DATA

Date \_

Vessel:	 Voyage	N

Fuel P.

Index

P-Comp. P. Max

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CYL

No. 1

, 2

3

4

5

6

7

8

9

10

Average

TEMPERATURES

Jacket Cooling Inlet

**Jacket Cooling Outlet** 

**Piston Cooling Inlet** 

**Piston Cooling Outlet** 

In/Out

In/Out EXH. GAS TEMP AFTER ECONOMIZER

Lub Oil Inlet Sea Water

Engine Room Exh Gas TC 1

Exh Gas TC 2

No: \_\_\_\_\_\_ From \_\_\_\_\_

I.H.P.

Exhaust

SAMPLE ONLY

CYL NO

H/L

Temp.

To \_\_\_\_\_

RPM:	
Total BHP.	
Fuel Lever Pos.	
Fuel Cons. Kg/Hr	
Fuel Density at 15 <sup>0</sup> C	
Fuel Viscosity. Cst.	
Fuel Me. Inlet Temp.	
Fuel Spec. Consumption G/BHPH	
Cylinder Oil Consumption Kg/Hr	
System Oil Consumption Kg/Day	

SCAV. AIR	
RPM FWD T/C	
RPM AFT T/C	
Scav. Air Press In Receiver	
Scav. Air Temp In Receiver	
Press Drop Cooler No 1	
Press Drop Cooler No 2	

Speed Log/OBS		
Draft F/A		
Combinator		
Slip	· · · · · · · · · · · · · · · · · · ·	
Wind/Sea Dir. Force		
Prop. Pitch		

CHIEF ENGINEER

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# **CRANKSHAFT DEFLECTION**







Crankpin	Deflection in 1/100 mm					Max deflection	
No	Bottom	Manoev side	Тор	Backside	Bottom	WIGA OCHOQUOIT	
1.			N.				×.
2							`
3							
4				ONLY			
5				LE .			
6			GAN				
7							
8							
9							
10							
11							
12							

Remarks



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# RECORD OF SHIP'S CERTIFICATES & SURVEYS

NATURE OF SURVEY	DATE OF ISSUE	PLACE	DATE OF EXPIRY	REMARKS CONDITIONS ETC		
Special survey hull						
Special survey Machinery						
Tailshaft survey						
Bottom survey			······			
Boiler survey Port						
Boiler survey Stbd	·	<u> </u>		•••		
Exhaust gas economiser						
Sea valves						
Annual general survey (tanker for oil annual)						
Tanker for oil intermediate						
International Loadline Cert.						
International loadline Cert (annual)						
Safety Equipment Cert						
Safety Equipment Cert (annual)						
Safety Construction Cert		ant				
Safety Construction Cert (annual)		NE				
Radio safety Cert	CAN	Nr				
IOPP Cert		<u></u>	· · · · · · · · · · · · · · · · · · ·			
IOPP Cert (annual)						
Life raft inspection						
CO2 plant inspection biannual	· , ,-			·		
CO2 measurement quantity						
Foam for deck fire extinguishing test						
Fire extinguishers	<u>.</u>		· · ·			
UMS/EO						
UMS/EO annual		<u></u>		· · · · · · · · · · · · · · · · · · ·		
RMC	<u></u>		· · · · · · · · · · · · · · · · · · ·			
SRMC		<b> </b>				
Cargo gear quadrennial				· · · ·		
Cargo gear annual		{				
Inert gas plant intermediate						
Inert gas plant 5 year	<u> </u>	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·		
USCG TVEL		· · · · · · · · · · · · · · · · · · ·				
REMARKS						

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This form is to be sent in half yearly

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# INTERNATIONAL MARITIME ORGANIZATION REGULATIONS

#### **MARPOL 73/78**

The International Convention for the Prevention of Pollution from Ships, 1973, was adopted by the International Conference on Marine Pollution convened by IMO from 8 October to 2 November 1973, This Convention was subsequently modified by the Protocol of 1978 relating thereto adopted by the International Conference on Tankers Safety and Pollution Prevention convened by IMO from 6 to 17 February 1978. In short form, MARPOL 73/78 which regulations covering the various sources of ship-generated pollution are contained in five annexes of the Convention listed summary below.

#### ANNEX I: REGULATION FOR THE PREVENTION OF POLLUTION BY OIL

Oil tanker means a ship constructed to carry oil in bulk in its cargo spaces and includes combination carriers like Chemical or Gas tanker must meet and comply the requirements of regulation stated above. A vessel must have the followings:

- a. Segregated Ballast Tank (SBT); Dedicated Clean Ballast Tank (CBT)
- b. Crude Oil Washing (COW) System
- c. Inert Gas System, Oil Interface Detector on Tank.
- d. Oily-Water Separating 100 ppm for Tankers.
- e. Oil Filtering Equipment for 15 ppm Designed.
- f. Enough Fuel Tanks, Sludge Tank with Adequate Capacity Voyage.
- g. Pumping, Piping, Discharge Arrangement and Safety System.
- h. Control of Discharge Oil for Tanker within Special Areas, 50 Nautical miles from Nearest Land and Proceeding Enroute.

**Special areas** – Mediterranean Sea, Baltic Sea, Red Sea, Gulf of Aden and Antartic Sea.

- i. Enough Reception Facilities for Oil Residues, Waste Oil, and Cargo Loading & Discharging System.
- j. Oil Discharge Monitoring and Control System, Sloptank and Ballasting & Arrangement.
- k. Shipboard Oil Pollution Emergency Plan, Safety Hazard Equipment Required.
- I. Oil Record Book Each for Machinery Space and Cargo Ballast Operation be Recorded.
- m. International Oil Pollution Prevention Certificate (IOPP) approved and Endorse by Administration and other Relating Documents.
- n. Double Plating Hull, Bottom, are Required to a New Constructed Vessel to comply with Regulation 13F effective July 1993.

# ANNEX II: REGULATIONS FOR THE CONTROL OF POLLUTION BY NOXIOUS LIQUID

SUBSTANCES IN BULK – Apply to all ship posing of harm to marine environment which divided into four categories like Chemical and Gas Tankers, It also applied same as Annex I requirements on regulation to comply.

#### **Category of Noxious Liquid Substances:**

A - Substance which are bioaccumulated and liable to produce hazard to aquatic life or human health which are highly toxic.

Ex: Alcohol, Butyl Benzyl, Coal Tar, Chlorinated, Paraffins Ether, Ethyl, Phosphorous, Phosphate.

- B Substance which are bioaccumulated with a short retention of the order of one week or less, liable to produce tainting of sea foods which are moderately toxic to aquatic life.
  - Ex: Chloride, Butene, Camphor oil, Carbon Tetrachloride, Methyl Acrylate, Isobutyl, Octene, Turpentine.
- C- Substance which are slightly toxic to aquatic life.
  - Ex: Benzene, Calcium Hypochlorite, Coconut Oil, Ferric Chloride, Isoprene, Sodium Carbonate, Sulfuric Acid.
- D- Substance which are practically non-toxic to aquatic life but slightly hazardous to human health.
  - Ex: Acetic Acids, Animal and Fish Oils, Citric Acid, Palm Oil, Vegetable Oil, Urea Solution.

ANNEX III - REGULATION FOR THE PREVENTION OF POLLUTION BY HARMFUL SUBSTANCE Carried by Sea in Packaged Forms or in Freight Containers. Party should supplement detailed requirement on Packaging, Marking, Labelling, Documentation, Storage, Quantity Limitation, Exception and Notification for preventing or minimizing pollution of the marine environment by harmful substance.

ANNEX IV- REGULATION FOR THE PREVENTION OF POLLUTION BY SEWAGE FROM SHIPS. Provision shall apply to all ship 200 tons gross tonnage and above carry more than 10 persons must fitted with sewage treatment plant and guidelines.

ANNEX V- REGULATION OF THE PREVENTION OF POLLUTION BY GARBAGE FROM SHIP. The guidelines are divided into seven categories to provide general framework for educating and training of seafarers and others to comply the regulation in method, handling, storage, use of shipboard and action to ensure compliance with the regulation. (see page 575)

#### SURVEYS, INSPECTIONS, CERTIFICATES REQUIRED BY IMO.

According to Marpol 73/78 Regulation 4 on Annex I stated that every oil tanker of 150 tons gross and above and every other ship of 400 tons and above shall be subject to the surveys specified below.

- a. **Initial Survey** before the ship is put in service or before certificate required for the first time, include complete survey of its structure equipment, system, fittings arrangement ship is covered that must comply with regulation applied.
- b. **Periodical Surveys** at interval specified by the law but not exceeding five years, which shall be ensure that structure, equipment, system, etc. must fully comply with the requirement. Five years Continuous Machinery Survey Program of all machinery equipment are subdivided for 5 annual group survey and check up.
- c. A minimum of one **Intermediate survey** during the period of Validity of the Certificate, that ensure all equipment and associated pump and piping systems including oil discharge monitoring, control system, COW, IGS and separating and filtering system must be in good order about 30 months period. Also include Boiler, Economizer and Tailshaft Survey. The administration nominate a surveyor that recognize by the organization to conduct surveys and inspection during repairs require by the ship, carry out surveys and inspections if requested by the authorities of a port state.
- d. Annual Survey within three months before and after the day and month of the date issue of the certificate which include general examination of structure, fitting arrangements and material remain in all respect satisfactory for the service of the ship carrying Noxious liquid sustance like Chemical, Gas tanker and other ship related hereto. Survey Checklist are: Maintenance Record and Function Testings of Mechanical, Electrical Equipment, Fire Safety, Function Test of all Communication, Automation Control, Emergency Power Test, Black out, Alarms, Fire Detection, Signal Devices.

#### CERTIFICATES

- 1. IOPPC International Oil Pollution Prevention Certificate shall be issued after survey in accordance with regulation required and compliance to any oil tanker of 150 tons above and any other ships of 400 tons gross tonnage and above engaged in voyages to ports or offshore terminal under jurisdiction of other parties to the Convention.
- 2. SOLAS Safety of Life at Sea, 1974 Convention adopted by IMO, guidelines for Inert Gas System, covering application and technical requirement for satisfactory operating conditions applied to all ship concerned.

- 3. STCW Standard of Training, Certification and Watch Keeping for Seafarers, 1978 convention by IMO, such as Firefighting and Prevention; Lifeboat Handling, Survival Technique at Sea, First Aid, Tankerman Certification for Oil, Chemical, Gas Carriers and Watchkeeping.
- 4. Regulation For Prevention Collisions at Sea, 1972
- 5. Establishment of an International Maritime Satellite System, 1976
- 6. Prevention of Pollution of theSea by Oil, 1954
- 7. Maritime Search and Rescue, 1979 adopted by IMO
- 8. Load Line Certificate 1966
- 9. Tonnage Measurements of Ships 1969, ratified and enforce 1982, include all ship from 24 meter above must have universal tonnage computed and new certificate issued until July 1994.
- 10. OPA '90 and MARPOL regulation require both on vessels should have on board a "Vessel Respon Plan" or "Oil Pollution Emergency Plan" giving detailed instruction and guidelines on how to react to an accident with danger of oil spill between shipboard personnel, operator, and local authorities enforced April 1993 for new ships, 1995 for existing ships.
- 11. GMDSS Global Maritime Distress and Safety system; NAVTEX Navigational Telex; EPIRB - Satellite Emergency Position Indicating Radio Beacon base on Solas 1974 as amended, Chapter IV - Radio Communication, apply to all ships, new and existing; date of entry into force August 1, 1993 until 1995.



#### ANNEX TO REPORT OF PERIODICAL SURVEY

Name of ship

DnVC ld. No.

Survey time

TYPE OF SURVEY: Periodically Unattended Machinery Space - E0						
Ann	ual Survey	1)	Special Periodical Survey Note: To be performed in addition to requirements for annual survey		1)	
1.	Maintenance/General Condition	<b> </b>	ļ	requirements for exists our of		
11	Records of systematic maintenance and function testing inspected		3.	General		
12	Testing equipment inspected		3.1	Duty instructions, component markings and instruction manual		
1.3	Mechanical, electronic and electrical installations for instrumentation surveyed			checked		
14	Fire safty precautions surveyed	.6	onl?	Function Testing		
	N	81r				
2.	Function Testing 5P		4.1	Manual overrule/local control from the engine room tested	-	
21	Telephone system between bridge/ engine room/officers' cabins tested _		4.2	Overriding/emergency manoeuvre from the bridge tested		
2.2	Communication between bridge and engine local control stand tested	<b> </b>	4.3	Bridge control system tested:		
2.3	Bridge control system performance verified	<b> </b>		<ul> <li>From ahead to astern</li> <li>Stop</li> <li>From stop to astern</li> </ul>		
24	Transfer of control responsibility from engine room to bridge and vice - verse tested		44	- Stop by emergency device		
			1	Control stability verified	┼┤	ļ
2.5	Automatic control system performance verified	<u> </u>	4.5	Transfer of alarm responsibility		
2.6	For plants with automatic start and connection of standby generator.			tested	11	
	- Automatic start and connection after blackout tested	<b></b>	4.6	Group alarms and extensions to the bridge, cabins and day-rooms		
2.7	For plants with several units	1	1			
	- Automatic disconnection of non- essential consumers tested		4.7	Alarm functions tested		
20	Automatic consection of standby		4.8	Redundant power supply alarm system tested		
20	transformer or emergency lighting in engine room after power failure on		4.9	Interlocking of alarms tested		
	lighting system tested	<u> </u>	4.10	Safety functions tested	╉╍╼┥	
29	Alarm system performance verified _	<u>                                      </u>	ł			
2.10	Safety systems performance verified		1			
2.11	Fire detection system performance verified					
2.12	Fire alarm signalling devices tested _		ļ			



# ANNEX TO REPORT OF PERIODICAL SURVEY

SURVEY CHECK LIST

Name of ship

DnVC id. No.

Survey time

	·····			
TYPE OF SURVEY:	Boiler/Steam Heated Steam	n Gene	rator	
Type of boiler: (Mark with an "X" as appropriate) Give position:	MB = Main boiler SB = Steam heated stea ABo = Auxiliary boiler oilf ABe = Auxiliary boiler ext ABoe = Auxiliary boiler cor	m gener ired haust fire nbined	ator [] 	
I. External/III				ט
1.1 Water/stean internals	n drums and shells with	1.19	Oilburning unit(s)	
1.2 Casing and in	nsulation	1.20	Forced circulating pumps for oilfired boilers	
1.3 Furnaces/cor	mbustions chambers		_	
1.4 Brickwork _		2.	Tests	
1.5 Headers		2.1	Safety valves boiler	
1.6 Downcomers			Set pressure: bar	
17 Tubes			bar	
1.8 Internal pipes	·	2.2	Safety valves superheater	
~ 1.9 internal stays			Set pressure: bar	
1.10 Outer stay ar	nd fastening		bar	
1.11 Superheaters	· · · · · · · · · · · · · · · · · · ·	2.3	Hydraulic test boiler	
1.12 Desuperheate	er		Set pressure: bar	
1.13 Air preheater			bar bar	
1.14 Economiser		2.4	Safety/alarm systems	
1.15 Reheater		2.5	Remote control of safety valves	
1.10 Attemperator	d fittings	20	Automatic costsel sustance	
118 Soot blowers		<b>Z</b> .1		
LIG GOOL DIGMEIS				
NB: Repairs to be rep Remaining items given as recomm	ported on Form No. 40.9a and possible deficiencies to be rendations on Form No. RPS 11.1.	Place	//	I
1) Marks to be used:	rvovora ostietostica	Date:		
N = Not surve R = Not in ord N/A = Not applic	veryor's satisfaction yed/tested (RS given) er (RC given) able	Surve	yor.	

#### What do you understand of the following terms?

- **Tonnage of vessel** might be said to be the number of tons she should carry when full cargo. It might be stated as the weight of water displaced when the ship is fully loaded minus the weight of water displaced when all the cargo is out.
- **Gross tonnage** is the internal capacity of the enclosed spaces of the vessel allowing 100 cubic feet to be equal to one gross ton.
- **Registered tonnage** is the term used in entering the ship on Lloyd's register. It is equal to the gross tonnage minus a percentage of the spaces used for propelling power, bunkers, crew spaces, navigating spaces, etc.
- Deadweight capacity is the actual weight of the cargo carried by the ship.
- **Centre of Gravity** is the point at which the whole weight of ship and cargo can be assumed to act and is usually denoted by the letter G.
- **Centre of buoyancy** is the centre of gravity of the water displaced y the ship and is usually denoted by the letter B.
- **Transverse metacentre** since we are considering the transverse section of the ship. If we consider a longitudinal section of the ship and alter the trim a few degrees, we get the longitudinal metacentre.
- *Metacentric height* The metacentre is the point at the intersection of the centre line of the ship through G and the vertical line drawn through B<sub>1</sub>, and is denoted by the letter M.
- *Flush deck vessel* as implied in the term, is a vessel having a continuous deck fore and aft with no erections on it extending to shipside which would involve the side plating being extended upwards.
- **Three island vessel** is one having three erections on deck extending to shipside and necessitating the upward extension of shipside plating. The three erections are known as the forecastle at forward end of vessel, the bridge or midship section and the poop aft. The sunk decks lying between forecastle and bridge, and bridge and poop are known as well-decks.
- *Forecastle* –makes a vessel more seaworthy in heavy weather, as not only does it give added lifting power and buoyancy but also prevents to a marked degree seas from breaking over the bow and sweeping the deck.
- **Poop aft** provides a suitably enclosed compartment for housing the steering engine in addition to providing accommodation for the crew.

Length overall - is measured between the extreme points of stem and astern.

- Length between perpendiculars is the length from fore part of stem to after part of rudder post, in vessels having a straight stem. In vessel having a cut away stem the distance between perpendiculars is taken through the point where the front of stem intersects the upper deck.
- Breadth moulded is the maximum breadth of hull measured to outside of frames.
- Breadth registered is the maximum breadth measured to outside of plating.
- **Depth moulded** is the depth measured amidships from the outside of the frame to the level of the top of main deck beam of gunwale or ship's side.

**Draught** at any part on the length of the ship is the perpendicular distance from bottom of ship to the water level. The maximum mean draught is marked on the side of the ship, for fresh water, and sea water, for winter sailing, and summer sailing.

- **DEPTH OF HOLD** is measured from the top of the tank top planking to the underside of the hold beams.
- **SPARRING** is the arrangement of boards fitted to inside edge of frames in hold to keep cargo from touching sides of ship.
- **TONNAGE OPENING** If a small part of the 'tween deck hold is plated off so as to reduce the measurements included when deciding the tonnage of a vessel, the hatch leading from the deck to this space is called the tonnage hatch and the opening from this space to the 'tween deck hold is called the tonnage opening.
- **ENGINE CASING** is the plating which forms the opening from the engine room through the main and upper decks to the boat deck. This casing usually closed on top by the engine-room skylights. This provides for lighting and ventilating engine room.
- LIMBER BOARDS are the boards covering the bilges in the ship's hold from the tank margin plate to the ship's side and are usually fitted inclined to the ship's side. These boards keep the cargo from coming in contact with the bilge water.
- **CHAIN LOCKER** is a small compartment immediately below the windlass forward and is used, as the name implies, to store the anchor chain.
- **BOATSWAIN'S STORE** is a compartment immediately usually forward for storing hemp and wire hawsers or ropes and shackles and ship's rigging material.
- Q. The ship side has a disc marked on it, make a sketch of this and explain the meaning of the markings. What name is given to the disc and why?

The disc and other markings referred to, are called the Plimsoll mark, after the name of them who did so much in Parliament to have them made compulsory in the Merchant Shipping Act.



The large disc has a line through its centre marked S, which is the summer freeboard in sea water, W being the winter time mark, and W.N.A. being winter, North Atlantic, Tropical summer, and F.W. fresh water mark, which allows for the rise which takes place when the ship goes to sea and the more buoyant sea water causes the ship to draw less water. The F.W. mark is so many inches above S mark, but it must be understood or refer to a distance above all others for various conditions of loading.

- **TEMPLATE** a wire heavy cardboard or piece of wood that can be shaped or cut to a specific design to be used as a pattern when making new piece, also is an instrument used to measure the burn away part of the valve, top of the piston crown wear.
- **METALOCK** –the process of emergency repairs of a certain crack metal or engine parts by the process of drilling a hole on both ends of the crack and make a thread and fit threaded bolt to prevent temporarily extended damage.
- **METAL FATIGUE** fatigue is the phenomenon that gives rise to metal failure under condition of repeated cycle stressing by forces less than these normally necessary to cause significant yielding.
- STATIC BALANCE the part to be balance is placed on knife edge which have previously been leveled, and the low spot which has been determined by force of gravity to be heaviest spot, marked and afterward lightened by the removal of a certain amount of metal.
- **PROPELLER CAVITATION** when a propeller turns, causes a depression on the face opposite the working face of the blade. At the ends of the blades where velocity is higher, a vacuum can be produced which entrains tiny particles of vaporize water that strike the screw with great force causing erosion and loss material on the blade, also the formation and subsequent collapse of bubbles in a liquid in the path of a fast moving propeller blade.
- WELD REINFORCEMENT a welded joint with a doubler plate or some other type of backing piece to add strength.
- **THERMIT WELDING** Thermit is a trade name for a mixture of finely powdered aluminum and iron oxide. An ignition powder, composed largely of barium peroxide is used and is started into reaction with a magnesium ribbon. The reaction produces one-half its weight of superheated molten steel and a molten aluminum slag at a temperature of approximately 5000°F in less than a minute. To the basic mixture are added oxides of other elements than iron and in this way the analysis of the steel and its physical properties are controlled. It's a method of joining ferrous metals by casting molten steel between abutting surfaces. The two surfaces are surrounded by mold cover which is suspended a crucible containing the Thermit mixture.
- **DYNAMIC BALANCE** the force of "unbalance" is measured while the rotor is in motion, and the angle at which the correction should be made is located. This is done on a dynamic balancing machine and, after the part has been properly balanced dynamically, it can be rotates at any speed within the safety factor of the material without apparent vibration.

**CRITICAL SPEED** –at critical speed all the vibrations are in harmony, their sum producing a total vibration which would cause the metal of the part to become fatigues, the tensile strength to be lowered, and the part of fly apart due to centrifugal force if it was maintained at that speed for any length of time.

#### Q. What are the mechanical defects which can cause reduced compression pressure of each cylinder in the engine?

- 1. leaking piston rings
- 2. burnt piston crown
- 3. worn cylinder liner
- 4. burnt exhaust valve
- 5. incorrect exhaust valve timing

# Q. What are the fault parameters causing increased exhaust temperature level of the engine.

- 1. Fault in the injection system leaking or incorrectly working fuel valves such as defective spindle and worm seat.
- 2. Poor cylinder condition blow-by including leaking exhaust valves.
- 3. Reduced cooling capability of the air cooler often resulting from fouling on the air side.
- 4. Operation at extreme ambient climatic condition includes sea water, engine room temperatures.
- 5. Turbo charger fouling turbine side or gas side.
- 6. Fuel oil quality often result of inadequate fuel oil cleaning operation system.

#### Q. What are the main causes of Main Engine Turbo-charger Surging?

During normal operation, a few shots of surging will often occur at crashstop or other abrupt maneuvering, and this sporadic surging is harmless, however should be avoided, in order to avoid the risk of damaging rotor, compressor blade. All cases of turbo charger surging can be divided into three main categories:

- 1. Malfunction in the fuel system causes of low supply pump pressure, air-water in the fuel, low preheating temp, defective suction plunger, spindle, nozzles, crankshaft, timing faulty.
- 2. Restriction in the air/ gas system malfunction of exhaust valve, back pressure before turbo charger, fouled or damage turbine and compressor sides dirty air filter, bearing failure, dirty air cooler high receiver temperature, coke in scavenge port.
- 3. Rapid variation in engine load defective governor, propeller racing in bad weather, also to rapid rpm change during maneuvering.

# Q. What necessary measures to be taken when oil mist has occurred in the crankcase of the engine?

The following steps should be followed:

- 1. Reduce speed to slow and ask bridge for permission to stop.
- 2. When engine stopped, close the fuel oil supply.

- 3. Stop the auxiliary blowers, if fitted.
- 4. Open the skylights and leave the engine room.
- 5. Lock the casing doors and keep away from them.
- 6. Prepare the fire fighting equipment. Note: Do not open the crankcase until at least 20 mins. after stopping the engine. No naked light and do not smoke.
- 7. Stop the circulating oil pump, cut off the starting air and engage turning gear.
- 8. Locate the hot spot by feel over by hand to all sliding surfaces such as bearings, thrust bearing, crossheads etc.
- 9. Rectify further hot spots by making a permanent repair.
- 10. Start the circulating oil pump and turn the engine by means of turning gear. Check oil flow to all bearings parts.
- 11. Start the engine after few mins. stop again and feel over look for oil mist.

# Q. What types of metals are used in the following Diesel-engine parts: foundations, holding-down bolts, frames, crankshaft, connecting rods, pistons, liners, water jackets, cylinder heads, cams, rollers, valve springs, piston rings?

- 1. FOUNDATIONS: May be considered from two angles. The foundation built into the ship to support the engine is of fabricated steel plate. The bedplate is usually cast iron. However, some modern engine builders are using fabricated steel plate for bedplate.
- 2. HOLDING-DOWN BOLTS: Are usually made of Grade A steel and corrosion resisting steel (body-bound and very close fitting).
- 3. FRAMES: Are usually of alloyed cast iron. A recent development, however, resulting from the trend toward light weight, is the welded steel frame.
- 4. CRANKSHAFT: Marine Diesel engine crankshaft are usually made of openheart steel and in the smaller sizes turned from smaller forgings.
- 5. CONNECTING RODS: Are usually made of comparatively soft steel, well suited to withstand shocks.
- 6. *PISTONS*: Pistons for the larger engineers are made in two parts. The head is of forged steel and the shirt of cast iron. For smaller engines, many builders use aluminum alloys instead of cast iron.
- 7. LINERS: Are usually of cast iron (sometimes cast steel in new construction).
- 8. WATER JACKETS: Are usually of cast iron.

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- 9. CYLINDER HEADS: Are usually of cast iron or an aluminum alloy.
- 10. VALVES: Ignition valves may be made of forged steel or cast iron, but the latter is generally used. Exhaust and inlet valve have a cast-iron cage. The valve itself is made of carbon, nickel or chromium-alloy steel in small engines. With cylinder sizes above 16" or 18", however, the valve size becomes so large that it is found practicable to make the valve disc of chilled cast iron and only the stem of steel. In some cases, carbon-steel valves with welded stellite seats are used.
- 11. CAMS: Are usually made of spring steel, hardened all over, or the main body of the cam may be of soft steel with hardened insert mortised in the toe.

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- 12. CAM ROLLERS: Are usually made of froged steel and hardened all over.
- 13. VALVE SPRINGS: Are usually made of spring steel.
- 14. PISTON RINGS. Are usually made of cast steel or cast iron with an inserted brass ring to allow for wearing in.

#### Q. What are the normal operating procedure in starting a Turbine Unit?

In starting any turbine unit with which he is not familiar, the engineer should thoroughly study the manufacturer's recommended procedure. The procedure given below to generalized and may differ details from that furnished by any particular manufacturer:

- 1. Start up the lubricating oil pump. Check gravity tank to see if oil supply is sufficient. See that oil pressure is established on bearings and that oil is passing through sight glasses leading to reduction gear housing. If the oil temperature is less than, say, 65°, it must be passed through the heater until its temperature reaches 90 to 100°F.
- 2. Open turbine-casing and throttle-valve drains.
- 3. The turbine is then jacked over for at least one hour by using the turning gear. Check with the bridge so that the deck officer on watch can investigate mooring lines and whether or not the propeller is clear.
- 4. Start the circulating and condensate pumps. Open the recirculating valve from feed tank to condenser so that condensate pump is assured a water supply.
- 5. Check level of water in boilers. If the level is as it should be, open the main steam stop valve.
- 6. Start the second-stage air ejector and bring vacuum up to approximately 15 inches of mercury.
- 7. If control valve is actuated by oil pressure, open valve admits oil to governing mechanism.
- 8. Put steam on sealing glands. Admit steam to steam seal regulator.
- 9. Remove jacking gear.
- 10. Open throttle valve wide enough to start the rotor turning immediately; then throttle down until the turning over slowly. On gear-driven installations, steam should be first admitted to the astern element.
- 11. Check the emergency-governor mechanism. Trip the turbine out, reset, and readmit steam to turn rotor slowly.

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12. Listen for unusual noises.

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- 13. On electric drive, keep rotor turning over slowly. On gear drive, alternate rotation of turbine slowly, ahead and astern.
- 14. Start-up first-stage air ejectors and bring vacuum to normal.
- 15. Circulate sufficient cooling water through oil cooler to maintain temperature of oil entering bearings between 110 to 120°F.
- 16. Stand by to maneuver. Observe pressure and temperatures to see that they remain normal.
- 17. When underway, close recirculating valve and turbine drains. Precaution: Proper warming up of the turbine is extremely important.

#### D. TEST PROCEDURES ON BOARD SAFETY MAINTENANCE PROGRAM

#### A. Test of pressure alarm

#### Low pressure alarm

Connect the test equipment to the sensor's test cock. Increase pressure till about 20% above given set point and decrease pressure slowly till action occurs. Note the actuating point compare with given set point and previous note, readjust if necessary.

#### High pressure alarm

The test to be done in the opposite way for the low pressure alarm. Increase pressure slowly till action occurs. Note the actuation point compare with given set point and previous note, readjust if necessary.

#### B. Test of temperature alarm

Remove the sensor from the protecting well, and put it into the temperature simulator.

Raise or lower the temperature slowly until the temperature contact works.

Check the temperature on the test equipment during the test. If the set point does not correspond with the previous setting, readjust.

#### C. Test of level alarm by level

#### Low level alarm

Empty the tank until alarm occurs, if this is not possible, operate the test lever on the level switch and note the time delay.

#### High level alarm

Fill the tank alarm occurs if this is not possible, operate the test lever on the level switch and note the time delay.

#### D. Test of flow alarms

With the sensor in it's mounted position, gradually reduce the flow until the alarm sounds.

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#### E. Test of salinity alarm

Remove the sensing element from it's mounting and immerse it in a bath of distilled water. Note reaction of the instrument, then immerse the sensor in a bath with a known salinity corresponding to approximately half scale of the instrument.

Then adjust set point from high towards low salinity, so that alarm sounds.

#### F. Test of fire detection system (smoke detectors / heat detectors)

The fire detection system for the engine room is to be realistically tested by simulating fire in all potential fire hazardous area in engine room.

Heat detectors in accommodation area to be tested by simulating fire.

#### G. Test of various alarm

To simulate supply faults remove fuses, break lines at junction clips or disconnect from switch board or power source.

#### H. Test of st-by pump control system

- Test normal operation by starting and stopping each pump with variable control possibilities.

- Test automatic start of stand by pump.

- By cutting power to the running pump while the other is stand-by position, or,
- By reducing the pressure to the press switch of the stand-by pump. The set point is to be tested according to test method "A".

#### I. Test of viscosity

The viscosity control system for the main engine can be tested by simulating temp increased or decreased. Viscosity indicator on E.C.R. console shall be shown above condition.

#### J. Test of differential pressure

Insulate system pressure on both side of the pressure sensor, connect the pressure calibrator on the pressure side, the other side of the pressure switch must be open to atmospheric pressure. Increase pressure until alarm is initiated.

#### K. Safety valve popping test (Boiler)

- Increase steam pressure to the predetermined set value of safety valve and then confirm that the steam release the safety valve.

- After evaporation the steam, the safety valve to be closed.
- Check steam pressure at the time of open and close of the valve.

#### L Steam accumulation test

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- keep the boiler under maximum load by means of closing of all stop valve.

 Open safety valve 7 minutes and then confirm that the boiler pressure does not exceed 10% of the design pressure.

- After completion of the test, stop the burner and open each valve.

#### M. Alarm and safety system-

- Ignition failure
- Start boiler with extracting photo sensor from boiler
- Flame failure : Extract photo sensor, while boiler running
- Fan or pump stop : Open fuse or circuit in side panel. :
- Water level
- Use feed water pump and drain valve for the water up and down. Confirm water level in glass gauge when alarm occur. Water level high & low : alarm Water level too low : Burner trip.

#### N. Engine safety device test (Generator)

#### Over speed trip

- Start one of generators without load.
- Adjust governor manually at engine side until engine trips.
- Confirm that engine stops at 100% 115% of rated R.P.M.

#### O. High cooling water temperature alarm and/or trip.

- Start one of generators without load.
- Remove cooling water temperature sensor from engine and then immerse the sensor into the water whose temperature is monitored in temperature simulator (water pot)
- Increase the temperature of water in temperature simulator up to 95° C Confirm that lamp for high cooling water temperature lights and audible alarm sounds in engine room.
- Confirm that engine shut down at 95° C and then lamp for 'aux' engine shut down lights and alarm sounds in E/R.

#### P. L.O low pressure alarm and trip.

- Connect hand pump (press simulator) to L.O pressure switch on test flange.
- Pressurize the switch (0) to (5) Kg/Cm2 using the pressure simulator.
- Start engine while generator disconnecting to the bus bar.

#### Q. Insulation resistance measurement.

#### Measure insulation resistance between conductors and ground using 500V. D.C. megger.

- Confirm that the measured value of every out going circuit is to be more than once (1) megohm and /or classification society requirement.
- Measuring points are shown on attached test record.
  - Stator winding to earth
  - Space heater to earth
  - Governor motor to earth
#### FRESH WATER DISTILLER Alfa-Laval

#### **Principles of Operation:**

The vacuum necessary for the evaporation is established and maintained by the combined air/brine ejector. Cooling water pump.

The feed water enters the evaporator section through an orifice, and distributes itself into every second plate channel (evaporation channels).

The jacket water distributes itself into the remaining channels this transferring its heat to the feed water in the evaporation channels.

Having reached the boiling temperature the feed water undergoes a partial evaporation.

The mixture of generated steam and brine enters the separator vessel, where the brine is separated from the steam.

The brine is extracted by the combined air/brine ejector.

Having passed a demister (filter) the steam enters every second plate channel in the condenser section

The sea water supplied by the combined ejector/cooling water pump distributes itself into the remaining channels thus absorbing the heat transferred from the steam during the condensation.

The produced fresh water is extracted and transferred to the tank by the fresh water extraction/transfer pump.

On the delivery side of the pump an electrode unit is fitted, which, together with the salinometer, continuously checks the salt content of the produced water.

The NIREX fresh water distiller is a vacuum evaporation distiller, normally using the waste heat from the fresh cooling water of a diesel engine as heating medium.

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FRESH WATER DISTILLER

## The distiller consists of the following main components and their specific functions:

#### 1. Separator Vessel

The separator vessel separates the produced steam from the brine.

## 2. Evaporator Section

The evaporator section consists of a plate heat exchanger, and is enclosed in the separator vessel.

## 3. Condenser Section

The condenser section like the evaporator section consists of a plate heat exchanger, and is enclosed in the separator vessel.

## 4. Combined Air/Brine Ejector

The combines air/brine ejector extracts air and brine from the separator vessel.

#### 5. Combined Ejector/Cooling Water Pump

The combined ejector/cooling water pump supplies sea water for the condenser, jet water for the combined air/brine ejector, and feed water for evaporation.

#### 6. Fresh Water Extraction/Transfer Pump

The fresh water extraction/transfer pump extracts the produced water from the condenser, and transfers same to the fresh water tank.

#### 7. Salinometer

The salinometer checks continuously the salinity of the produced water. The alarm point is adjustable.

## AIR COMPRESSOR

#### A. Design and Safety:

1. The machine is a single cylinder, 2-stage single-acting water cooled air compressor. The first stage of the compressor is the low pressure stage (LP) and the second is the high pressure stage (HP).

All bearings are pressure lubricated by a gear pump fitted to the end of the crankshaft.

2. Two replaceable tube-type coolers are fitted in the compressor cylinder block. The first serves to cool the air after first-stage compression. The second proceeds cooling after second stage compression. The cooling water inlet and outlet are located so that the water circulates through the cylinder block and ensure efficient cooling of the air and compressor cylinder walls.

3. The compressor is designed with an electric motor, to compressor air from atmospheric pressure to rated design pressure. It supply compressed air for engine starting and for the operation of air power equipment and instrument.

4. The compressor fitted with two safety valves, one after the first-stage compression and the other after second-stage compressor. The cylinder block cooling jacket is fitted with safety plate which will blow-out if the cooling pressure is subjected to excessive pressure, also fitted with thermostat, oil and water trap system.

5. A pressure switch is generally included in the automatic control system, which serves to stop the compressor if the lube oil pressure falls below a predetermined minimum. The compressors is shown in Figure, in cross sectional view. The letters indicate:

- A Suction filter
- B LP suction valve
- C LP delivery valve
- D LP safety valve
- E LP cooler

- F HP suction
- G HP delivery valve
- H HP cooler
- I HP safety valve



## **CROSS-SECTIONAL DRAWING AIR COMPRESSOR**

## **B. Starting Procedures:**

# Before initial starting up and after long periods out of use, carry out following operations:

- A. Check the oil level.
- B. Check the quality of the oil has not been impaired by water or other foreign matter.
- C. Check compressor valves and lubricate the cylinders with oil.
- D. Turn over the compressor by hand, with the suction valve relieved by means of the manual valve opener.
- E. Check cooling water circulation.
- F. Check that the air line cock between the compressor and the air reservoir is open.

- G. Open the manual drain cocks on the water trap.
- H. Start the compressor and check lube oil pressure.
- I. If everything is operating normally, close the drain cocks and set the valve opener in the operating position. Allow the compressor to run for a few minutes before loading it to maximum working pressure.
- J. During normal operation pressures and temperatures should be checked and monitor by pressure switch for lube oil, thermostat for cooling water temperature.

## C. Stopping Procedures:

## Stopping the compressor manually for short periods:

- 1. Operate the manual valve opener to relieve the LP suction valve.
- 2. Open the water trap drain cocks.
- 3. Stop the compressor.

## If compressor to be shut down for a long period, e.g. when a ship is to be laid up, the procedure are as follows:

- 1. Lubricate compressor valves, non-return valves, cylinder walls and exposed crankshaft surfaces with corrosion-inhibiting oil, suitable for the envisages period of shut down.
- 2. If there is any risk of frost, drain the cooling water from the compressor.
- 3. Drain off old oil, clean the sump and refill with new one.
- 4. Set the manual valve opener in the horizontal position to relieve the load on the suction valve.
- 5. Turn over the compressor manually once a month.
- 6. The starter cabinet and other electrical equipment should also be protected from damage by corrosion.

## **D.** Trouble Shooting:

The following are some of the faults that may arise in operation.

#### A. Compressor capacity is low and/or compressor not supplying full pressure.

Possible Cause	Remedy
1. Dirty, damaged or worn valves	Clean and check all valves. Replace defective parts.
2. Sticking piston rings	Dismantle rings. Clean grooves and rings. Replace defective parts. When reinstalling, lubricate cylinder walls with oil.
3. Leaking safety valves	Overhaul safety valves, adjust to cor- rect lifting pressure.

	4. Defective gasket between crankcase and cylinder block	Replace gasket
	5. Air filter blocked	Clean filter
<i>B</i> .	LP safety valve blows.	
	1. HP valves damaged or dirty	Check and clean valves. Replace de- fective parts.
	2. Non-return valve blocked	Remove and clean non-return valve. Replace defective parts.
D.	Valves require maintenance too frequently.	
	1. Overheating	Check cooling water circulation and temperatures. Inspect cooler and clean if necessary.
	2. Dirty intake air	Check suction filter.
	3. Inferior lube oil	Change lube oil type. See list of recom- mended types.
	4. Incorrect tightening of compressor valve	Tighten valve clamping screws to specified torque
E.	Overheating or knocking in crankcase.	
	Possible cause	Remedy
	1. Defective bearing	Inspect earnings, check clearances
	2. Insufficient lube oil or lube oil contaminated with water.	Drain sump, clean and add new oil.
F.	Overheating and scoring piston.	
	1. Piston or gudgeon pin bearing incorrectly fitted.	Replace defective parts, check piston clearances, piston ring clearances and gudgeon pin bearing.
	2. Deficient cooling	Check cooling water circulation and temperatures.
G.	Excessive lube oil consumption	-
	1. Piston rings worn out	Replace piston rings.
	2. Defective crankcase breather valve	Replace breather valve.
E.	Maintenance Routines:	
	Routine ADailyCheck:- Lube oil pressure- Lube oil- Cooling water circulation a	and temperatures

- Automatic functions
- Drain condensate

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<i>Routine B</i> Check:	Every 500 hours - LP delivery valve - HP delivery valve - Compressor bedplate bolts
<i>Routine C</i> Check:	Every 1000 hours - LP suction valve - HP suction valve - Cylinder through valve apertures - Pipe connections
Overhaul:	<ul> <li>LP delivery valve</li> <li>HP delivery valve</li> </ul>
Replace:	<ul> <li>Lube oil after cleaning crankcase</li> <li>Lube oil filter</li> </ul>
<i>Routine D</i> Check:	Every 3000 hours - Big-end bearings - Piston and cylinder walls through valve apertures - Flexible couping - Safety valves
Overhaul	<ul> <li>LP suction valve</li> <li>HP suction valve</li> <li>Air filter (clean)</li> </ul>
<i>Routine E</i> Check:	Every 9000 hours - Coolers (clean)
<i>Routine F</i> Check:	<i>Every 12000 hours</i> – Main bearings – Piston, gudgeon pin bearing – Lube oil pump

The above maintenance schedule is intended as a guideline for formal maintenance. However, compressor operating conditions vary widely from installation to installation and it is therefore important to adapt the maintenance schedule to the experience of the individual on board.

#### PURIFIER

#### Principle of Centrifugal Separation:

Separation takes place in the separator bowl which is driven by an electric motor via a worm gear transmission. The separator bowl rotates with very high speed generating a substantial centrifugal force. Sludge and water is then efficiently separated from the oil.

Unseparated oil is fed into the bowl through the oil inlet (1) and is forced inwards to the distack (G). The oil is continuously cleaned as it travels towards the center of the bowl. When the cleaned oil leaves the disc stack, it rises upwards and flows over the level ring (O) where it enters the oil paring chamber (L). From there it is pumped by the non-rotating oil paring disc (N) and leaves the bowl through clean oil outlet (4).

Separated water and sludge will be accumulated in the bowl sludge space (H).

Under normal operation the upper paring disc (M) and flow control disc (K) are used for internal oil circulation in the top of the bowl. This circulation is necessary for maintaining a minimum temperature increase of the oil in the upper paring chamber (R). See figure below.



## **VERTICAL SECTION OF SEPARATOR BOWL**

#### Parts: 1. Oil inlet

- 4. Clean oil outlet
- 5. Water outlet
- 10 Displacement/conditioning water inlet
- 15 Bowl opening water
- 16. Bowl closing water
- B. Bowl spindle
- G. Disc stack
- H. Sludge space
- I. Top Disc
- K. Flow control disc
- L. Oil paring chamber
- M. Upper paring disc
- N. Oil paring disc
- O. Level ring
- R. Upper paring chamber

#### **Operations:**

#### 1. Before the separator is started check the following in the system.

- a. Separator must correctly assembled.
- b. Oil level correct
- c. Brake is released
- d. Control unit is ON and program setting and mode selector in correct position.
- e. Valve for feed pump, supply, delivery and recirculation tanks, must open.
- f. Operating water tank is full and valve open.
- g. Electrical mode for automatic are working like solenoid valves, safety alarms.
- h. Air supply is correct and open for operation.

## 2. Starting Procedure

- a. Start the oil feed pump for circulation.
- b. Start the heater until reach desired temperature.
- c. Start the separator motor until reach desired speed. Check any vibration occur. Stop immediately.
- d. Open air supply to control mechanism.
- e. Start the control program for automation.
- f. At normal operation, checked regularly the oil inlet temperature, oil sump level, sound or vibration of separator and control program.

## 3. Stopping Procedure:

- a. Stop the control program and initiated by automatic sludge and separator stop.
- b. Secure the heater.
- c. Stop the oil feed pump.
- d. Shut off air supply and power off to control.
- e. Apply brake after stopping few minutes before standstill.
- f. Release the brake and start separator manually using motor starter and run it for about 1 minute to empty the bowl, if necessary.

## 4. Trouble Shooting – Separating Operation:

## Causes:

- a. Liquid flows out through bowl casing drain and /or sludge outlet.
  - 1. Sludge discharge or water draining in progress.
  - 2. Strainer in operating water high pressure side. Clogged or water pressure too low.
  - 3. Hose between solenoid valve block (pos 10) and separator kinked.
  - 4. Control paring disc dirty.
  - 5. Seal ring at flow control disc or small lock ring (paring chamber cover) defective.
  - 6. Seal ring in sliding bowl bottom defective.
  - 7. Bowl hood seal ring defective or sealing surface of sliding bowl bottom damaged.
  - 8. Seal rings in control paring disc device defective.
  - 9. Valve plugs defective.
  - 10. Sludge deposits on operating slide.
  - 11. Bowl speed too low.
- **b.** Bowl opens unintentionally during operation
  - 1. Strainer in operating water low pressure side clogged.
  - 2. No water in operating water tank or valve(s) closed.

- 3. Hose between solenoid valve block (pos.16) and separator kinked.
- 4. Nozzles in dosing ring clogged.
- 5. Seal ring in sliding bowl bottom defective.
- 6. Valve plugs defective.
- 7. Sludge deposits on operating slide.
- 8. Seal ring in operating slide defective.
- c. Bowl fails open for sludge discharge
  - 1. Strainer in operating water high pressure side clogged or water pressure to low.
  - 2. Hose between solenoid valve block and separator kinked.
  - 3. Dosing ring tightened too much
  - 4. Nozzles in dosing ring clogged.
  - 5. Seal rings in control paring disc device.
  - 6. Valve plug defective.
  - 7. Seal ring in operating slide defective.
- d. Unsatisfactory sludge discharge
  - 1. Dosing ring tightened too much.
  - 2. Sludge deposits in operating system.
- e. Unsatisfactory separation result
  - 1. Wrong separating temperature.
  - 2. Thoughput too high.
  - 3. Bowl disc stack clogged.
  - 4. Sludge space in bowl filled.
  - 5. Bowl speed too low.
- f. Indicating pressure (in water outlet) too high
  - 1. Throughput too high.
  - 2. Valve(s) in oil outlet line closed.
  - 3. Wrong separating temperature.
  - 4. Oil paring disc defective.
  - 5. Bowl disc stack clogged.
  - 6. Bowl incorrectly assembled.

## 5. Trouble Shooting – Mechanical Functions: *Causes:*

## a. Separator vibrates

- 1. Bowl out of balance due to: bad cleaning, incorrect assembling.
- 2. Uneven sludge deposits in sludge space.
- 3. Height position of paring disc or bowl spindle is wrong.

- 4. Bearing damaged or worn.
- 5. Bearing overheated.
- 6. Bowl spindle bent.
- 7. Vibration damping rubber washers worn out.
- 8. Top bearing spring broken.

## **b.** Run-up time too long

- 1. Brake applied.
- 2. Friction pads worn or oily.

## c. Smell

- 1. Normal occurrence during start as friction blocks are sliding.
- 2. Brake applied.
- 3. Bearing overheated.

## d. Noise

- 1. Oil quantity wrong.
- 2. Height position of paring discs or bowl spindle is wrong.
- 3. Worm wheel and worm are worn.
- 4. Bearing damaged or worn.
- 5. Bearing overheated.
- 6. Wrong play between coupling pulley and elastic plate.

## e. Speed too low / high

- 1. Brake applied.
- 2. Friction pads worn or oily.
- 3. Bowl not closed or leaking.
- 4. Motor failure.
- 5. Bearing damaged or worn.
- 6. Bearing overheated
- 7. Wrong gear transmission (50 Hz gears for 60 Hz current or vice versa).

## f. Water in worm gear housing

- 1. Bowl casing drain obstructed.
- 2. Leakage at top bearing.
- 3. Condensation

#### **BOWL DISMANTLING - FOPX 605**





**Important!** Never start dismantling until the bowl has come to a **complete standstill**.

The heavy bowl parts must be lifted by means of a hoist. Position the hoist very exactly. Use a lifting hook with catch.

Don't place parts directly on the floor, but on a clean rubber mat, fibreboard or a suitable pallet.

- Loosen clamp screw (F) and lower clamping stirrup (G). Remove plug (A) and support (B). Undo the coupling nuts of inlet and outlet piping at the pipe support.
- 2. Unscrew inlet pipe (C) using the special pin spanner and lift out the pipe.
- Disconnect the oil outlet pipe and remove support (D). Undo water outlet coupling nut of connection housing (E).
- 4. Remove connection housing and lift out frame hood (H). It necessary, use a hoist.
- 5. Unscrew small lock ring (1) using the special spanner.

Force out flow control disc (K) and upper paring disc (J) from small lock ring.

- A. Plug
- B. Support
- C. Inlet pipe
- D. Support E. Connection
- housing
- F. Clamp screw
- G. Clamping stirrup
- H. Frame hood
- I. Small lock ring
- (with paring chamber cover)

🔼 Left-hand thread

- J. Upper paring disc
- K. Flow control disc













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- L. Large lock ring
- M. Bowl hood
- N. Top disc
- O. Lower paring disc P. Level ring
- Q. Bowl disc

- 6. Unscrew large lock ring (L) using the special spanner.
- Ease off and lift out bowl hood (M) by means of the special lifting tool. Be careful not to scratch the bowl hood seal ring.
- Remove top disc (N). Then screw inlet pipe (C) in lower paring disc (O), located in top disc. Note. Left-hand thread!

Put a piece of wood (a) between the tin hammer and the pipe and force out level ring (P) and lower paring disc from top disc.

- 9. Lift out distributor (T) with bowl discs (Q,S) and wing insert (R). Use the special lifting tool.
  - Soak the bowl discs and the wing insert in suitable cleaning agent, see 7.1.1.
- 10. Unscrew cap nut (U).

Wing insert

Bowl disc

Distributor

Distributing cone

Cap nut

R.

**S**.

**T**.

U.

V.

11. Lift out distributing cone (V) by means of the special tool.













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- 12. Lift out sliding bowl bottom (W) using the special tool.
- 13. Unscrew the three screws from bowl body (WW).
- 14. Ease off bowl body with central screw of lifting tool. When necessary knock on spanner handle. When the bowl body has come loose from the bowl spindle taper, turn the central screw of the tool another two turns in order to avoid damaging the control paring disc when lifting the bowl body.
- 15. Remove bowl body. Ifnecessary, use a hoist.
- 16. To take apart the discharge mechanism:
  - a. Turn bowl body upside down.
  - b. Loosen the screws for the spring support (YY) successively a litte at a time. Remove the screws.
  - c. Remove spring support and springs (Y)
  - d. Undo the screws of dosing ring (Z).
  - e. Lift dosing ring and operating slide (XX) with two of the dosing ring screws (a). If necessary, prize loose the dosing ring as shown in figure. Place the operating slide with the valve plugs (X) facing upwards in order not to scratch the sealing surface of the plugs.
  - Clean all parts thoroughly in suitable cleaning agent,

Check for damage, corrosion and erosion prior to assembly.

Clean nozzles (ZZ) in dosing ring with a soft iron wire:



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W Sliding bowl bottom WW.Bowl body X. Valve plug XX Operating slide Y. Spring YY. Spring support Z. Dosing ring ZZ. Nozzle



- Apply lubricating paste\* on the locating surfaces of operating slide (XX) and dosing ring (Z).
- 2. Fit operating slide and dosing ring.
  - Note that only a thin film of paste is to be applied on the dosing ring screws. If too much paste, the surplus would collect between operating slide and bowl body with risk for operating trouble.
  - It is imperative to use a torque meter when tightening these screws.
     First tighten diametrically, then all around. The tightening torque should be 7 Nm.
- Apply lubricating paste\* on the locating surface of the spring support (YY). Fit springs (Y) and spring support.

Tighten the screws of the support successively a little at a time. Finally tighten firmly (by hand).

- 4. Wipe off spindle top and nave bore in bowl body. Apply oil onto the tapered end of the spindle to prevent the bowl seizing on the spindle. Use a few drops of oil only, smear it over the surface and wipe it off with a cloth.
- 5. Fit bowl body (WW) on the spindle. Proceed as follows:

Central screw (a) screwed home. Lower bowl body until central screw supports on spindle top. If necessary, use a hoist. Then screw up the central screw so that bowl body sinks down on the spindle.

 Rotate the bowl body slowly and align it so that the screw holes in its bottom are exactly above the holes in the operating device. Tighten the bowl body screws firmly.











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- Apply lubricating paste<sup>\*</sup> on the locating surfaces of bowl body (WW) and sliding bowl bottom (W). Fit sliding bowl bottom.
- Fit distributing cone (V). The guide pins on underside of distributing cone must enter recesses in bowl body nave.
- 9. Screw cap nut (U) on spindle. Tighten firmly.
- Slip bowl discs (S,Q) and wing insert (R) on to distributor (T).

Number of discs: (S):40 (Q):40 - 42

Fit distributor with disc stack in bowl. Recesses in underside of distributor must fit over guide pins of distributing cone.

 Check that the small hole (d) on top disc (N) is not clogged. Fit lower paring disc (O) and level ring (P) in top disc. Be sure to turn the paring disc the right way round. Fit top disc on distributor (drill mark (e) on disc must face guide lug (b) of bowl body.)

- These surfaces are to be primed with lubricating spray Molykote 321 R with Major Service (MS) - see Operator's Service Manual (OSM).
  - a Drill mark on distributing cone
  - b Guide lug in
  - bowl body
  - c Guide rib on distributor
  - d Small hole in top disc
  - e Piece of wood









- Put bowl hood (M) in place. The guide lug on bowl body must enter recess in hood.
- Apply lubricating paste\* on lock ring threads, contact and locating surfaces (see arrows in figure). Tighten large lock ring (L) until bowl hood lies tightly against bowl body. In a new bowl assembly marks will now be in line with each other - see arrows in figure.

**Note**: The assembly marks must never pass each other more than 25°.

Height position of paring disc and disc stack pressure - see Operator's Service manual (OSM).

14. Check that the small holes in upper paring disc (J) and in flow control disc (K) are not clogged. Fit paring disc and flow control disc in small lock ring (I).

Tighten small lock ring.

- Put frame hood (H) in place and clamp it with the hinged bolts. Then fit connection housing (E) (note its angular position) and connect water outlet pipe. Fit support (D) and connect oil outlet pipe.
- 16. Fit inlet pipe (C). Tighten the pipe using the special pin spanner.
- Fit support (B) and plug (A) and tighten clamp screw (F) firmly. Tighten the pipes at the pipe support.
  - The threads and surfaces stated are to be primed with lubricating spray Molykote 321 R with Major Service (MS) - See (OSM).

S Left-hand thread



12

16 Contractions of the second second

#### **GENERAL TERMS:**

- **Purification** Separation of two insoluble liquids with different densities, and at the same time, removing of solids.
- Clarification Separation of solid contaminants from a liquid.
- Viscosity Low viscosity facilitates separation. Viscosity can be reduced by heating.
- **Density Difference** The greater the density difference between the two liquids, the easier the separation. The density difference can be increased by heating. Also called specific gravity ratio.
- **Centrifugal separation** In a rapidly rotating vessel gravity is replaced by centrifugal force, which increases the settling velocity by a factor of several thousand. What takes hours under the influence of gravity takes only seconds in a high speed separator bowl.
- **Separation by gravity** A dirty liquid in a stationary vessel will clear slowly as the heavy particles in the liquid settle to the bottom under the influence of gravity. In the case of insoluble liquids the heavier liquid will place itself underneath the lighter liquid.

Solid contaminants in the liquid mixture will settle and form a sediment layer (sludge) on the bottom of settling tank.

- Sludge Separated contaminants and heavy water/oil emulsion.
- Sludge discharge Ejection of sludge from separator bowl.
- Throughput Oil feed to the separator. Expressed in m<sup>3</sup>/h or l/h.
- Back pressure Pressure in separator clean oil outlet.
- *Indicating pressure* Pressure in separator water outlet.
- Density Mass per volume unit. Expressed in kg/m<sup>3</sup> at specified temperature normally at 15°C.
- Viscosity Fluid resistance against movement. Normally expressed in centistoke (cSt=mm<sup>2</sup>/s), at specified temperature.
- **Displacement water** Addition of water to separator bowl to displace the oil prior to a sludge discharge.
- **Conditioning water** Addition of water to separator bowl after a sludge discharge, in case "dry" oil is being separated. The water will soften the sludge when passing the water to the bowl periphery.

# Guidelines when Ordering Spare Parts and Consumable Items

When an order or inquiry for Main Engine, Diesel Engine Auxiliary Equipments like pumps, boilers, etc. It is important that the following data are stated in your order for spare parts, in order to ensure correct supply part for the individual engines.

- 1. Ship Name
- 2. Type of Engine and Cylinder number
- 3. Classification, Engine Number
- 4. Maker or Builder
- 5. Part name, Plate number, Item number
- 6. Capacity Design
- 7. Quantity required

Ex.	Plate No.	item no.	Quantity	Unit	Name
	90801-73	540	2	set	Oil cylinder
	90201-56	059	4	pcs.	Piston rings, Right
	90201-56	096	1	set	Piston rod

When ordering through ISSA (International Ship Suppliers Association) is a catalogue of items used on board ship, coded and illustrated to ease identification between shipowners or ship personnel and the ship supplier on shore, thus saving time, money and preventing mistake and misunderstandings. Articles listed like Safety, Painting, Nautical, Lavatory, Electrical and Welding Equipments; Measuring, Cutting, Pneumatic and Electrical Tools; Clothing, Linen, Galley and Table Ware Products; Stationery, Hardware, Chemical, Fittings, Pipes, Valves, etc.

**HOW TO ORDER:** Using the specified code number, name of the items, sizes, type, capacity, materials, weight, ranges and other data.

- Ex. 33-11-62 Slotted V-gard safety helmet, white color 6 pcs.
  - 59-03-01 Grinder, Angle, pneumatic Model USG-45 1 pc.
    - 65-05-02 Caliper, veniers, stainless steel, 150 mm metric graduation 2 pcs.
    - 69-01-01 Hexagon head bolt, steel M12 x 50 mm 36 pcs.
    - 71-01-09 Pipe, Carbon steel, galvanize 50 A x 5.5 mtr. 2 pcs.
    - 79-04-01 Lamp, navigation, E-26, 24 V, 40 watts 3 dozens
    - 85-10-31 Electrode holder, grip type 200 amp. 1 pc.

## LUBE OIL ANALYSIS: TEST ON BOARD PROCEDURE:

On board, oil analysis program should be done in order to eliminate or minimize catastrophic failure and extend the useful life service of expensive equipment.

Samples are to be taken while a system is operating and after the filter leading to the engine. Most common system to be analyzed either ashore or onboard test kit, are Main Engine, Aux. Engines, Stern Tube, Cargo Oil Turbines with an interval length of every 3 months on shore test maintenance check.

#### COMMON DIAGNOSTIC TEST RESULTS ARE:

**Appearance** - significant darkening from normal color is an indication of contamination or oxidation.

Water - presence of water may cause the oil to appear hazy or cloudy. Free water is a prime cause of rusting, sludging and impaired lubrication, so the source should be located and eliminated as soon as possible. Measured in %.

**Viscosity** - measure of the internal friction or the resistance to flow of a liquid. Measured in centistokes at 40<sup>o</sup>C.

**Insolubles** - amount of insoluble material remaining after the lube oil is mixed with pentane. Measured in %.

**Base number** - measure of the alkalinity of an engine oil needed to counter slow speed diesel engines operating with a sulfur content fuel oil. Measure in numerical values.

**Total Acid Number** - measure the level of acidity of the turbine, hydraulic or compressor oil. Measure in numerical values.

Wear metal - analysis of metal measured in PPM present in the lubricant.

**MOBIL WATER TEST KIT** - is a unique tool to check water content present in the system. Its action is base on the generation of a gas by the chemical reaction between a powder (calcium hydride) and water present in the oil sample.

The volume of gas generated is directly proportional to the amount of water in the oil. Thus, when the gas is allowed to displace kerosene from the container body of the kit into the collector on the side, the amount of gas (and therefore the amount of water) present can be determined by measuring the level of kerosene in the collector.

#### **TEST RESULT:**

- a. When no kerosene is displaced the oils sample is, of course, free of water.
- b. If all of the 150 cc of kerosene is displaced into the collector, this is and indication that the sample contains more than 1.5% water. In normal circumstances this will provide sufficient evidence for taking prompt action to detect and eliminate the source of the water contamination.
- c. It is recommended that any water is removed from the oil by purifying at 85-90<sup>0</sup>C and a centrifuge throughput 18-22% of rated capacity for detergent trunk engine oils and 25-30% for crosshead diesel system oils.

## AUTOCHIEF III CONTROL SYSTEM:

Autochief III is a main engine control system for single plant with fixed propeller. It is designed for engines having extensive pneumatic maneuvering equipment delivered as a part of the engine, in order to get maximum benefit out of the engine standard system.

Autochief III is constructed to fit easily into the control consoles on bridge and in engine control room. The maneuvering handle is built-into the bridge panel, and is a combined telegraph and maneuvering lever. The engine room panel contains all the electronic logic needed for this system.

Autochief III is an electronic-pneumatic system, using electrical signal transmission from bridge to engine room and between sensors and the central unit. Starting, reversing and speed are controlled directly by a maneuvering handle on the bridge which also has a built-in telegraph system. The speed control output, (4-20 mA) is given directly to the digital governor system of converted into pressure-signal in the speed-set unit giving signal to the woodward governor.

Its duty is to control and monitor the safety functions such as RPM, overspeed, shut downs, slow downs, emergency stop and the cancelling functions.

#### **DIGITAL GOVERNOR SYSTEM:**

The Digital Governor System (DGS 8800) is a complete package which fulfills all tasks for governing the speed of low-speed, long-stroke diesel engines. The speed setting may be from two different systems, usually the bridge control system and the engine-room control system.

The main purpose of the DGS 8800 system is to regulate the position of the engine fuel servo, in order to maintain an engine speed equal to a reference setting. The system is composed of two separate and self-contained subsystems: the speed Regulating Function (RF), and the fuel Actuating Function (AF).

#### **Regulating Function**

- Speed reference computation.
- Speed measurement and filtering.
- Output and limit the command signal to the fuel actuating function.

In addition, the Regulating Function has several sub-functions, such as:

- Displaying data values.
- Programming user-dependent parameters.
- On-line testing.
- Off-line testing.
- Selection of alternative mode operations.

## Actuating Function

The main purposes are:

- Sense the fuel-rack position command from the Regulator.
- Positioning the fuel-rack according to command value.

In addition, the Actuating Function contains several secondary functions:

- Limiting speed of fuel-rack.
- Outputting fuel-rack indication (option).
- Displaying data values.
- Automatic tuning of servo system.
- Repeatedly testing of System failures.

## The DGS 8800 Digital Governor System consists of five basic units:

Power Unit, Actuator Unit, DGU 8800 Digital Governor Unit, Scav Air Pressure Sensor, and Speed Pick-Up Unit.





OPER	ATING	INSTRU	<b>JCTION</b>

Condition	Working Pump	Work Cylinder	Stop Valve		Stop Valve By-Pass Valve		Logic Valve					8	Solenoid			1			
			A	В	С	D	1-2		3-4	е	f	g	h	i	1	a	Ъ	c	d
Normal	No.1																		
	No. 2	All			0			x		0	0	x	0	0	x		x		
Emergency	No. 1 & No. 2																		
Emergency	No. 1	No. 1 & No. 2			0			x		x	x	x	0	0	0	0	x	x	0
(Automatic)	No.2	No. 3 & No. 4			0			x		0	0	0	x	x	×	x	o	0	x
Emergency	No. 1	No. 1 & No. 2			x		×		0	0	0	x	0	0	x		x		
(Manual)	No. 2	No. 3 & No. 4					0		x										
							0:0	Ope	n								0:	ON	
							<b>x</b> :	Shu	t								0:	OF	F

## WORKING PRINCIPLE OF POSITIONER

The signal pressure from the controller enters into the input chamber from the connection opening SIG via by-pass cock. The flapper is displaced by the force generated through the difference of the effective areas of two sheets of diaphragm. The distance between the nozzle and flapper is increased, while the nozzle back pressure is lowered.

On the other hand, the supply pressure is introduced in the constant pressure room. Therefore, the pilot shaft (bleed fitting) is moved to the right direction and pushes the valve rod.

The output pressure is introduced into the diaphragm actuator via by-pass cock and OUT 1, thus to move the valve stem.

The movement of the valve stem is converted into the rotation movement by means of the lever. The relay lever, which is fixed at the level shaft, is moved and then the feedback lever is swayed via the relay pin. This swaying motion gives the displacement to the feedback spring, and the stem is moved until the spring tension and the force generated at the input chamber come to the equilibrium. In this way such stem displacement is obtained as is proportional to the input signal.

- A. Direct Plug Valve with Direct Action Diaphragm Motor
- B. Reverse Plug Valve with Direct Action Diaphragm Motor
- C. Direct Plug Valve with Reverse Action Diaphragm Motor
- D. Reverse Plug Valve with Reverse Action Diaphragm Motor





# **CALIBRATION OF INSTRUMENTS:**

Formula:

	Output X	=	Input x K + Offset YK + Offset
where:	X	=	output Y = input
	ĸ	=	constant K = X/Y
	Offset	=	min. output from true zero

## **Problem:**

1. If 50  $^{\circ}$ C is the output in PT -100 Thermocouple, what is the mAmp? Output current = 4-20 mA.

Υ	=	$0-100 \ ^{0} C$ Offset = 4		0 °C	=	4 mA
X	=	4-20 mA (DIN)		20	=	7.2
V		20-4 16		40	=	10.4
n	=	= =.1 100 - 0 100	16	50	=	12.0
				60	=	13.6
X	=	50 <sup>0</sup> C (.16) + 4		80	=	16.8
X	=	8 + 4		100 °C	=	20 mA
X	=	12 mA				

# 2. In calibrating Pressure Differential Transmitter with a 3 bar range, what is output current in mA?

κ	=	20 - 4	<u> </u>	5.33
		3-0	3	
X	=	0.5 (5.3	33) + 4	
X	=	2.665 +	- 4	
X	=	6.6 mA	۱.	
	inpu	st (bar)	Output (current)	
	0.0	=	4 mA	
	0.5	=	6.6	
	1.0	z	9.5	
	15	_	10.6	

1.0	-	10.0
2.0	=	12.3
2.5	=	15.0
3.0	*=	20 mA

#### SETTING/ADJUSTMENT OF INSTRUMENTS:

#### Setting

The pressure and temperature controller is set by rotating the knob (5), at the same time reading the main scale (9).

The differential is set by rotating the differential adjusting nut (19) to have the value indicated by the use of the nomogram. The maximum operating pressure and temperature is thus the sum of the setting pressure and the differential.

#### Pressuretat

#### Example:

It is desired to control the pressure in an oilfired steam boiler by the use of an RT 116. Maximum pressure 9 bar. Minimum pressure 8.2 bar. Differential 9-8.2 = 0.8 bar.

- 1. Connect the oil burner to terminals 1-2 of the pressure controller.
- 2. Set the pressure controller for 8.2 bar by rotating the knob (5).
- 3. Set the differential adjusting nut (19) at the figure 6 which is found by reading the monogram.

#### Thermostat

#### Example

It is desired to control the size letter plus the temperature of an oil-fired central heating boiler by the use of an RT 101. Maximum temperature 76  $^{\circ}$ C. Minimum temperature 70  $^{\circ}$ C. Differential 76-70 =  $6^{\circ}$ C.

- 1. Connect the oil burner to terminals 2-1 of the thermostat.
- 2. Set the thermostat for 70 °C by rotating the knob (5).
- 3. Set the differential adjusting nut (19) between figures 2 and 3, as indicated by the monogram.



## PNEUMATIC CONTROL VALVE DESIGNATION

Alpahabets	Designation	Numbers
A, B, C	Working Ports	2, 4, 6
P	Supply Ports	1
R, S, T	Exhaust Ports	3, 5, 7
L	Leakage Ports	9
X, Y, Z	Control Ports	10, 12, 14, 16



5/2 WAY VALVE

## SAFETY CHECKLIST FOR WELDING

## A. Equipment

- 1. Check that the power source functions correctly, is correctly connected to mains, and that you are familiar with its operation.
- 2. Ensure that gas cylinders are properly secured, in upright position, and fitted with correct and properly functioning regulators for the gas. Acetylene and Oxygen regulators shall be fitted with flashback arrestors.
- 3. Hoses shall be in good condition, without leaks or damage, and with correct color coding for the gas. Red for Acetylene, Blue for Oxygen.
- 4. Cables shall be of oil resistant type with undamaged insulation and properly mounted cable connectors.
- 5. Check that torches and electrode holders are in good working order, including check of blowpipes, nozzles and insulation.
- 6. Check all gas connectors for leaks, including torch valves. Replace defective gaskets with original gaskets only.
- 7. Keep hoses and cables clear of passage ways and protected from sparks, hot metal and mechanical damage in doorways, hatches.
- 8. Both welding and ground clamp cables should be stretched to the work place, and the ground clamp should be fastened with good electrical contact directly on the work place.

#### **B. Work Place**

- 9. Tidy up the work place and remove any flammable materials, liquids and gases from workplace and adjacent spaces including spaces above/below decks, behind bulkheads and inside pipes or containers which are to be worked on.
- 10. Cover any openings through which sparks may be led to other areas onboard which have not been prepared for hot work.
- 11. If necessary, shield the work place to protect others from sparks and radiation form the arc, and post a warning sign that welding is in progress.
- 12. Ensure that sufficient and correct fire fighting equipment is available at the workplace, and that personnel familiar with its use is present.
- 13. Ensure that the work place is properly ventilated, if necessary with special fume extraction equipment.

#### C. Hot Work Procedure

- 14. Ensure that all relevant check lists, certificates and permits for hot work have been issued.
- 15. If work is being done outside the ship's workshop an assistant protected like the welder should accompany him.
- 16. If work has been done inside a confined space the assistant should be placed outside, within view of the welder and with possibility to cut off gas and power supply.
- 17. When working, wear safety shoes and a proper boiler suit with long sleeves.
- 18. Welding gloves should always be used, and when necessary also use additional leather clothing for protection against sparks, heat and electric shock.
- 19. Use head and face protection (helmet, shield, goggles) according to the job.
- 20. Where necessary use a dust filter or breathing apparatus to avoid inhaling fumes and dust from the welding process.
- 21. Never use Acetylene or Oxygen to blow away dust from yourself or the workplace. Always keep dry and keep the workplace dry, especially when you are welding.
- 22. Always remove coated electrodes from the electrode holder and switch/close off gas and current at the source during short break.
- 23. Do not leave the workplace unattended. When hot work is completed the work place shall be inspected at regular interval to ensure that no risk of fire remains.



## WELDING TECHNIQUE

In order to obtain a good weld we must ensure that the following points are correct:

#### 1. Current

Current output is the most important factor in arc welding, and this is where most mistakes are made. It is a good rule to use slightly more current than required rather than risk using too little. If the current output is insufficient, fusing with the base material will be unsatisfactory. Slag may become embedded in the weld.

#### 2. Length of arc

When arc welding with electrodes, it is important that the arc be kept as short as possible in order to avoid the formation of pores and to prevent slag becoming embedded in the weld. A short arc prevents the formation of molten slag ahead of the molten pool. This is of particular importance when welding with basic electrodes. The guiding rule is that the arc gap should be equal to the diameter of the wire core of the electrode.

#### 3. Electrode angle

The electrode must be held at the correct angle during the welding operation. The angles to be used when welding in the horizontal welding position, is 60-80 degrees.

#### 4. Electrode travel

Move the electrode at an even rate in the welding direction, with or without weaving. Correct rate of travel is important to achieve a good weld. The illustration shows the faults that can occur if the electrode is moved too quickly or too slowly in a fillet weld.

When building up a flat surface, the electrode should be held at an angle of 60 degrees and weaved gently from side to side as the weld advances so that the height of the deposited filler is about 1/3 of the width of each bead. When starting the next parallel buildup run, the tip of the electrode should overlap the previous bead by about 1/3 of the bead width. In this way an even surface can be built up without high spots or craters.

## **1. CORRECT CURRENT VALUE**



## 2. CORRECT ELECTRODE TRAVEL



3. CORRECT ELECTRODE ANGLE AND LENGTH OF ARC





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## **OPERATING INSTRUCTIONS FOR CUTTING TORCH**



- a. All valves are shut at the commencement of work: Cylinder valves (1 and 2) are shut, the regulator adjusting screws (3 and 4) are screwed so far out that they run freely on their threads, and all torch valves (5, 6, 7 and 8) are closed.
- b. Select your cutting nozzle (9) to suit the type and thickness of the workpiece. The required nozzle and working pressure for mild steel when using 5 mm hoses 10 m long are given in the cutting table. Other materials and hoses may require other nozzles and working pressures than those given in the table.
- c. Slowly open the cylinder valves for oxygen (1) and acetylene (2).
- Fully open the torch oxygen needle valve (5) and the valve for preheating oxygen (7). Then press the cutting oxygen valve lever (8), and adjust the working pressure by means of the oxygen regulator adjusting screw (3).
- e. Release the cutting oxygen value lever (8) and shut the value for preheating oxygen (7).
- f. Fully open the torch acetylene needle valve (6), and adjust the working pressure by means of the acetylene regulator setting screw (4).
- g. Slightly open the preheating oxygen valve (7) to provide a little extra oxygen to prevent troublesome sooting when the torch is lit.
- h. Light the torch and adjust to neutral flame, using the valve for preheating oxygen (7).
- i. Press down the cutting oxygen lever (8) and readjust to normal flame by means of the valve for preheating oxygen (7). The torch is now ready for cutting. When cutting, the torch oxygen needle valve must be kept fully open.
- j. In the event of sustained backfire, which is recognized by a whistling or hissing sound, first close the valve for preheating oxygen (7) as quickly as possible, releasing the cutting oxygen valve lever (8) at the same time. Then shut the torch acetylene needle valve (6).
- k. The torch is normally extinguished by first closing the torch acetylene needle valve (6) and then the valve for preheating oxygen (7). Finally, relieve the pressure in the hoses and close all valves.

## **CUTTING PROCEDURE**

#### Starting the cut from an edge

1. Direct the preheating flame against the starting point at the edge of the plate.

Keep the flame cores 2 - 3 mm above the steel plate and preheat until the steel is brightly red hot.

2. Move the torch tip slightly off the edge of the plate to ensure that the cutting oxygen jet passes the edge of the plate.

Open slowly but fully for the cutting oxygen by depressing the cutting oxygen lever. Keep the nozzle at the distance from the plate indicated in the cutting table (2 - 5 mm) and move the nozzle onto the plate.

3. Guide the torch steadily along the line to be cut. Use a cutting speed within the limits given in the cutting table and ensure that the slag blows through completely resulting in a steady stream of sparks downwards from the bottom of the cut.

#### Starting a cut by piercing

- Direct the preheating flame against the starting point. Keep the flame cores
   5 mm above the steel plate and preheat until the steel is red to white hot.
- 2. Lift the nozzle to approximately 12 20 mm above the surface. Open slowly for the cutting oxygen. Make sure that spatter of molten metal does not reach the nozzle tip, if necessary by inclining the torch slightly so that the sparks fly sideways.
- 3. With the cutting oxygen lever fully depressed lower the nozzle as the cutting jet plerces the plate. Keep the nozzle at correct distance from the plate (see cutting table) and proceed in the direction to be cut.







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## OPERATING INSTRUCTIONS FOR BRAZING, WELDING AND HEATING TORCH

- a. All valves are shut at the commencement of work: Cylinder valves (1 and 2) are shut, the regulator adjusting screws (3 and 4) are screwed so far out that they run freely on their threads and both torch needle valves (5 and 6) are closed.
- b. Select your blowpipe (7) to suit the type and thickness of workpiece. The required blowpipe and working pressure for mild steel when using 6,3 mm (1/4") hoses 10 m in length are given in the welding table. The working pressures relate to medium-strength flame.
- c. Slowly open the cylinder valves for oxygen (1) and acetylene (2).
- d. Fully open the torch oxygen needle valve (5) and adjust the working pressure by means of the oxygen regulator adjusting screw (3).
- e. Shut the torch oxygen valve (5).
- f. Fully open the torch acetylene needle valve (6), and adjust the working pressure by means of the acetylene regulator adjusting screw (4).
- g. Slightly open the torch oxygen needle valve (5) to provide a little extra oxygen to prevent troublesome sooting when the burner is lit.
- h. Hold the torch so that the nozzle points away from flammable objects. Light the torch, and adjust to desired flame characteristics by means of the torch oxygen needle valve (5). The torch is now ready for use.
- i. In the event of sustained backfire, which is recognized by a whistling or hissing sound, first close the torch oxygen needle valve (5) as quickly as possible, then the acetylene needle valve (6).
- j. The torch is normally extinguished by first closing the torch acetylene needle valve (6) and then the torch oxygen needle valve (5). Finally, relieve the pressure in the hoses and close all valves. (See Figure for cutting torch)

#### Standard arc welding equipment



- Unitor Safety electrode holder with cable and cable connectors.
- Ground clamp (155 mm) with cable and connector.
- Chipping hammer.

- Wire brush.
- Face shield with head band and glass.
- Hand-held face shield with glass.
- Two pairs welding gloves

## BASIC PRINCIPLE OF TIG WELDING

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The Gas Tungsten Arc Welding (GTAW) process, (also called Tungsten Inert Gas process, TIG) is based on an electric circuit and requires proper grounding of the workpiece with return cable to the power source. The torch or electrode holder is supplied with argon gas at a certain flow rate. The gas flows out through the torch nozzle, surrounding the tungsten electrode.

When the arc is struck between the electrode and the workpiece the gas is ionized, and a stable arc through which the welding current flows is established. The arc is the heat source for the process. The gas flow protects the electrode and heated area on the workpiece from the oxidizing effect of the surrounding air.

The tungsten electrode does not melt. Welding may be done by just using the arc to melt the edges of the base material. If necessary, additional filler metal may be supplied in the form of a separate filler rod, which is inserted into the molten pool, and melts together with the base material.

Onboard applications normally require welding current up to max 200-250 ampere direct current (dc).

The Unitor Welding Rectifiers are suited for GTAW welding based on the touchstart principle described under welding techniques. Remote control for welding current should be used, as it is a definite advantage for the process. The large rectifiers also have the possibility to select a current characteristic especially suited for GTAW welding, ensuring optimal conditions.

Select the diameter of the wire according to the thickness of the workpiece. Clean all rust, scale and old paint from the area to be welded.

In general, GTAW (TIG) and gas welding of unalloyed steel is suitable for thin sheets and pipes of small diameters, wall thickness of pipes not exceeding 6 mm.

For larger dimensions it may be advantageous to use electric arc welding with coated electrodes.



## TYPICAL WELDING FAULTS



#### 1. Root faults

When laying the first bead along the root in a butt joint, penetration at the root may be irregular or insufficient. When current is excessive, penetration will be too high. Insufficient penetration may be due to the current setting being too low, or the rate of travel too high. The electrode may also be too large for the groove to be welded.

#### 2. Fusion faults

If the current is too low or rate of travel too high, fusion faults may result, i.e. insufficient melting and fusion between the filler and the base metal.

Fusion faults may also occur if a small electrode is used on a large area of cold base material. A larger electrode diameter should be used, and the base material preheated.

#### 3. Slag embedded in weld

Slag consists of non-metallic particles originating from the coating of the electrode. All slag must be properly removed after finishing each weld bead. Use a chipping hammer and wire brush for this purpose. Slag embedded in the weld will seriously affect the strength of the weld. Try to avoid burning cavities, as any slag deposited in such cavities will be difficult to remove.

#### 4. Bead edge defects

Bead edge irregularities can occur if current output is too high. Bead edge faults may also occur at correct current output if the arc is too long or if the electrode movement is incorrect. When welding upwards on a vertical plane and using a weaving movement, the electrode should be momentarily held still at each side of the bead to obtain good penetration and avoid edge defects. Edge faults may act as fracture indicators in the welded connections.

#### 5. Pores

Pores in the weld may be due to moisture content in the electrode coating, especially when welding with basic electrodes. Pores in the weld may also arise if the base material to be welded is wet or damp. A porous weld will have reduced strength properties.

#### 6. Heat cracks

Heat cracks may appear during or just after the cooling off period. There are two main causes:

- Impurities in the base material which have a tendency to segregate and may form a layer in the middle of the weld.
- Tension across the weld can cause heat cracks even if the base material does not segregate in the weld.

## **METAL IDENTIFICATION**

## A. SPARK TEST

This test may be carried out in the ship's workshop and is very useful for identifying the type of steel and determining its approximate carbon content.

Hold a sample lightly against the grindstone and note the shape, color and length of the sparks. Unalloyed and low-alloyed steels are difficult to tell apart, but when tested together it is comparatively easy to see the difference.

MILD STEEL		The sparks separate at the end into several small sparks (leaf shaped). Some sparks are short.
MANGANESE STEEL		The sparks split up and end in stars.
HIGH-SPEED STEEL		Weak red sparks, with forked ends.
STAINLESS STEEL		Bright yellow sparks with pointed ends.
CAST IRON		Weak red spraks, ending in manypronged yellow stars.
MONEL METAL	×	Weak red sparks, quickly extinguished.

## **B. FILING TEST:**

Type of steal		<b>Resistance</b> to file
Low-carbon steel (mild stee	I)	No resistance, the file bites into the metal
Medium-carbon steel		Little resistance, the file bites into the metal, but the pressure has to be increased
High-alloy steel		Medium resistance. The file does not bite into the metal and the pressure has to be increased
High-carbon steel		High resistance. The metal can be filed, but with difficulty
Tool steel		High resistance. The file leaves marks, but the metal is almost as hard as the file
Hardened tool steel		High resistance. The metal is harder than the file; the file does not grip
C. COLOR APPEARANCES:		
Mild, Carbon Steel	-	Dark gray or rusty
Stainless steel	-	Shiny silver gray if polished
Cast iron	-	Dark gray or rusty
Aluminum	-	very light gray
Lead and white metal	-	white to gray, smooth velvety surface

- Copper red brown to green
- Brass and Bronze yellow brown or green brown
# **ELECTRODES RANGE AND ITS APPLICATION.**

- GPO An all-around electrode of organic rutile type for easy welding of unalloyed steel. Electrode sizes are 2.5, 3.2, 4.0, 5.0 mm respectively.
- **GPR** GPR is a heavily coated rutile type of electrode for welding unalloyed steel in all positions. Specially suitable for welding in flat position.
- GPA A rutile type electrode for easy welding of unalloyed steel. Good welding characteristics in all positions and suitable for all types of weld.
- **HOP** HOP is a high-recovery electrode of rutile type for welding unalloyed steel in flat and horizontal vertical position.
- LH A reliable basic all-round electrode for welding unalloyed and low alloyed steel. Particularly suitable for welding in vertical-up position.
- LHV In the fastest electrode for vertical welding. For use in verticaldown position.
- LHT LHT is a heavily coated basic electrode for welding low alloy steels and cast steels which are subject to high working temperatures, up to 550 degree Celsius. Used for boiler plates and tubes.
- **TENSILE** A high alloy chrome-nickel-manganese electrode with austenitic-ferritic structure for welding of various steel alloys. Excellent for building up worn rocker arms and pushrods.
- **IMPACT** Unitor Impact is a special electrode for repairing and building up exhaust valves.
- **NIFE** An electrode for "cold welding" of cast iron in all positions. Also suitable for malleable castings and welding cast iron to steel and copper alloys. Good binding to oily cast iron. Welding in all positions.
- NICKEL A universal electrode for "cold welding" of different types of cast iron. High crack resistancy and good fusion. Suitable for joining cast iron to steel, copper, alloys and stainless steel. Good binding to sulphurous cast iron and oily cast iron.
- **TINBRO** A bronze electrode for welding bronze, copper and brass, and for joining these metals to steel, cast iron and nickel alloys. Suitable for building-up work.
- ALBRONZE A bronze electrode for building-up and joining copper, bronze, aluminumbronze, brass, and welding these materials to steel and cast iron.
- ALUMIN An electrode for welding sea-water resistant rolled, drawn and cast aluminum in thicknesses over 2 mm.

#### **Gouging Technique**

1. Hold the electrode vertically and press lightly against the workpiece. The arc will strike after a few seconds.

- 2. Hold the electrode at an angle of 15-20° to the workpiece.
- 3. Direction of travel.
- 4. Warning! Do not cut dow

Do not cut down into the workpiece. Should this happen inadvertently, move the electrode back and lower to the correct angle.



UNITOR CH-2 electrode for chamfering and forming welding grooves in steel, stainless steel, cast iron, copper, copper alloys, aluminium and aluminium alloys, or opening up cracks to be welded, and for removing old welding beads.

5. Work downwards when cutting into a vertical surface,

6. If a deeper groove is required, proceed as in this sketch.



**Forehand welding** 







Vertical backhand welding

An exccellent stimulant beverages for a person suffering from shock is

A. Medicinal brandy B. Hot coffee C. Warm water D. Cold water

The allignment of coupling faces can be checked:

- A. Inserting a feeler gauge between the coupling faces at various points around the circumference
- B. Using an inside micrometer
- C. Inserting a thermocouple
- D. Rotating and measuring to nearest permanent fitting

The pressure remaining constant a rise in temperature would cause a liquid to:

A. Condense B. Contract C. Vaporize D. Expand

If the buoyant force on a ship's hull is equal to or greater than the displacement tonnage, the ship will \_\_\_\_\_\_.

- A. Sink
- B. Require ballast D. Float

The annealing of a cutting bit is usually done by what means?

- A. Cooling of the cutting bit C. Heating of the cutting bit from the grinder
- B. None D. At the factory before you receive it

The proper treatment for shock is:

- A. Raise the head C. Keep the body cool
- B. Give the victim warm liquids
- D. Raise the feet

C. Be down by the head

If liquid freon should come in contact with your skin, you should:

- A. Wash with sterile mineral oil C. Treat it like any burn
- B. Wash with salt and water **D.** Treat it like frostbite

What is the freezing point on the Centigrade thermometer?

A. 15 degrees B. 32 degrees C. 0 degrees D. 30 degrees

If you have to abandon ship in a life raft, your course of action should be to \_\_\_\_\_

- A. get a majority opinion
- B. remain in the vicinity of the sinking vessel
- C. head for the closest land
- D. head for the closest sea lanes

The tool to use in checking a workpiece mounted in a four-jaw chuck to see if it is accurately centered is a:

A. surface gauge B. dial indicator C. center gauge D. micrometer

While you are fighting a fire in a smoke-filled compartment, one of your shipmates falls and suffers severe laceration and ceases breathing. Your first response is to:

- A. treat for shock C. remove him from the compartment
- B. control the bleeding D. begin artificial respiration



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# SCHEMATIC DRAWING OF PISTON AND PISTON ROD

- A. Piston ring, right
- B. Piston ring, opposite
- C. Piston crown
- D. Cooling oil pipe
- E. Piston rod
- F. O-ring

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4.0

- G. O-ring
- H. Piston Skirt
- I. Lock nut
- J. Locking

- K. Nut
- L. Washer
- M. Stud
- O. Screw
- P. Lock washer
- Q. Screw
- R. Locking wire
- S. Lock washer
- T. Screw
- U. Shim

#### Part Description of B & W Piston and Piston Rod



STARTING VALVE - B & W Engine



SCHEMATIC DRAWING OF CONNECTING ROD AND FITTINGS

019	Discharge pipe	343	Crankpin bearing shell in 2/2
020	Split pin	355	Crankpin bearing cap
032	Nut	402	Crosshead bearing cap
115	Stud	414	Guide pipe
127	Guide shoe	392	Nut
139	Lock washer	402	Crosshead bearing cap
140	Stop screw	414	Guide pipe
152	Screw	426	Nut
164	Locking plate	438	Locking plate
176	Thrust piece	451	Stud
223	Distance piece	463	Shims, please state thickness
235	Bracket		0.25-0.50mm
247	Plug	475	Guide pin
259	Guide pin	<b>499</b>	Stud
260	Stud	509	Guide pin
284	Crosshead	510	Connecting rod
296	Crankpin bearing shell in 2/2	522	Locking plate
318	Screw	514	Plug
331	Disc	524	Plug

## Parts of B & W Connecting Rod and Fittings:



#### Parts:

- A. Top Scraper ring
- B. Cover-Pack Sealing ring
- C. O-ring
- D. Guide pin
- E. Scraper ring

- F. Stuffing housing
- G. Spring
- H. Screw, washer
- I. Flange

# PISTON ROD STUFFING BOX



FUEL INJECTOR VALVES

ARRANGEMENT OF STAYBOLTS ME B & W S70 MC



END CHOCK BOLTS (B & W)



**CRANKSHAFT** 



CYLINDER LINER



BEDPLATE



FRONT VIEW OF SCOTH BOILER



SIDE VIEW OF SCOTH BOILER



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1. 1. **1. 1. 1. 1. 1. 1. 1. 1. 1.** 

SIDEVIEW OF B & W STRAIGHT TUBE, CROSS DRUM WATER TUBE BOILER – SECTIONAL HEADER



FRONT VIEW OF B & W STRAIGHT TUBE, CROSS DRUM WATER BOILER



SCHEMATIC DIAGRAM OF MARINE BOILER



**STERN TUBE AND PROPELLER SHAFT** 





Two STroke Cycle, Hydraulic, Supercharged, Superlong Stroke, 20590 BHP. In Line Engine CROSS-SECTIONAL VIEW B & W S70 MC/MCE



SCHEMATIC DIAGRAM OF STEAM TO WATER CYCLE

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TWO-STAGE STEAM CONDENSER



**KINGSBURY THRUST BEARING** 



<u>ب عار الم</u>

Fortistial

1280.51

#### SCOOP TYPE MAIN CONDENSER

್ ಕ್ರೌತ್ರಮಕ್ಕೊಡುಗಾರ್ ಕರಗಾಗಿ ಕ್ರೌಷ್ಟವಾಗಿ ಕಾರ್ಯಕ್ರಮ ಸ್ಪಾರ್ ಸ್ಪ್ರೇಶ್ ಕ್ರೌಸ್ ಪ್ರಸ್ಥೆಕ್ಷಣೆ ಸ್ಪಾರ್ಗ್ ಎಂದು ಸ್ಥಾನಿಗಳು ಸ ಸ್ವಾನ್ಯ ಸ್ಥಾನಕ್ಕಡೆಯಾರ್ ಕರ್ಶಗಾಗಿ ಕ್ರೌಷ್ಟವಾಗಿ ಕಾರ್ಯಕ್ರಮ ಸ್ಪಾರ್ ಸ್ಥಾನಗಳು ಕ್ರೌಸ್ ಪ್ರಾಣಿಕ್ರಮ ಸ್ಥಾನಕ್ಕೆ ಸ್ಥಾನಕ್ಕೆ ಸಹಸಾ

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シークション 大学学校 一般をつかった かいしょう しょうし

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## **TWO-STAGE AIR EJECTOR SYSTEM**



**FRESH WATER GENERATOR (ATLAS)** 





FOUR STAGE FLOW- CLOSED FEEDWATER HEATER



# FLAP (CLACK) VALVE

#### **BUTTERFLY VALVE**

419







DIESEL ENGINE TIMING DIAGRAM (Pressure Charged and Intercooled)

B.H.P. = 131. Cylinder diameter, 10.25 in. (260.5 mm.), (5 cylinders) Stroke 14.5 in. (368 mm.) Revolutions = 600 Firing sequence, 1, 3, 5, 4, 2 Starting air valve opens, 10° B.T.C. Starting air valve closes, 61° B.B.C.  $\}$  Open for 71° Fuel injection starts, 17° B.T.C. Pressure, 3,000 lb. Inlet valve opens, 80° B.T.C. Inlet valve closes, 35° A.B.C.  $\}$  Open for 295° Exhaust valve opens, 45° B.B.C. Exhaust valve closes, 60° A.T.C.  $\}$  Open for 285° Scavenge period= 80° + 60° = 140° Inlet valve open = 80° + 180° + 35° = 295° Exhaust valve open = 45° + 180° + 60° = 285°



DIESEL ENGINE TIMING DIAGRAM (Normal Aspirated)

B.H.P. = 68. Cylinder diameter, 10 1/4 in. (260.5 mm.), (5 cylinders) Stroke 14.5 in. (368 mm.) Revolutions = 600 Firing sequence, 1, 3, 5, 4, 2 Starting air valve opens, 10° B.T.C. Starting air valve closes, 61° B.B.C. Open for 71° Fuel injection starts, 16° B.T.C. Pressure, 3,000 lb. Inlet valve opens, 5° B.T.C. Inlet valve closes, 25° A.B.C. Open for 295° Exhaust valve opens, 40° B.B.C. Exhaust valve closes, 15° A.T.C. Open for 285° Overlapped period inlet and exhaust = 5° - 15° = 20° Air admission period = 5° + 180° + 25° = 210° Exhaust period = 40° + 180° + 15° = 235°





## **GENERAL CONSTRUCTION AND OPERATION OF A BBC TURBOCHARGER**

In exhaust-gas turbocharging, the energy in the exhaust gases from the engine (diesel or gas) is used to compress the air led to the engine, resulting in increased power output.

In the VTR turbocharger, exhaust gas from the engine flows through the gas inlet casing (1), and expands in the nozzle ring (2). It imparts energy to the blades of the turbine rotor (3), and then passes via gas outlet casing (4) along an exhaust pipe to the atmosphere.

The air required by the engine is drawn through a suction pipe or combined filter/ silencer (5) to the compress (6). It then flows through the diffuser (7) and finally leaves the turbocharger via the pressure pipe of the compressor casing (8).

A partition (9) with heat insulating interspace separates the air chamber from the gas chamber.

Sealing air for the labyrinth glands of the turbine rotor is obtained from the compressor through passage X. This prevents exhaust gases from entering the balance chamber Z or the bearing housing.

Passage Z allows the pressures in the bearing space to be balanced and prevents loss of oil.

The rotor runs in spring-mounted rolling-contact bearings, which are readily accessible at both ends of the rotor. Each bearing has its own lubricating and oil cooling system.



## DRAWING

#### FOURTH ENGINEER

#### EXERCISE

1988-1992

- 1. Draw a longitudinal section of the piston of a four-cycle diesel engine. Indicate and label the following parts: Compression rings,Oil or Scraper rings an Wrist pin.
- 2. Draw a sectional view of a gear type of rotary pump. Indicate and label the parts and show with arrow the direction of flow of the liquid.
- 3. Sketch a cross-sectional view of a cross-head type piston and level its parts.
- 4. Sketch the four different types of piston ring cut and identify each type.
- 5. Sketch the operational flow of an oily bilge water separator.
- 6. Sketch a cross-sectional view of a trunk type piston assembly and level its parts.
- 7. Sketch the different welding symbols for the following:
  - а. fillet weld f. surfacing weld b. plua or slot welding backing weld or back g. double vee welding flare vee bevel groove C. h. d. spot weld flange edge weld i. flash or upset weld melt through weld (one side) i. е.

## **THIRD ENGINEER – EXERCISES**

- 1. Draw a longitudinal section of a steam driver air educator. Indicate and label the following parts: Steam inlet, Steam nozzle, Air inlet and Air and steam outlet.
- 2. Draw a side view of a lubricating oil cooler of the main diesel engine. Indicate and label the following parts: Cooling water inlet, Cooling water outlet, Tube nest, Oil inlet, Oil outlet, Zinc anodes and End covers.
- 3. Sketch a cross-sectional view of a gear pump showing the direction of rotation and level its parts.
- 4. Sketch a cross-sectional view of a fuel valve-solid injection and level its parts.
- 5. Sketch the operational flow of an oily bilge water separator.
- 6. Sketch the different welding symbols for the following: Single vee welding; Bevel groove weld; Flare bevel groove; Flange edge weld; Spot weld; Fillet weld; Square groove welding; Surfacing weld; Flange corner weld and seam weld.
- 7. Draw a cross-sectional view of a Diesel water cooled exhaust valve cage with valve. Label parts.

8. Draw a cross-sectional view of a lub-oil cooler, shell and tube type. Show direction of operational flow of oil and water by arrows. Label parts.

#### SECOND/CHIEF - EXERCISES

- 1. Draw the side view of fire-tube scotch boiler. Show and label the following parts: Safety valves, main steam stop valve, fire tubes, stay rods, furnace and combustion chamber, gauge glass and oil burner.
- 2. Draw the longitudinal section of a stern tube showing and labeling the following parts: Tailshaft, stuffing box and gland, packing and tailshaft bearings.
- 3. Draw a sectional view of a 2-stage Air Compressor showing the pistons in tandem. Label the characteristic parts.
- 4. Draw a longitudinal section view of a Fire Tube Boiler and label its characteristic parts.
- 5. Sketch a Shell Type Condenser and label its parts.
- 6. Sketch a Cross-Sectional view of a Centrifugal Pump showing their parts and direction of rotation at normal operation.
- 7. Draw a side view of steam and water drum of an auxiliary water tube boiler. Indicate and label the following mountings: Safety vave, Air cock, Steam stop valve, Main feed and check valves and Auxiliary feed and check valves.
- 8. Draw a longitudinal section of a tailshaft with the following parts labeled: Tapered portion with keyway, Coupling flange and Continuous bronze liner.
- 9. Sketch a cross-sectional view of an "atlas" fresh water generator (evaporator) and level its parts.
- 10. Sketch a cross-sectional view of a sulzer-valveless cylinder heads and level its parts.
- 11. Sketch the operational flow of an oily bilge water separator.
- 12. Sketch a lube oil cooler shaft type and label its parts.
- 13. Sketch the different welding symbols for the following: Flash or upset; Melt through weld; "U" groove weld; Double vee welding; Fillet weld; Flange edge weld; Plug or slot welding; Surfacing weld; Bevel groove weld; Flare vee bevel groove.
- 14. Draw a piston of a 2-stage air compressor, vertical-tandem. Label 1st stage and 2nd stage.
- 15. Draw a cross-sectional view of an oily water separator for bilge oil and water. Show direction of operational flow of oil and water to outlets, and also oily water inlet by arrows.

## **CHIEF ENGINEER – EXERCISES**

- 1. Draw a side view of a water tube boiler with straight tubes and a cross drum. Locate and label the following major parts: Generating tubes; Water and steam drum; Uptake; Furnace; Forced draft fan; Gauge glass; Steam stop value; Safety valve.
- 2. Draw a longitudinal section of a stern tube indicating the following parts: Inner bearing (lignum vitae); Outer bearing (lignum vitae) and Sea water sealing arrangement (stuffing box).
- 3. Sketch a cross-sectional view of the main reduction gear of a steam turbine main propulsion showing the high and low pinion gears indicating the direction of rotation.
- 4. Sketch and indicate the parts of a "hollow crankshaft" and a solid crankshaft.
- 5. Sketch the operational flow of an oily bilge water separator.
- 6. Sketch a cross-sectional view of a valveless cylinder head for sulzer engine and label its parts.
- 7. Sketch the different welding symbols for the following: Double vee welding; Square groove welding; Backing weld or back; Surfacing weld; Flange corner weld; Seam weld; "J" groove weld; Single vee weld; Spot weld and Plug slot welding.
- 8. Draw a piston of a 3-stage air compressor Vertical-tandem. Label 1st stage, 2nd and 3rd stage.
- 9. Draw a cross-sectional view of an oily water separator for bilge oil and water. Show direction of operational flow of oil and water to outlets, and also oil water inlet by arrows.



AIR EJECTOR
# PART VII

**SECTION I** 

# SAFETY OF LIFE AT SEA

- FIREFIGHTING
- FIRST AID
- SURVIVAL AT SEA
- LIFEBOAT HANDLING

SECTION II

# **OIL TANKER SAFETY**

SECTION III INERT GAS SYSTEM

# SAFETY OF LIFE AT SEA

## FIREFIGHTING

## I. THEORY OF COMBUSTION

**Oxidation** is a chemical process in which a substance combines with oxygen. During this process, energy is given off, usually in the form of heat. Rusting of iron and rotting of wood are common examples of slow oxidation.

Fire, or combustion, is **rapid** oxidation; the burning substance combines with oxygen at a very high rate. Energy is given off in the form of heat and light. Because this energy production is so rapid, we can feel the heat and see the light as flames

#### Burning

**Burning** is rapid oxidation of millions of vapour molecules. During this process vapour molecules break apart into individual atoms and recombine with oxygen to form new molecules. Energy is released as heat and light during the breaking recombining process.

The radiant heat released from the oxidation process travels in all directions and some of it travels back to the seat of the fire or the burning fuel.

The heat that is radiating back to the fuel is termed as Radiation Feed Back and this plays a very important role to keep the fire going. This heat releases more vapour and raises the vapour to its ignition temperature. At the same time air travels in the area where vapour and flames meet. So the newly formed vapour begins to burn resulting in increase of flames.

## The Chain Reaction

The burning vapour produces heat which radiates back to release and ignite more vapour – that is the start of the chain reaction. The additional vapour burns producing more heat and as mentioned earlier releases and ignites still more vapour. This continues as long as there is plenty of fuel and oxygen. The vapour released from fuel would reach a maximum rate after a certain time and would produce a steady rate of burning. This usually

continues till most of the fuel has been consumed. At this stage, there is less vapour to oxidize – so less heat is produced. The whole process starts to break down. A solid fuel would leave an ash residue and smolder for some time. Liquid fuel burns up completely.



# II. SKETCH OF A FIRE TRIANGLE

THE TRIANGLE OF COMBUSTION.



a. Concept of Fire Triangle – One way of discussing combustion is in terms of the triangle of combustion. (Refer to sketch No. 1 above). It is considered that for combustion to occur three factors are necessary: heat, oxygen and a combustible substance or fuel. Combustion will continue as long as three factors are present. Removal of one of them leads to the collapse of the triangle and combustion stops.

b. **Concept of "Fire Tetrahedron"** – Modern combustion theory now depicts combustion as a tetrahedron. The 'fire triangle', however, still accurately describes the ignition process. A fourth factor is necessary for fire to sustain itself and increase in size. This factor is the chemical chain reaction between the fuel and oxidizing agent. As process of combustion continues, more fuel molecules will break down, enter into the chain reaction, reach their ignition point, begin to burn, cause a temperature rise, draw additional oxygen and continue the chain reaction.

# Flash Point

Flash point is the lowest temperature at which there is sufficient vaporization of the substance to produce a vapour which will flash momentarily when a flame is applied.

# **III. CAUSES OF FIRE ON CARGO HOLDS AND DECK**

- 1. Smoking in the cargo holds or on deck.
- 2. Many materials that are carried as cargo are subjected to spontaneous ignition. Combustion occurs through the interaction of two or more substances, one of which is often air or water. Some cargoes that present a danger of fire through spontaneous ignition are charcoal, cod-liver oil, corn meal feed, fish meal, linseed oil, oiled and varnished fabrics and red skin peanuts.

# Some types of combustible cargo are

- a. Chlorine, which catches fire in the presence of organic materials.
- b. Metal powders such as: magnesium, titanium, calcium and zirconium. These oxidise rapidly in the presence of air and moisture.

# **Causes of Fire in Accommodation**

- a. Smoking is the main causes of a fire in the accommodation.
- b. Smoking in bed.
- c. Smoking under the influence of alcohol.
- d. Overloading of electrical appliances/wiring.
- e. Jury-rigging to operate many electrical equipment from one outlet socket.

# Causes of Fire in the Engine Room

- a. Vapours given off when fuel is transferred under pressure.
- b. Overfilling of tanks and consequent overflow of oil.
- c. Leaks in the transfer system of oils.
- d. Fire in the bilge area due to vapour produced by excess accumulation of oil underneath.
- e. High temperature sparks and slags are thrown off when gas or arc welding is carried out.
- f. Gas cutting is even more hazardous as molten metal is removed in the process and this can cause stray fires.

# Causes of Fire in Boiler Room

- a. Improperly maintained oil burner tips and burning equipment.
- b. Incomplete combustion of fuel in the boiler. If this accumulates it could eventually ignite and cause a fire.

# **Causes of Fire in Storage and Work Spaces**

- a. Examples of such spaces are paint and rope lockers, carpenter shops etc all of which contain large amounts of flammable materials.
- b. Careless disposal of storage material can lead to spontaneous ignition.

Note: The following is an explanation for spontaneous ignition.

c. A rag soaked with vegetable oil or paint discharged together with other bulky material, may begin to oxidise – i.e. react chemically with the oxygen in the surrounding warm air. Oxidation produces heat. Heat causes the remaining oil to oxidise faster and produce more heat, and if this heat is not conducted away, the temperature raises gradually to the point at which the rag will burst into

1

flames. This is known as spontaneous ignition.

# Causes of Fire due to Electrical Machinery/Wiring

- a. When electrical equipment wears out, misused or poorly wired it becomes a source of ignition.
- b. Short circuiting.
- c. Over sized fuse wires.
- d. Defective wiring.
- e. Jury-rigging" using many electrical component from one outlet socket.
- f. On weather deck, high intensity flood lights have canvas or plastic covers. If this covers remains in place when the lights are "on" fire can occur.
- g. Improperly protected cargo light bulbs.
- h. Improper use of hand lamps.
- i. Faulty electric motors.
- j. Motor winding becoming short circuited or grounded.
- k. Overheating of motor bearings due to lack of lubrication.
- I. Overloading of motor causes the motor to overheat.
- m. Hydrogen accumulation in the storage batteries compartment.

# Causes of Fire in the Galley

- a. Open flames, fuel lines.
- b. Rubbish and grease accumulation.
- c. Clothing, rags, towels etc may be ignited through carelessness.
- d. Not using range battons.
- f. Deep fryers being shifted due to ship's movement.
- g. Leaving galley unattended.

# **BASIC WAYS OF PREVENTING FIRE**

## **Elements of Effective Fire Prevention Programme**

- a. Training
- b. Maintenance and use of portable extinguishers
- c. Good housekeeping
- d. Elimination and control of ignition sources
- e. Safeworking procedures
- f. Periodic inspections
- g. Preventive maintenance and repair

a. *Training Curriculum.* The training should be focused primarily on the prevention of fires. A secondary goal should be to teach the crew how to isolate and then extinguish small fires.

b. *Maintenance and Use of Portable Extinguishers*. Portable fire extinguishers can control a fairly large fire if they are used promptly and properly. Through training, crewmen should develop confidence in these appliances. They should check to see that fire extinguishers are in their proper places, in good condition and ready for use. Additionally, every crew member should be absolutely certain about the proper use of the different types of extinguishers.

c. **Good Housekeeping.** Basically this means **cleanliness**. Badly kept storage spaces, engine room etc., become a "breeding ground" for fire. However, from the fire prevention standpoint it means the elimination of sources of fuel for fire. Almost every one of them can be eliminated with a minimum of effort. Some are listed below.

- 1. Cleaning rags and waste should be stored in covered metal containers.
- 2. Accumulation of oily rags should be placed in covered metal containers and discarded as soon as possible.
- 3. Accumulations of packaging materials should be disposed of immediately.
- 4. Dunnage should be stored in the proper area only. Wood chips or shavings should be disposed of properly.
- 5. Accumulations of flammables in crew or passenger quarters should be avoided.
- 6. Oil-soaked clothing should not be worn by crew men. They should be kept in crew lockers.
- 7. Paints, varnish etc., should be stored in the paint locker when not in use even overnight.
- 8. Leaks in produce, fuel-oil or lubricating oil piping and spilled oil or grease should be cleaned up. Oil in bilges or on tank tops and floor plates should be removed without delay.
- 9. Kerosene and solvents should be stored in appropriate containers.

d. *Elimination and Control Ignition Sources*. Cleanliness can eliminate sources of shipboard fires. Good training, a good attitude and alertness can assist immeasurably in eliminating another necessary ingredient of fires, namely, the source of heat or ignition.

# These can be eliminated by:

- 1. Not smoking in restricted areas: discarding ashes, butts and matches carefully; using only safety matches on tanks vessels; closely observing shore work men in holds.
- 2. Not overloading electrical circuits; protecting circuits with proper fuses or circuit breakers; proper maintenance and repair of electrical equipment; proper wiring.
- 3. Keeping flammable materials clear of steam pipes, light bulbs and other sources of ignition.
- 4. Observing all precautions when welding or burning.
- 5. Using approved flashlights and portable lights and nonsparkling tools on tank vessels.
- 6. Not using electricals where a fire hazard may exist.

# e. Safe Working Procedures.

# 1. Working in confined spaces:

Knowledge of the gases present in ballast, fuel oil and fresh water tanks and their effects on human beings. Understand the signs and instructions relating to confined spaces. Provide sufficient lighting and ventilation. Seek permission to enter confined spaces from responsible officer in charge. Keep a person in constant attendance at the entrance to such spaces. Use approved electrical appliances.

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# 2. Performing hot work:

Seek permission from the supervising officer. Check the workplace for combustible materials, fuel oil and fuel oil vent pipes. Find out the type of portable fire extinguisher at the workplace. Check on the otherside for sludge, oily residue, combustible materials. Wear shipping and welding goggles.

## 3. Working on oil pipes:

Seek permission before starting the work on oil pipes. Insolate the pipe/ pipes by closing appropriate valves. Report oil spillage to the supervising officer. Avoid the use of cutting torch in place of spanners. Install drip-trays and provide adequate ventilation.

# 4. Working on machines:

Switch off and isolate the machine concerned. Close the appropriate valves. Seek permission before commencing the work. Replace all guards and other safety devices after completion of work.

5. Working on propulsion engine and propeller shaft:

Seek permission from the senior engineer before starting the work. Engage the turning gear and lock all controls. Lock the propeller shaft. Before turning the shaft warn other workers, clear the shaft of tools, ropes etc, check for workers inside the crankcase.

# 6. Working on boilers, steam machinery and steam pipes:

Allow boilers to cool before commencing work. Isolate the particular boiler in a multiple-boiler arrangement. Provide ventilation and lighting for furnace uptake. Do not set safety valve without the permission of authorised personnel. Isolate and drain steam machinery and steam pipes.

## 7. Working on refrigeration machinery:

Know the hazards of  $CO_2$ , freon, ammonia. Do not use heat – producing tools or equipment on refrigeration machinery. Provide adequate ventilation. Isolate the system or machinery.

## 8. Working at heights:

Keep means of access free from obstructions. Check and report defect in staging and scaffolding. Wear safety belt and anchor it to a lifeline. Keep tools in suitable tool boxes.

# 9. On completion of work:

Clean the workplace. Dispose of oil rags and combustible materials. Prevent obstruction of passage ways and means of escape by dismantling parts of scaffolding. Fence or cover all openings.

f. **Periodic Inspections.** Inspection is one of the most important parts of the shipboard fire prevention program. Its purpose is to find and eliminate fuels and ignition sources that could cause fires. Every crewmen should be an informal inspector, checking for fire hazards at all times, on and off duty. In addition, the master, chief officer, chief engineer and second engineer should make a joint formal inspection of the entire vessel

at least once each week. This should be a complete inspection, from bow to stern and bilge to bridge. The formal inspection should be systematic; a check list should be used to assure that no area is overlooked.

g. **Preventive Maintenance and Repair.** The basic elements of a preventive maintenance and repair program are lubrication and care, testing and inspection, repair and replacement and record keeping. The first three should be performed according to definite schedules that depends on the equipment in question. For example, some equipment might be serviced at various intervals during each watch. Other equipment might require maintenance once each watch, or daily or weekly, on up to annually or at even longer intervals. The manufacturer's manual is the best guide for establishing the schedules for periodic maintenance procedures.

h. **Cargo Operation.** Loading and unloading operations should be closely supervised by ship's deck officers. Leaking cargo should be rejected immediately; any liquid that has leaked into the hold should be removed or otherwise rendered harmless. (Remember, a vegetable oil that leaks onto baled cotton, rags or other fibrous material could cause spontaneous ignition.) When cargo is handled, it should not be allowed to bump heavily in the hold so that the packaging is damaged. Such damage could go undetected and cause serious problems after the ship leaves port. Even in home ports, loading and unloading should be carefully observed. In other ports, especially foreign, vigilance and close monitoring are of great importance.

i. **Transfer of fuel.** When fuel is taken aboard, it is stored in doubled-bottom to deep tanks. If necessary the fuel is heated, and then it is pumped to the service tanks or settling tanks. From there, it moves to a gravity or day tank, or to a fuel oil service pump, from which it is pumped to the fuel oil burners or diesel engines.

During this transfer of fuel under pressure, the liquid fuel itself is not a fire hazard if there are no mistakes. However, the fuel vapors that may be given off are very hazardous. Both the overfilling of fuel tanks and leaks in the transfer system can increase the danger of fire.

## V. CLASSIFICATION OF FIRES

I. CLASS "A" – These are fires involving solid materials normally of an organic nature (compounds of carbon), in which combustion generally occurs with the formation of glowing members.

Class "A" fires are the most common and the most effective extinguishing agent is generally water in the form of a jet or spray.

II. CLASS "B" - These are fires involving liquids or liquefiable solids.

The extinguishing agents suitable to this category of fire are water spray, foam, vaporising liquids, carbon dioxide and dry chemical powders.

III. CLASS "C" – These are fires involving gases or liquefied gases in the form of a liquid spillage, or a liquid spillage, or a liquid or gas leak, and these include methane,

propane, butane, etc.

Foam or dry chemical powder can be used to control fires involving shallow liquids spills. Water in the form of spray is generally used to cool the containers.

IV. CLASS "D" - These are fires involving metals.

Extinguishing agents containing water are ineffective, and even dangerous. Powdered graphite, powdered talc, soda ash, are normally suitable for this Class "D" fires. Special fusing powders have been developed for fires involving some metals.

*Electrical fires* : Any fire involving electrical equipment must, in fact, be a fire of Class A, B or D. The normal procedure in such circumstances is to cut off the electricity and use an extinguishing method appropriate to what is burning. Only when this cannot be done with certainty will special extinguishing agents be required. These include vaporising liquids, dry powders and carbon dioxide.

## VI. FIRE DRILL AND FIRE PATROL

Fire drills are carried out regularly on ships to ensure that the crew understand and are drilled in the duties assigned to them in the event of a fire or emergency. At fire drills each member of the crew shall be required to demonstrate his familiarity with the arrangements and facilities of the ship, his duties and any equipment he may be called upon to use. For this purpose, an outbreak of fire would be assumed to have occurred in some part of the ship and a mock attack made. (A seafarer upon joining a ship should get acquainted with the various alarm signals and his muster station at the earliest opportunity.)

Fire patrols with proper instructions have a part to play in fire prevention as well as early fire detection. They should have a good topographical knowledge of the ship, her fire-fighting appliances and their use, the fire-warning system and to be able to tackle an incipient fire. The patrols should have a check-list and take to their rounds systematically and when appropriate, e.g., upon ship leaving port especially where shore workers had performed some work on board.

# VII. METHODS OF EXTINGUISHING FIRES

Specific actions involved in extinguishing fire are as follows.

- a. **Cooling** This reduces the temperature of the fuel to below its ignition temperature. This is a direct attack on the heat side of the tetrahedron.
- b. Smothering This separates the fuel from the oxygen.
- c. Oxygen dilution This reduces the amount of available oxygen to a level below that is needed to sustain combustion. This is an attack on the oxygen side of the fire tetrahedron.

d. Breaking chain reaction – This disrupts the chemical process that sustains the fire.

## Boundary Cooling, Boundary Sealing

Whilst an attack is being made on the fire, the adjacent areas must be inspected for signs of heat spread and if necessary boundary cooling or boundary starvation should be commenced.

By successfully confining a fire to a single compartment or group of compartments, its size and intensity will be checked. The experienced fire–fighter would probably say that confining a fire within its bounds is as important as attempting to put it out, as a fire so confined is definitely under control.

Boundary Cooling. Intense heat radiated from a fire in a compartment will raise the materials nearby or adjacent to the compartment to ignition temperature. Boundary cooling, achieved by spraying water on the compartment walls/bulkheads or on the materials, should be done to prevent this.

Boundary sealing/starvation. Boundary sealing is the exclusion of air by shutting all openings in the compartment and boundary starvation is the removal of potential fuel (carpet, wardrobes, oil) that are lying nearby or adjacent to the compartment on fire.

#### **VIII. FIRE EXTINGUISHING MEDIA**

- 1. Water
- 2. Foam
- 3. Carbon dioxide
- 4. Dry chemicals
- 5. Dry powders
- 6. Vapourising liquids.

**Extinguishing Capabilities of Water**. Water is primarily a cooling agent. It absorbs heat and cools burning materials more effectively than any other of the commonly used extinguishing agents. It is most effective when it absorbs enough heat to raise its temperature to 100°C. At that temperature water absorbs the latent heat of vaporisation and moves the absorbed heat away from the burning material. This quickly reduces the temperature of the burning material to below its ignition temperature, and the fire goes out.

Water has an important secondary effect ie when it turns to steam, it expands in volume and surrounds the fire and displace the air. Thus the oxygen supply to the fire is cut off.

Thus water provides a cooling as well as smothering effect.

Advantages – It is available in large quantity. This can be easily handled and transported to the scene of fire.

#### Disadvantages – It is a conductor of electricity. So it should not be used on electrical

equipment. It can cause damage to cargo and machinery. It can cause stability problem when used in large quantities.

*Extinguishing Capabilities of Foam.* Foam is a blanket of bubbles that extinguishes fire mainly be smothering.

Foam available for fire fighting are either chemical foam or mechanical foam.

Chemical foam is formed by mixing an alkali (usually sodium bicarbonate) with an acid (usually aluminium sulphate) in water.

Mechanical foam is produced by mixing a foam concentrate with water to produce a foam solution. The bubbles are formed by turbulent mixing of water, foam solution and air.

The foam thus produced forms a blanket on the surface of flamming liquid, including oils. The blanket prevents flammable vapours from leaving the surface and prevents oxygen from reaching the fumes, thus making it difficult for the fire to exist. The water in the foam also has a cooling effect, which makes foam suitable for Class A fire also.

- Advantages Foam can be made with any type of water except the water that is contaminated with oil. Foam concentrates are not heavy. Foam does not breakdown readily.
- Disadvantages It should be not used on electrical equipment. It can damage the cargo and machinery. After a fire, it is very tedious to clean the foam.

**Extinguishing Capabilities of Carbon Dioxide**. Carbon dioxide puts off fire mainly by smothering. It dilutes the air surrounding the fire until the oxygen content is too low to support combustion. Carbon dioxide has a very limited cooling effect. The  $CO_2$  concentration must be maintained until all fire is out.

- Advantages It will not damage delicate machinery or instruments. It is safe to use on to electrical machinery. It is non-corrosive. It leaves no residue.
- Disadvantages It is highly asphyxiating and slightly toxic. There is a danger of reignition if air is readmitted into the compartment too quickly.

*Extinguishing Capabilities of Dry Chemical*. It puts off the fire by cooling. This cooling takes place simply because the dry chemical is at a lower temperature than the burning material.

It puts off the fire by smothering. When dry chemical reacts with the heat and burning material, some CO, and water vapour are produced.

Advantages - It is suitable for use on electrical equipment. It is non-toxic. It is

non-corrosive.

Disadvantages – It will clog and become useless if it is allowed to become damp. It leaves a residue. It does not offer protection against reignition.

*Extinguishing Capabilities of Dry Powders*. Dry powders composed of graphite cools the fire and creates a heavy smoke that helps smother the fire.

Dry powders having sodium chloride base forms a crust on the metal and smothers the fire.

Dry powders having sodium carbonate forms a crust on the surface of burning sodium to smother the fire.

Advantages – It can control metal fires without any violent reaction.

*Extinguishing Capabilities of Vapourising Liquids.* These puts off the fire by breaking the chain reaction.

# IX. FIRE-FIGHTING APPLIANCES (THE MERCHANT SHIPPING SAFETY CONVENTION REGULATION, 1984)

#### Fire-fighting Appliances for Cargo Ship (1000 tons and above)

*Fire Pumps*. Cargo ships of 1000 tons upwards must have at least two fire pumps independently driven.

*Fire Hydrant.* The number and position of hydrants shall be such that at least 2 jets of water not emanating from the same hydrant, one of which shall be from a single length of hose, may reach any part of the ship.

*Fire Hoses.* In cargo ships of 1000 tons and upwards the nuber of fire hoses to be provided shall be one for each 30m length of the ship and one spare but in no case less than five in all. The total length of the hoses provided shall not be less than 60% of the length of the ship. This number does not include any hoses required in any machinery space.

Fire hoses provided in compliance with these regulations shall not be used for any purpose other than for extinguishing fires or testing the fire extinguishing apparatus at fire drills and surveys.

*Nozzle and coupling*. Each hose shall be provided with a nozzle and the necessary couplings. The standard nozzle shall be 12 mm, 16 mm, 19 mm or as near thereto as possible.

For accommodation and service spaces, a nozzle size greater than 12 mm need not

be used. All nozzles shall be of an approved dual purpose type (i.e. spray/jet type incorporating a shut off).

*Portable Fire Extinguishers.* The number of portable fire extinguishers shall not be less than 5 in a ship of 1000 tons and upwards.

In each space approved foam type fire extinguishers, each of at least 45 litres capacity or carbon dioxide extinguishers of at least 15 kg. capacity or dry powder extinguishers of at least 23 kg capacity, sufficient in number to enable foam or its equivalent to be directed on to any part of the fuel and lubricating oil pressure system, gearing and other fire hazards. In adddition, there shall be provided a sufficient number of portable foam extinguishers or equivalent which shall be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least 2 such extinguishers in each such space.

In the case of domestic boiler of less than 175 KW in cargo ships, there shall be a receptacle containing 0.3 m<sup>3</sup> of sand, sawdust impregnated with soda, or other approved dry material together with a scoop for its distribution. An approved portable extinguisher may be substituted as an alternative.

# X. FIXED INSTALLATION IN MACHINERY SPACE

In machinery spaces containing oil fired units shall be provided with any one of the following fixed fire extinguishing system:

- 1. Fixed Installation CO, or Halogenated hydrocarbon system.
- 2. A high expansion foam system.
- 3. A pressure water spraying system.

# Fireman's Outfit

A fireman's outfit shall consists of:

- 1. Protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer space shall be water resistant.
- 2. Boots and gloves of rubber or other electricity non-conducting material.
- 3. A rigid helmet providing effective protection against impact.
- 4. A rechargeable electric safety lamp (hand lantern) with a minimum burning period of 3 hours. It must be fitted with means for easy attachment to the user.
- 5. An axe with a short handle of wood or other well insulated material and its head shall have a pick as well as a cutting edge. A carrying belt should also be provided.

# Breathing Appratus

A breathing apparatus of an approved type which may be either:

1. A smoke helmet or smoke mask which shall be provided with a suitable air pump and a length of air hose sufficient to reach from the open deck well clear of hatch or door way, to any part of the holds or machinery spaces. An air hose of 36 m in length would be necessary. 2. A self contained compressed air operated breathing apparatus, the volume of air contained in the cylinders of which shall be at least 1200 litres, or other self contained breathing apparatus which shall be capable of functioning for at least 30 minutes. Two spare charges suitable for use with every apparatus provided shall be available on board but the total number of spare charges need not exceed eight. The number of spare charges so specified may be reduced by 50% if approved means provided with air free from contamination.

For each breathing apparatus a fire proof lifeline of sufficient length and strength shall be provided capable of being attached by means of a snap hook to the harness of the apparatus.

All ships shall carry at least 2 fireman's outfits, complying with the requirements.

# International Shore Connexion

- 1. Ships of 500 tons and upwards shall be provided with at least one International shore connexion, complying with the provisions.
- 2. Facilities shall be available enabing such a connexion to be used either side of the ship.

# XI. DETECTORS, EXTINGUISHERS & FIXED INSTALLATIONS

# **Fire Detectors**

Fire detectors work on different principles and are chosen depending on the nature of fire expected, covered area, atmosphere in the space, etc. They can be categorised as follows:

Heat Detectors. These detectors or sensors are usually of the bi-metallic type and operate under one of the following conditions –

- 1. At a fixed temperature
- 2. Due to the rate of rise of temperature
- 3. A combination of (a) and (b).

*Flame Detectors.*These are usually 'Infra Red' flame detectors working on the principle of flame radiation actuating a photo-electric cell which in turn actuates an alarm system.

Smoke Detectors. Since smoke could develop without the evolution of much heat or flame these detectors or sensors are very commonly used. They usually comprises of a photo-electric cell operating due to one of the following reasons –

- 1. Smoke obscuring a beam of light falling on the photo-electric cell.
- 2. Smoke scattering a light which is shielded from a photo-electric cell and making it fall on it.

3. A combination of (a) and (b).

*Combustion Gas Detectors.* These work on an ionization principle. The combustion gas produced due to a fire gives a different current stength relative to air ionization and this actuates an alarm.

#### Fire Mains System

In this system water is supplied to a fire main, which is a pipe carrying sea water, by. at least two independently powered pumps in the engine room and an alternative supply which is the "Emergency Fire Pumps" installed outside the machinery space.

The fire main has branches leading to all decks fitted with hydrants or valves so as to cover the entire ship. An isolating valve is fitted in the rising fire main, outside the machinery space so that in case of a burst in the line inside the engine room, water can still be supplied to the accomodation and deck by the emergency fire pump.

There are two basic layouts for this fire mains sytem. viz -

- 1. The Single Main System
- 2. The Horizontal Loop Main System

The single main system as the name implies consists of a single main running the length of the ship that is in the fore and aft direction. Branches, both vertical and horizontal, extend out from this to cover the various spaces.

The disadvantages of this type is that it cannot supply water beyond a point where a burst may have taken place.

The horizontal loop system comprises of two parallel fire lines, one running on each side, and joined at the furthest point fore and aft. Cross-connecting branch lines serve the various spaces and isolating valves are provided after the hydrants.

The advantage of this design is that in case of a burst, the effected part can be isolated and the system still used for the rest of the ship.

#### XII. PORTABLE EXTINGUISHERS

#### **Purpose of Providing Portable Extinguishers**

Portable extinguishers are provided to fight a fire at the very initial stages. An early detection and use of a correct type of fire extinguisher can put off the fire and thereby damages to property or loss of lives can be avoided.

However, it must be remembered that portable extinguishers have limited capacity and require a proper training in handling them. With the help of a portable extinguisher it is possible to deposit the extinguishing agent on the right spot from a distance.

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# Method of Checking Contents

All extinguishers must be so designed that it is possible to permit their suitability for operation to be verified at regular intervals. Extinguishers operated by means of a gas cartridge (usually containing carbon dioxide) can be opened up for inspection and the gas cartridge is normally checked by weighing to see if there is any loss of weight. Carbon dioxide and stored pressure extinguishers cannot be opened up for inspection; CO<sub>2</sub> extinguishers are checked by weighing and stored pressure extinguisher may be checked by:

- 1. weighing;
- 2. checking the internal pressure by an independent manometer;
- 3. a pressure gauge, if fitted.

Any pressure indicator should show when the pressure has fallen below the level for efficient operation and when recharging or replacement is necessary.

## Corrosion

With the water (gas cartridge) type of extinguisher, there is a risk of corrosion by electrolysis because of the different nature of the metals of the gas cartidge and the outer container. To combat this the outer container, unless it is made of stainless steel, must have all surfaces completely coated with specified materials. Corrosion inhibitors may also be added to the water in the outer container and also non-corrosive freezing point depressants and non-corrosive wetting agents, but none of these additives should produce toxic fumes.

## Hose and Nozzles

All extinguishers with a greater capacity than 3 kg or with a volume of more than 3 litres should be fitted with a hose and nozzle, the length of which should not be less than 80 per cent of that of the extinguisher body. The hose should not be under pressure until the extinguisher is operated and should be impervious to attack by the contents of the extinguishers. If nozzles are fitted with a protective cap, this must be of a design so that it is readily removed or fractured by the discharge of the contents.

## Marking of Extinguishers

All extinguishers conforming to the British Standards specifications are clearly marked with the following information:

- 1. method of operation;
- 2. description of contents;
- 3. year of manufacture;
- 4. testing pressure;
- 5. BS number.

In addition, instructions regarding recharging, checking of weight where appropriate,

temperature range, class of fire for which the extinguisher is rated, dangers, if any, etc., will be found on the extinguisher.

# Soda Acid Fire Extinguisher

To operate the extinguisher, the knob on the top of the spindle is given a sharp blow; this breaks bottle allowing acid to mix with the alkaline solution, thus promoting a chemical reaction. The pressure of the  $CO_2$  so formed accumulates in the chamber and ejects the contents. It has an internal pipe therefore keep the extinguisher in an upright position while operating.

Note: That no discharge will take place if this extinguisher is inverted.

Use. Soda-acid extinguishers are useful on carbonaceous fires, usually in accommodation, involving wood, paper and furnishings where the primary purpose is to reduce the temperature of the burning material without doing more damage to the surroundings than is necessary.

# CO, and Water Fire Extinguisher

To operate the extinguisher, remove the locking pin. Hold the distribution hose with one hand; hold the extinguisher with the other hand and at the same time squeeze the handles. The squeezing action will lift the valve from its seat and the  $CO_2$  liquid will flow through the internal pipe, to the short flexible or swivel hose. The liquid changes to a gas and is spread evenly over the burning surface, thus excluding the air.

Use. CO, extinguishers are useful on fires involving electrical machinery.

## Chemical Foam Fire Extinguisher.

Operating the extinguisher. First release the valve from its seat by turning the spindle on the cap. Then invert the extinguisher. Now the two solutions will mix and a chemical reaction between the liquids will eject the chemical foam through the nozzle. Aim the nozzle to a nearby obstruction so that the foam will gradually flow on to the surface of the burning oil.

Use. These are suitable for oil fires.

*Discharge time.* The minimum for which 6 m jet must be maintained is 30 seconds and the maximum period of complete discharge of the expellable foam is 90 seconds.

#### Mechanical Foam Extinguisher.

Operating the Extinguisher. Remove the safety guard and strike the knob on the plunger. This breaks the  $CO_2$  cartridge. The gas thus released mixes foam concentrate and water and expels them through the diptube and discharge tube. At the end of the discharge tube there is a foam making nozzle. Air entrains at this nozzle and foam is produced. The foam can now be directed to a nearby structure so that it flows gradually on to the surface

of burning liquid.

Use. This is suitable for oil fires.

# Dry Powder Extinguisher.

Operating the Extinguisher. To operate the extinguisher, first activate the  $CO_2$  cartridge breaker. This gas pressure expels the dry powder through discharge hose. Hold the nozzle end and squeeze grip on the nozzle to release the powder. Direct and aim the nozzle to the fire.

*Diptube.* The diptube is provided to give a violent motion inside the container to induce the powder into the stream of gas.

Discharge Time. The discharge is very rapid and is completed in about 15 seconds.

# CO, Extinguisher.

Operating the Extinguisher. To operate the extinguisher, first remove the safety pin and then squeeze the release handle. Squeezing the release handle will lift the valve from its seat and the CO<sub>2</sub> liquid is discharged through a small flexible hose to a discharge horn. At this discharge horn the liquid changes to a gas and is spread evenly over the burning surface, thus excluding the air. While applying the CO<sub>2</sub> to the fire give a sweeping motion to the discharge horn across the surface of the burning material.

Internal Pipe. An internal pipe is fitted to ensure rapid release of liquid so that the evaporation will not take place in the bottle as this would cause icing due the extraction of latent heat causing the formation of solid  $CO_2$ .

Use. Suitable for fires involving electrical machinery.

# Fixed Fire Fighting Installations

For fighting large fires, ships are provided with fixed fire fighting installations such as

- 1. Fire mains and hydrants
- 2. Sprinkler system
- 3. High pressure water spray system
- 4. Carbon dioxide flooding system
- 5. Foam spreading system
- 6. Steam smothering system
- 7. Inert gas system
- 8. Halon flooding system

# XIII. SAFETY GEAR, PERSONAL SAFETY & BREATHING APPARATUS

# **Protective** Clothing

Protective clothing should be worn as necessary to protect those involved in cargo

operations from the hazards associated with the cargo. The Suits, Gloves Boots, Goggles and Face Shield, etc, should be suitable for the cargo. Many plastics become brittle and crack when subjected to low temperatures, or can be dissolved by the cargo, though clothing of PVC or similar types of material is less susceptible to absorption and should be worn when exposure to vapour or liquid emissions is involved.

In particular, hand protection (e.g. gloves) should be worn when handling cold equipment, valves or slip tubes; face protection should be wornwhen there is the danger of liquid emission. Respiratory protection should be provided for cargo operations involving toxic or asphyxiating gases. Cargo vapour may be absorbed into clothing in sufficient quantities to create a hazard if taken into accomodation, galley, smoke rooms etc.

#### Heat Resistant Suit

Fire protective clothing is made from a number of synthetic materials. The most commonly used are Glass Fibre reinforced Modicryl and Aluminised Rayon.

Fire fighters must be protected from both metabolic and environmental heat. Metabolic heat is generated within the body. The human pain threshold is reached at 45°C (approx.) but fire fighters are expected to carry out work up to a temp. of 1000°C. Latest approved suits will provide this protection. Suits made of Modicryl Beta Glass mixture are light, flexible, water resistant. It is not affected by oils, most acids or petrochemicals. Suits can be washed or dry cleaned.

Dangers associated with Asbestos for fire protective clothing have become well known in recent years. There have been cases of Asbestosis, a fibrosis of the lung. Asbestos has poor thermal conductivity, its strength is drastically reduced if sprayed with water and there is great danger of a wearer being literally boiled inside the suit.

Fire fighter should never be overprotected. One part of the body should act as heat sensor – protective clothing should be designed accordingly. Heat sensors currently favoured are thighs.

Fire Proximity Suits are not suitable for direct entry into fire areas. Fire Entry suits are designed for fire areas.

#### Torches (Flashlights)

The torch or flash light should be of approved type.

Approved Equipment. This is an equipment of a design that has been tested and approved by an appropriate authority such as a government department or classification society. The authority should have certified the equipment as safe for use in a specified hazardous atmosphere.

It must be made sure that the equipment is maintained in good order. It should be stowed in a safe, dry place so that the body or the internal parts do not get damaged.

# Respirators

**Respirators** are used for protection against harmful dusts and gases. Respirators afford NO PROTECTION against oxygen deficiency or carbon monoxide and have very definite limitations.

**Respirators may be divided into two categories:** 

- 1. Dust Respirator. Apparatus having a particle filter to remove finely divided solid or liquid matter from the air inhaled by the wearer.
- 2. Gas Respirator.

*Canister Type.* Apparatus that remove limited concentrations of certain toxic gases from the air inhaled by the wearer, by use of a filter contained in a replaceable canister connected to a full face piece.

This type may also incorporate a particle filter to remove dust.

*Cartridge Type.* Apparatus that remove low concentration of certain relatively non-toxic gases and vapours from the air inhaled by the wearer, by use of a replaceable cartridge filter usually fitted to a head mask. This type also incorporates a particle filter to remove dust.

# **XIV. CONDITIONS FOR ENTRY**

# **Enclosed Spaces**

No one should enter a cargo tank, Double Bottom Tank or similar enclosed spaces as mentioned earlier without the permission to do so free a responsible officer who has ascertained immediately before entry that the atmosphere there is in all respects satisfactory for entry. The officer responsible should ensure that:

- 1. Effective ventilation is maintained continuously while men are in the compartment.
- 2. A responsible member of the crew is in constant attendance outside the compartment and knows how to raise the alarm in an emergency. In no circumstances should he enter the tank before help has arrived. The lines of communication for dealing with emergencies should be clearly established and under stood by all concerned.
- 3. Life lines and harnesses are ready for immediate use.
- 4. Approved Breathing Apparatus and Resuscitating Equipment are in an easily accessible position.
- 5. A separate means of access should be available where possible for use as an alternative means of escape in an emergency.

# Cofferdams, Double Bottoms and Other Enclosed Spaces

Oxygen content should be ensured by thorough ventillation and should be checked by oxygen meter.

Toxic gas should always be suspected and same precautions as for cargo tanks should be observed.

# Pumprooms

- 1. Ventillation. Should be thoroughly and continuously ventilated and atmosphere checked for petroleum gas as long as men are at work. Special attention should be paid to levels below the lower plateform where petroleum gas is liable to accumulate.
- 2. Descent into Pumproom. No one should descent into a pumproom at anytime without first advising a responsible officer of his intention. Appropriate safety measures should be taken including means of communication so that immediate help will be available if necessary.
- 3. Availability of Safety Equipment. Approved safety equipment should be easily available.
- 4. Opening of Pumps, Valves or Equipment. Responsible offficer should be informed. There is a risk that unsuspected pockets of petroleum liquid or gas or inert gas may be released when such equipment is opened up, even after a tanker or tank has been cleaned and pronounced gas free.
- 5. Accumulation of Oil, Waste, etc. To minimize fire and gas hazards, bilges should be kept clean and no oil should be allowed to accumulate.
- 6. *Pumproom Lighting.* Integrity of the approved lighting system should be maintained. If additional lighting is required, only approved equipment should be used.
- 7. Pump Room Notices. These are usually as follows:
  - "Do not enter Pumproom if blowers are not ON."
  - "Inform responsible officer before entering pumproom".

# Non Gas Free and Suspect Compartments

It is stressed that entry into tanks or compartments which are not gas free or are oxygen deficient should only be permitted in exceptional circumstances and when there is no practicable alternative. In this highly hazardous situation, the personnel must be well trained in the use of Breathing Apparatus and aware of the dangers of removing their breathing apparatus while in the hostile atmosphere.

## Work in Enclosed Spaces

*General.* All conditions for entry should be observed. No loose scale or sludge should exist in the vicinity which, if disturbed or heated, could give off toxic or flammable gases. Effective ventillation should be maintained.

Opening up equipment and fittings. Whenever cargo pumps, pipelines, valves or heating coils are to be opened, they should first be flushed with water. Even then there is a possibility that some cargo may remain the line which may be a source of gas. Special care should be taken and additional gas test should be made.

Use of tools. Tools should not be carried by personnel but should be lowered in a canvas bag or bucket to avoid their being dropped. It must be made sure that the atmosphere is gas free before any hammering or chipping is undertaken.

Electric lights and electrical equipment. Unless the compartment is gas free for hot work, that is the LFL is less than 1% and all sludge, scale, sediment have been removed, no electric light or equipment should be taken into the compartment, other than approved type.

*Removal of sludge, scale and sediment.* Periodic gas tests should be made and continuous ventilation should be maintained throughout the period men are at work.

There may be increase in gas concentration in the immediate vicinity of the work, and care should be taken to ensure that the atmosphere remains safe for personnel.

Cold work. Tests with a combustible gas indicator should give a reading of NIL (not higher than 1% LFL) and it is advisable that any sludge, scale and sediment is removed from the area where, and below which, the work is to take place.

# Hot work.

- 1. Immediately before hot work the compartment should be ventilated and tested as mentioned earlier.
- 2. All sludge, scale and sediment should be removed from an area of at least 3 meters around the area of hotwork (including reverse side of frames, bulkheads etc.). Other areas which may be affected by hot work should be cleaned e.g. the area immediately below the place of hot work.
- 3. Periodic gas tests should be made while the hot work is in progress and before restarting work after it has been stopped. A suitably trained fire watcher should be in attendance in the compartment.
- 4. All pipelines to a tank being worked on should be isolated, and adjacent tanks and spaces should be rendered safe by gas freeing, Inerting or Filling up with water.
- 5. Checks should be made that there is no ingress of flammable gases or liquids, toxic gases or inert gas from adjacent tanks or spaces by leakages into the working space.
- 6. It should be made sure that common bulkheads do not transfer heat and create an explosion hazard.
- 7. If hot work is to be done on piping, valves, heating coils, or other equipment, they should first be flushed and opened to ensure that they are gas free.
- 8. Pumping of cargo or ballast, tank washing, and other operations which could produce flammable gas on deck should be stopped.
- 9. Adequate fire extinguishing equipment should be laid out ready for immediately use.
- 10. No hot work should be allowed when alongside a terminal.

# Handling Chemicals

Chemicals may cause serious and permanent damage to the skin and eyes.

It is extremely important that personnel involved in handling chemicals wear proper protective clothing to cover whole body.

# FIRE STATION BILL

Fire Team no. 1	SPECIAL DUTIES	Fire Team no. 2		
1. Leader: 2/0	In charge of fire team group	1. Leader: 3/0		
2. Bosun	Wear fireman's outfit breathing apparatus	2. Pumpman		
3. A/B no. 2	Provide nozzles and fire hose	3. A/B no. 3		
4. OS no. 1	Carry portable fire extinguisher connect hoses to Fire Hydrant	4. OS no. 2		
5. Oiler no. 1	In charge of opening and closing of fire hydrant, hose tender	5. Fitter		

#### Technical Squad, Coordination/Tactical Team

- 1. Chief Mate At the scene of emergency, in charge of fire on deck coordinate bridge, Assist 1A/Engr. when Fire in the engine Room.
- 2. 1A/Engr. At the scene of emergency. In charge of Fire in the engine room. Assist Chief Mate when Fire on deck.
- 3. D/Cdt Messenger, Assist to Chief Mate and 1A/Engr.

#### Engine Room Emergency Power Supply Team

- 1. Leader: Chief Engr. In charge in the engine room.
- 2. 2A/Engr. Assist Chief Engr. in emergency fire pump.
- 3. Elect. In charge of Generator and main switch.
- 4. Oiler no. 1 Assist the operation on engine room.

#### **Emergency Team**

- 1. 3A/Engr. In charge of Halon or CO2 and foam proportion room. Ventilation flaps, doors, vents.
- 2. E/Cdt. Assist operation to 3A/Engr.

#### **First Aid Team**

- 1. Leader: C/Stwd In charge of first aid team
- 2. 2/Cook Provide/Carry First aid kit to the scene of emergency
- 3. Messman Provide stretcher to the scene of emergency

#### GENERAL FIRE INSTRUCTION Intermittent Sounding of Bells followed by:

- 1. One Prolonged Blast Fire on Deck.
- 2. Two Prolonged Blast Fire on the accommodation room.
- 3. Three Prolonged Blast Fire on the Engine Room.

When fire Break out shout Fire for the other crew awareness, inform the bridge and sound the alarm located on alleyway and other station.

Gathered crew to appointed station and form Fire Fighting squad complete Fire Fighting gear under the supervision of responsible Officer.

# **FIRST AID**

**FIRST AID** – is an immediate relief and temporary care given to a victim of an accident or sudden illness before the service of a physician is or can be obtained.

# **Roles of First Aid:**

- 1. First aid bridges the gap between the victim and the physician.
- 2. First aid does not complete with the physician.
- 3. First aid ends when doctors medical services begin.

# **Objectives of first Aid:**

- 1. To alleviate suffering.
- 2. To prolong life.
- 3. To prevent further injury.

# **Characteristics of a Good First Aider**

OBSERVANT -	-	should notice all signs and symptons.
RESOURCEFUL -	-	should make the best use of things at hand.
Gentle -	-	should not cause pain.
TACTFUL –	-	systematic and correct when giving first aid treatments.
SYMPATHETIC -	-	should be comforting.
CHEERFUL -	-	a happy expression inspires confidence.

# Values of First Aid Training

- 1. Makes a person safety conscious.
- 2. Medical expenses are lessened.
- 3. To know what to do in case of injury or sudden illness.
- 4. To save a life.

# **GENERAL DIRECTION WHEN GIVING FIRST AID**

## Essentials of First Aid

- 1. Plan your action.
- 2. Gather needed materials.
- 3. Instruct helpers, if there's any.
- 4. Carry out first aid procedures.

## Procedures

- 1. Keep victim in a comfortable position.
- 2. Examine and care for the (3) "Hurry Cases" which are the following:
  - Stoppage of breathing
  - Severe bleeding
  - Poisoning
- 3. Keep the victim warm and guard against chilling.
- 4. Activate the emergency medical system with the following informations:
  - The exact location.
  - The nature and extent of injury.

- The number of injured or ill individuals involved.
- First aid given.

# Some Do's in First Aid

- 1. Be calm and deliberate.
- 2. Keep on lookers away from the victim or vice versa.
  - To provide adequate ventilation to the victim.
  - To provide privacy, and,
  - To avoid confusion from wrong suggestions.
- 3. Talk to the victim to comfort and reassure him. Tell him what first aid steps you are going to take and how they can help him.

i:

- 4. Loosen any tight or constructing clothing.
- 5. Protect the victim from unnecessary movement and disturbance.
- 6. Remain incharge until help arrives.

# Some Don't in First Aid

- 1. Don't try to arouse an unconscious person.
- 2. Don't give food and drink to unconscious victim.
- 3. Don't let the victim see his own injury.
- 4. Don't talk to bystanders about the condition of the victim.
- 5. Don't attempt to diagnose or judge the injuries or illness, just care for the individual.

# Checking for Injuries

It is important that the first aider should make a systematic examination in order to locate all possible injuries. The three hurry cases should be given top priority before proceeding to other injuries. The following procedures should be observed when checking for injuries:

- 1. Check for breathing and pulse and any severe bleeding.
- 2. Check for obvious signs and injury.
- 3. Examine the head for lacerations, contusions, swelling or depressions.
- 4. Continue by examining body surfaces of neck, chest, pelvis and extronites for depressions or protrusions.

Sometimes it may be necessary to remove the victims clothing in order to examine him better. In that case try to avoid unnecessary exposure.

# **RESPIRATION SYSTEM**

**SHOCK** – is a sudden depressed of the vital function of the human body and circulatory deficiency.

## Kinds of shock

TRAUMATIC SHOCK – resulting from a severe blow in the solar plexus or testicles or from cutting a large nerve trunk or from severe injury. Lost of blood or blood pressure.

CARDIOGENIC SHOCK – occurs after the victim suffers a severe heart attack.

First aid measure - the same as traumatic shock.

ANPHYLACTIC SHOCK – due to allergen or allergy such as drugs, food, insect bites and odor of solids and gases by inhalation.

NEUROGENIC SHOCK - results from injury to the brain or spinal cord.

PSYCHOGENIC SHOCK – due to lack of oxygen in the brain. (anoxia)

ELECTRICAL SHOCK - due to contact with an electrical current or lighting.

EMOTIONAL SHOCK – due to several factors as in witnessing a horrible incident, extreme pain, fear, anxiety, or the receipt of shocking news.

# Signs and symptoms of shock

EYES – vacant, lack luster PUPILS – dilated BREATHING – irregular, shallow SKIN – pale, cook, moist PULSE – rapid, weak MOUTH – nausea, vomitting

# First aid measure for shock

POSITION – keep the injured person lying down, shock position, feet position higher than the head.

TEMPERATURE – conserve body heat, cover body with blanket.

FLUIDS - restore lost body fluids, or salt solution and salt tablets.

# **General First aid procedures for shock**

- S Sips of fluids should be given unless unwise (salt solution)
- H Heat of the body should be conserved
- O Oxygen supply should be maintained
- C Clear the airway for possible obstruction
- K Keep the victim in a comfortable position.

ARTIFICIAL RESPIRATION – is a procedure for causing air to flow into and out of a man's lungs when his natural breathing is inadequate to support life.

# Cases benefited by artificial respiration

Non-breathing but living victim of:

- 1. Drawing
- 2. Electrical shock
- 3. Gas poisoning
- 4. Compression of chest
- 5. Blue unconscious
- 6. Prolonged exposure to cold
- 7. Drug poisoning
- 8. Anesthetics
- 9. Excessive alcohol
- 10. Hanging
- 11. Choking
- 12. Puncture wound of chest

# **CPR COMPARISON CHART**

			. F 1 52
ADULT ONE-RESCUER	ADULT TWO-RESCUER	CHILD	CHILD
"Are you okey?"	"Are you okey?"	"Are you okey?"	"Are you akey?"
Call for help	Call for help	Call for help	Call for help
Open airway	Open airway	Open airway	Open airway
Assess breathing	Assess breathing	Assess breathing	Assess breathing
Pinch Nose Make Seal over mouth	PINCH NOSE MAKE SEAL OVER MOUTH	Pinch Nose Make Seal over mouth	Make Seal over Mouth and Nose
Two initial breaths	Two initial breaths	Two initial breaths	Two initial breaths
CHECK CAROTID PULSE	CHECK CAROTID PULSE	CHECK CAROTID PULSE	CHECK BRACHIAL PULSE
COMPRESSIONS:	COMPRESSIONS:	COMPRESSIONS:	COMPRESSIONS:
TWO-HANDED	TWO-HANDED	HEEL OF ONE HAND	2-3 FINGERS
1 1/2" to 2" DEEP	1 1/2" to 2" DEEP	1" to 1 1/2" DEEP	1/2" to 1" DEEP
80-100 PER MIN.	80-100 PER MIN.	80-100 PER MIN.	100 PER MIN.
15 COMPRESSIONS 2 BREATHS	5 COMPRESSIONS 1 BREATH	5 COMPRESSIONS 1 BREATH	5 COMPRESSIONS 1 BREATH
4-CYCLE ASSESSMENT	10-CYCLE ASSESSMENT	10-CYCLE ASSESSMENT	10-CYCLE ASSESSMENT

#### **RESCUE BREATHING COMPARISON CHART**

ADULT **1 BREATH EVERY 5 SECONDS** 

CHILD **1 BREATH EVERY 4 SECONDS** 

INFANT **1BREATH EVERY 3 SECONDS** 

5.5

# **OBSTRUCTED AIRWAY COMPARISON CHART CONSCIOUS VICTIM**

CHILD **HEIMLECH MANEUVER** 

ADULT HEIMLECH MANEUVER INFANT

1.1.1

4 BACK BLOWS, 4 CHEST THRUSTS

**UNCONSCIOUS VICTIM** CHILD

**6 TO 10 ABDOMINAL THRUSTS** 

**FINGER SWEEP** 

FINGER SWEEP IF OBJECT IS VISIBLE Attempt to ventilate

ADULT

**6 TO 10 ABDOMINAL THRUSTS** 

Attempt to ventilate

# INFANT **4 BACK BLOWS 4 CHEST THRUSTS** FINGER SWEEP IF OBJECT IS VISIBLE

Attempt to ventilate

**CARDIO-PULMONARY RESUSCITATION** – is a combination of artificial respiration and **manual artificial circulation** that is recommended for use in case of cardiac arrest victim.

**RESPIRATION ARREST** – victim with pulse but do not have breathing

CARDIAC ARREST - victim has no pulse and no breathing.

First aid measure. For respiratory arrest victim only.

- 1. Position the victim on his back on a flat hard surface
- 2. Clear the airway
- 3. Tilt the head backward to open airway
- 4. Pinch the nose
- 5. Give the initial four (4) blows.
- 6. Start counting, one (1) and two (2) and three (3) and four (4) and blow, repeat the procedures until the victim breath or doctor arrives, 5 seconds one breath.

# **PROCEDURES IN RESUSCITATION (CPR)**

- 1. Lay the patient flat on his back.
- 2. Open throat by tilting head back.
- 3. Look listen and feel for breathing.
- 4. If no breathing, give 4 short, hard breaths.
- 5. Check for neck pulse, if no pulse, begin resuscitation (CPR) at once.
- 6. Two-person resuscitation at the rate of 60 chest compressions a minute, regular, smooth, even, and without interruptions. Rate of one breath between every five compressions.
- 7. One-person resuscitation (CPR) at the rate of 80 chest compressions per minute, regular, smooth, even, and without interruptions. Rate of two quick breaths within five seconds between each series of 15 compressions.
- 8. Check the pulse and examine the pupil of the eyes to determine if resuscitation (CPR) is effective. Keep going.
- 9. Continue as long as possible, until help arrives or pulse resumes beating.

**CHOKING** – is an obstruction within the airpassage which tends to impair or stop breathing. The most common causes of choking on food are:

- 1. Large, poorly chewed pieces of meat.
- 2. Laughing and being otherwise distracted when there is food in the mouth.
- 3. Moderate to heavy drinking of alcohol while eating.
- 4. Upper and lower dentures.

# **ACTION SEQUENCE FOR CHOKING VICTIMS**

If Victim is Conscious. Give 4 sharp blows between the shoulder blades, then 4 strong abdominal thrusts.

If Victim is Lying Down. Kneel then roll victim on side up against your knees and strick

4 sharp blows with the heel of your hand between the shoulder blades.

Kneel beside the victim and use the heel of your palm for 4 sharp abdominal thrusts.

If *Victim is Unconscious*. Try to ventilate him. Give 4 sharp blows to the back. Give 4 deep abdominal thrusts. Probe the mouth for blocking matter. Remove.

If Victim does not respond. Don't give up. Keep repeating the above-stated 4-step sequence.

If Victim is Fat or Pregnant. Use chest thrust instead of abdominal thrusts.

Infants and Small Children. Infant may be held feet high, head low and face down along your forearm as you slap.

If You are Choking and Alone. Use your two fists for abdominal thrusts. Bend over the back of a chair, over edge of a sink, railing, etc. Exert hard and repeated pressure to force the blocking object up. Push your fingers deep down the throat to regurgitate.

# WOUNDS AND THEIR CARE

# **Classifications of wounds**

CLOSED WOUNDS – are injuries sustained from a blow with a blunt object or collision rupturing blood vessels internally without penetrating the skin.

OPENED WOUNDS – injuries sustained from a blow with a sharp object causing the skin to be torn open.

# DEFINITION

WOUND - is a break in the continuity of the tissues of the body, either internal or external.

# Kinds of wound

1.	Abrasion		
	Causes	:	Scraping or rubbing against rough surfaces.
	Characteristics	:	Shallow wide slight bleeding, dirty
	Danger	:	Infection
2.	Incision		
	Causes	•	Cut by blades of sharp instruments like knives, razors, scissors, bolos, etc.
	Characteristics	:	Clean cut, deep, severe bleeding wound is clean.
	Danger	:	Hemorrhage, Infection, Shock.
3.	Laceration		
	Causes	:	Rough edge instruments like broken glasses, tin cans,

			barb wires, sharpnels, blunt instruments like pipes, baseball bats, fist.
	Characteristics	:	Torn, irregular edges, serious bleeding, sometimes slight dirty.
	Danger	:	Hermorrhage, Infection, Shock
4.	Puncture		ંગે
	Causes	:	Penetrating, pointed instruments like nail, icepicks, daggers, knives, bullets, pins, etc.
	Characteristics	:	Small opening, deep, serious slight bleeding, dirty.
	Danger	:	Internal Hemorrhage, Infection, Shock.
5.	Avulsion		
	Causes	:	Accidents such as motor vehicle, wreck gunshot, explo- sions, animal bites, and other body crushing.
	Characteristics	•	Tissue is forcibly separated or torn from victims body, there is heavy and rapid bleeding.
	Danger	:	Hemorrhage, Infection.

# NATURE OF INFECTION

- 1. Germs enter into wound and thrive.
- 2. No matter how slight the wound nor how free from previous infection the victim has been, there is definite danger in ever wound.
- 3. The most dangerous of all infections is tetanus.

# **FIRST AID**

- 1. When bleeding is not severe
  - a. Wash the wounds with soap and water or possible use of antiseptic
  - b. Apply mild tincture of iodine (3%)
  - c. Apply dressing and bandage.
- 2. When bleeding is severe

Stop the bleeding by:

- a. Direct pressure main help
  - 1. Into the wound usually with thumb or palm of the hand.
  - 2. With cloth material, the cleaner, the better.
  - 3. Can be applied all over the body areas.
- b. Digital pressure
  - 1. Definition shutting off the artery feeding the wound.
  - 2. There are many body areas where digital pressure cannot be applied in bleeding control.
  - 3. Direct pressure must also be applied. Digital pressure does not completely

stop blood flow immediately.

- 4. The six digital pressure points (location and control).
- c. Tourniquet, as a last resort.
- d. Elevate injured part as supplement.

# THE SIX DIGITAL PRESSURE POINT

Temporal	
Location :	Directly in front of the ear.
Control :	Bleeding from the head.
Facial	
Location :	About an inch from the angle of the lower jaw towards the chin.
Control :	Bleeding from the face.
Carotid	
Location :	In the neck, beside the wind pipe.
Control :	Bleeding from the throat and the upper neck.
Subclavian	
Location :	Behind the collarbone, near its inner end.
Control :	Bleeding from the shoulder, armpit and part of the upper arm.
Brachial	
Location :	Inner aspect of the upper arm.
Control :	Bleeding from the arm.
	TemporalLocation :Control :FacialLocation :Control :CarotidLocation :Control :SubclavianLocation :Control :BrachialLocation :Control :

6. Femoral

Location	:	In the mid–groin
Control	:	Bleeding from the leg.

# FRACTURES AND THEIR CARE

**Definition** – A fracture is a break or a crack in the bone.

# **Kind of Fractures**

CLOSED (simple) FRACTURE – bones broken but no connecting wound from break area of the skin.

**OPEN (compound) FRACTURE :** 

- 1. Broken bone, with connecting wound to surface. Bone itself may have broken through the skin or a missile from outside may have penetrated skin, then struck and fractured the bone.
- 2. A compound break, because of entrance of germs is much more serious than simple break.

# Prevention

- 1. Knowledge
  - The frequency of serious accidents such as fractures.
  - The price, especially to the victim himself and his family. One serious accident may affect the entire life of a victim and the lives of the family.
- 2. Action
  - Creating a safe environment so that accidents aren't likely to happen. (List some hazards.)
  - Learning and using safe methods. Self-discipline is important for personal safety.
  - Teaching others. Most important to the citizen himself is the teaching he does in his own home and job.

# INJURIES RELATED TO SKELETAL SYSTEM

**DISLOCATION** – occurs at the joint of the body. The bones at a joint are no longer on its normal position. Proper alignment of the bones end may require surgery and the first aider should not attempt to set any dislocation. Attempted or even improper alignment may result in nerve, soft tissue or blood vessel injuries or a permanent deformity. The first aider should handle dislocation as suspected fractures.

# First Aid

- 1. Immobilize the affected joint as a fracture.
- 2. Keep bandage firmly in place so it would not slip out.
- 3. Prevent and care for shock.
- 4. Seek immediately medical attention.

**SPRAINS** – injuries of the soft tissues which surround a joint. Sprains may occur at any joint in the body, the most common being at the ankle. It occurs when the joint is forced beyond its normal range movement.

# First Aid

The objective is to prevent swelling and hemorrhage in the affected joint.

- 1. Elevate the affected joint if possible.
- 2. Apply ice to the affected area. After 10 minutes, apply hot compress.
- 3. Immobilized the affected area as a fracture.
- 4. Prevent and care of shock.

**STRAINS** – when a muscle or group of muscles are overstretched. Strains differ from sprains and dislocations in that they do not affect the bony structure of the body but rather involve the muscles which allows for body movement.

# First Aid

- 1. During the first 10 minutes, put ice or cold cloths over the swollen joint, this helps reduces swelling and shock.
- 2. Elevate the affected part if possible.

- 3. After the first 6 minutes use hot soaks or hot compress.
- 4. After the affected area or muscles.
- 5. Seek medical attention if pain persist or severe.

**POISONING** – a poison is any substance, liquid, solid, or gas that tends to impair health, or cause death, when introduce into the body or into the skin surface.

First Aid - Physician should be called in all cases.

# GENERAL

- 1. Dilute the poison immediately, administer fluid in large amount four (4) glasses or more.
  - a. Water most readily available
  - b. Milk protects the digestive tract–lining; slows the absorption of poison.
  - c. Baking Soda Solution nauseating effect.
  - d. Milk of magnesia preferable because it produces less gas.
- 2. Induce vomitting; the important measure is the prompt production of vomitting.
  - a. Diluting fluid may cause vomitting, the larger the amount, the greater the tendency to vomit.
  - b. Tickling the back of the throat.
  - c. Repeat the dilution and induction of vomitting if poison still appears to remain in the stomach.
- 3. Give/administer antidote:
  - a. If known, may be given after vomitting has occured or with the diluting fluid.
  - b. If not known, administer universal antidote.
    - 1 part strong tea
    - 2 parts crumbled burnt toast
    - 1 part milk of magnesia

## BURNS

BURNS - is an injury caused by dry heat, hot gases, hot liquids or chemicals.

#### Classification of burns according to source

THERMAL BURNS – caused by hot gases, solids and liquids. CHEMICAL BURNS – corrosive substances such as acids and alkalies. ELECTRICAL BURNS – caused by electric current passing through the body. RADIATION – caused by ultra rays or atomic radiation.

## Classification of burns according to degrees

1ST DEGREE – reddening of the skin only. 2ND DEGREE – presence of blisters, deeper than the first degree. 3RD DEGREE – charring of the tissues.

# First Aid Measures

1ST DEGREE – apply skin lotion/skin cream/talcum powder

2ND DEGREE - do not puncture the skin/blisters. Apply burn ointment/vaseline/oil.

- 3RD DEGREE undress the burned area.
  - cut around the clothing sticking to the burned area.
  - apply burn ointment /vaseline/oil.
  - treat for shock.

Note: Give the victim as much water as he could drink.

**HEAT CRAMPS** – caused by prolonged physical exertion in high temperature due to lost of large amount of body salt because of profuse perspiration.

# **Indicators of Heat Cramps**

- 1. Victim complaining of severe abdominal cramps or in the muscles of lower limbs.
- 2. A feeling of thirst.
- 3. Dizzy and nauseated.
- 4. Pulse strong
- 5. Spasm
- 6. Excessive perspiration

# First Aid Measures for Heat Cramps

- 1. Stop him from physical activity
- 2. Let him rest in cool environment
- 3. Give one table of salt or 1/4 tsp. of table salt after which one glass of water follows.

# Injuries due to Colds

- 1. FROSTBITE- is a term usually applied to injuries resulting from exposure to dry cold.
- 2. IMMERSION FOOT a term usually applied to injuries of the part of the body in cold survivors of shipwrecks especially in the feet due to sitting on life rafts with feet in the water.

# First Aid Measures for injuries due to Colds

- 1. If conscious and feet are affected, do not allow the victim to walk.
- 2. GEt patient to a moderately warm room. Undress him quickly and immerse him at 36.5°C 39°C to 10 minutes. (except the head)
- 3. Dry him carefully and place him on bed keep covered but don't permit the covering to come in contact with the affected part.
- 4. Keep part dry and put dry sterile cotton between the toes and fingers.

# Cravat Phase

- a. Forehead bandaging
- b. Eye bandaging
  - bucaneer (loose)
  - tight eye

- d. Elbow-knee bandaging
- e. Crushed palm bandaging
- f. Five overlap bandaging
- g. Ankle bandaging
- c. Neck-forearm-leg bandaging

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# **METHODS OF RESCUE AND TRANSPORTATION OF VICTIM**

# **One Man Carry**

- a. Assist to stand
- b. Assist to walk
- c. Two-arm carry (lover's carry)
- d. Pack strap carry
- e. Fireman's carry

# Two Men Carry

- a. Assist to walk (2-man)
- b. Carry by extremeties
- c. Four hand seat carry
- d. Three hand seat carry
- e. Chair carry
  - along side
    - front & back

## Three Men Carry

- a. Hands as liter
- b. Bearers along side

# Six to Eight men Carry

- a. Alternate hands carry
- b. Blanket carry
- c. Improvised stretcher carry
  - triangular bandage
    - jackets
    - empty jackets
    - blankets as stretchers

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This guide is to aid the seaman in understanding the subject by himself. This will also serve as a refresher to those who are aboard.

SURVIVAL – is the action of living longer or continuing life beyond and/or inthe presence of difficult condition.

# PREPARATIONS

# Prior to the occurrence of any emergency

- 1. Know what survival equipment are available aboard your ship. Do you have lifeboats, lifejackets and liferafts? How many lifeboats and what is the capacity of each? Do you have life rafts and what is the capacity of each? How many life jackets are available for use by the crew? For use of the passengers?
- 2. Know the *location of the survival equipment* aboard your ship. Do you know where the lifeboats and liferafts are? Where are the lifejackets? Were you issued one for your own use?
- 3. Know how to use the survival equipment aboard your ship. Everyone aboard ship should familiarize himself on how to use the lifejacket issued to him.

## Survival Equipment

*Life jacket.* Reports from survivors proved that the lifejacket is the most important survival equipment for abandonship. Everyone must familiarize himself with the life jacket that he will use; it may mean the difference between life and death.

# Inflatable liferaft

## Construction

- 1. When fully inflated it is stable in a seaway.
- 2. Maybe dropped from a height of 18.3 meters without damage to it or its equipment.
- 3. Total weight not to exceed 181 kilograms.

# Lifeboat

## Specifications for efficiency

- 1. Constructed with rigid sides
- 2. Of such form and proportion as to have ample stability in a seaway
- 3. Of sufficient freeboard when loaded with full complement
- 4. Sufficiently strong to permit safe lowering into the water with its full complement on board.
- 5. No less than 4.8 meters in length; not more than 20 tons in weight when fully loaded.
# Equipment

- 1. Two (2) plugs for each plug hole a bailer, and two (2) buckets
- 2. A line becketed around the outside of the boat an grab lines from gunwale to gunwale under the keel.
- 3. Mast and sails colored orange and marked with first and last letter of the ship's name.
- 4. Efficient compass in binnacle with means of illumination
- 5. Sea anchor with painters; one secured forward with strap and toggle and one firmly secured to stem of the boat.
- 6. Two (2) light buoyant heaving lines.
- 7. Two (2) hatchets
- 8. Oil container with 4.5 liters capacity for use of sea anchor
- 9. Six (6) red hand flares, four (4) parachute signals (gives bright red light at high altitude) two (2) smoke floats (giving a volume of orange colored smoke) one flashlight with spare battery and a daylight signalling mirror.
- 10. Lamp with oil to burn 12 hours and two (2) boxes of matches
- 11. Jack knife with can opener, a hand pump or a dipper. Fishing line with six (6) hook.
- 12. Approved first aid outfit in a watertight case.
- 13. Provisions for each person must remain in the boat while ship is at sea; 3 liters of fresh water, 450 grams biscuits, 450 grams of barley sugar, 450 grams of condensed milk.

**FLOATSAM** – any floating debris which is capable of supporting a certain weight in the water and will help save a person from exhaustion.

# Initial actions on hearing emergency signal

# Signals: Sounding of alarm/or ship's whistle

- 1. *Put on plenty of warm clothing.* Wooly clothing is best; as many layers as possible with an anorak or oil skin as the outer layer.
- 2. Put on your lifejacket. Without a lifejacket even good swimmers will have difficulty in staying afloat in cold water because of the disabling effects of cold shock and cramps. A lifejacket will keep you afloat without effort of swimming no matter how much clothing is worn. If unconscious a lifejacket will keep your mouth clear of the water.
- 3. Take with you important articles for survival:
  - Waterproof flashlight;
  - Police whistle;
  - Knife;
  - Six-foot line tied under your arm;
  - Wallet, money belt, ID, passport.
- 4. Go to your muster station in orderly manner.

# PREPARATION FOR ABANDONING SHIP

# Actions to take before leaving the ship

1. If possible, drink hot tea or coffee toward off the effects of cold water.

- 2. Test lifejacket valves and inflating tubes. (Inflatable types)
- 3. Stimulate circulation by deep and rapid breathing and by moving arms and knees, DO NOT OVER EXERT.
- 4. KEEP CALM.

# **Follow instructions**

- 1. Follow instructions in preparing the ship's survival craft.
- 2. It may or may not be necessary to abandon ship; the order to abandon ship will be given by the Master/Skipper only.
- 3. In many cases the ship itself proves to be the best lifeboat.
- 4. Abandonship only when told to do so.

# SYMPTOMS FOR HUMAN BODY DURING COLD WEATHER

### TEMPERATURE

### SYMPTOMS

36.9℃	1.	Goose
	2.	Blood vessel contract
	3.	Muscles stiffen
	4.	Heart beat fast
	5.	Desire to sleep
	6.	Pulse rate slow
	7.	Rigid muscles
30°C	8.	Heart beat slow down
	9.	Loss of reflexes
	10.	Heart beat stop
24°C – 26°C	Dea	th (Hypothermia)

### WATER TEMPERATURE

### **RESCUE TIME**

2ºF)
)°F)
50°F)
30⁰F)
70ºF)
30⁰F)

Within one (1) hour 1/2 to 3 hours 1 to 6 hours 2 to 24 hours 3 to 40 hours longer

- **EX.:** 1. If sea water temperature is 15° Celcius With shirt only, will survive about 2 hours.
  - 2. Get into the survival craft as soon as possible. Otherwise get clear of the ship. The danger of being struck from below by surfacing wreckage is greater than the suction caused by the sinking ship.
  - 3. After getting clear of the ship do not swim aimlessly. Float as still as possible in your lifejacket if you can not get into a survival craft. Swimming increases heat loss.
  - 4. Use the whistle to attract attention. You may not be visible, but using the whistle

will enable you to let others know where you are.

5. If possible, form a group with other survivors in the water. There is safety in number. A group is more easily located.

# HOT CLIMATE

- 1. Able-bodied seaman stay out of crowded rafts and hang on the side. Ropes on rafts should be sufficiently loose to permit an easy grasp.
- 2. If the sea is rough, breath as in swimming, inhaling through the mouth and exhaling through the nose as big waves wash over you.
- 3. Beware of drowsiness, which often comes between 15 to 45 minutes after you enter the water. If others become drowsy, get tough with them. Make them do the same with you if you feel drowsiness coming on.
- 4. Shivering saps strength quickly. Deep, rapid breathing and moving the arms and legs will usually stop it.
- 5. Encourage non-swimmers who are most likely to lose heads and keep talking to them calmly and quietly.
- 6. STAY CALM.

# LIFEBOAT HANDLING

Types of emergency situations you may encounter aboardship -

- 1. FIRE
- 2. COLLISION
- 3. ABANDON SHIP

### Special duties assigned to each crew member

- 1. Found in the Station Bill
  - a. Each person assigned specific duties
  - b. Everybody must Memorize his duties by heart
  - c. Difference between fire and survival crafts alarms:
    - Fire Ship's Bell/Rapid Ringing for at least 10 seconds
    - Survival crafts station Ship's Whistle/Seven (7) Short Blast/One Long Blast
    - Alarm should be followed by Public Address System

### **Construction, Characteristics and Equipment of survival craft** Lifeboat construction – materials

- 1. METAL
- 2. WOOD
- 3. FIBER WOOD

# Characteristics of efficient lifeboats -

- 1. Constructed with rigid sides and double-ended
- 2. Of such form and proportion to have ample stability in a seaway
- 3. Of sufficient freeboard when loaded to full complement
- 4. Sufficiently strong to permit safe lowering into the water with full complement on board
- 5. No less than 4.8 meters in length; not more than 20 tons in weight when fully loaded
- 6. Fitted with Internal buoyancy appliances
  - a. Air cases of bouyant material not affected by oil
  - b. Total volume of internal buoyancy 10% of cubic capacity of boat plus buoyancy required to float lifeboat with its full complement
    - When flooded
    - Open to the sea
    - Top of gunwale amidships not submerged
  - c. To carry more than 18 persons but not to exceed 150 persons

# MUST BE MOTOR LIFEBOAT

### Equipment -

- 1. Two (2) plugs for each hole, Bailer and Buckets
- 2. A line becketed around the outside of the boat, life line with seine float
- 3. Mast and Sails (orange colored) marked with 1st and last letter of ship's name
- 4. Efficient compass in binnacle with means of illumination
- 5. Sea anchor with painter
  - a. one secured forward with strap and toggle
  - b. one firmly to the stern of the boat
- 6. A buoyant heaving line
- 7. 2 Single-edge hatchets
- 8. Oil container with 4.5 liter capacity of storm oil for use with sea anchor
- 9. Six red flares, four parachute signals (1) gives bright light at high altitude
- 10. Two smoke floats gives a volume of orange colored smoke
- 11. Lamp with oil to burn for 12 Hrs., two boxes of matches, one flashlight with spare battery and bulb, a daylight mirror for signalling
- 12. Jack knife with can opener, hand pump or dipper, fishing line with six (6) hooks
- 13. Approved first aid outfit in water tight case
- 14. Provisions (must remain in the boat while ship is at sea) for each person
  - a. Three (3) liters of fresh water
  - b. 450 grams biscuits
  - c. Candies of the non-thirst inducing type
  - d. Condensed milk

Floatsam - will help save a person from exhaustion

# LIFECRAFTS INFLATABLE

- 1. Stowed on cannisters
- 2. Cannisters stowed in racks along ship's railings
- 3. Provided with hydrostatic release mechanism
  - a. automatically releases lifecraft after certain depth is reach
- 4. Launching
  - a. Be sure painter is secured to a strong point on he ship
  - b. Throw cannister overboard
  - c. Painter will inflate raft by jerking or pulling.

### Lauching survival crafts into rough sea

- 1. Stop ship after heading up to a direction which she will lie the steadiest
- 2. Clear the lifeboats away and have boat rope ready as in fine weather
- 3. Get crew in and lower down to deck level
- 4. Keep boat well trapped in and held by the gunwale
- 5. Wait for favorable opportunity to launch
  - When ship rolls the right way
  - Let go frapping lines
  - Spread storm oil on water
  - Lower quickly and hophook boat falls
- 6. Steer off the side of the ship
- 7. Out oars and get a safe distance from the ship

### Action to be after leaving the ship

- 1. Avoid remaining in the water for one second longer than necessary
- 2. Board a lifeboat or liferaft immediately

### Rescue by Helicopter

- 1. Not normally undertaken
  - at night
  - when wind velocity exceeds 45 knots
- 2. Can rescue up to 16 persons at a time
- 3. Can operate 180 miles from a base
- 4. To help pilot in locating ship/craft
  - Send smoke signals (smoke floats)
  - Use (Aldis lamps) in communicating with pilot
  - Use life boat heligraph (in bright sunlight)
    - Paint large white letter H on a stretch of ship's deck

### Starting instruction for life boat engines

When a makers Instructional manual is available, it should be carefully studied but in the absence of this, the following routine should be followed:

- 1. Check engine oil level by means of a dip stick.
- 2. Turn on sea cock. If fresh water cooling is fitted, check water level in header tank.
- 3. Turn fuel.
- 4. Check that the reverse gear in neutral.
- 5. If starting a sea-water-cooled engine with boats in davits, turn water pump greasers on or pump will dry run.

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- 6. Set throttle at least one third open and if starting from cold trip excess fuel device fitted to fuel pump.
- 7. For hand starting, set valve decompressor lever to decompress position if engine is fitted with electric starting, it is not necessary to use the decompressor.
- 8. Engage starting handle and swing engine briskly. When it is running at maximum speed, pull decompressed level back to full compressor which continuing to bring as fast as possible.
- 9. As soon as engines starts, close the throttle.
- 10. Check pressure gauge for correct oil pressure. See that cooling water is flowing through the engine.
- 11. If engine fails to start, it maybe due to any one of the following reasons:
  - a. Air in fuel system or faulty injection
  - b. Lack of compression
  - c. Lube oil too heavy

# BOAT NOMENCLATURE

**KEEL** – A strong timber that goes fore and aft and underneath the bottom sometimes called the backbone of the ship.

**STEM** – The forward timber.

FOREFOOT - The rounded where it turns to meet the keel.

STEM HEAD - The top part that rises a little above the boat.

BINDING – A metal strip to take any chafe or bump that could damage wood.

**GUDGEONS** – Two metals eyes fastened to stern post.

**PINTLE** – It is a long pin fittings form part of the hinge on which the RUDDER WORKS.

**PLANKING** – Going from the stern post to the stem; is the skin of the boat.

**GRAB LINES OR BECKETS** – For supporting person in the water.

**BEAM** – The widest part of the boat.

**BOW** – The sloping part forward.

**QUARTER** – The sloping part aft.

KEELSON OR KEELSON BOARD - On the bottom, directly above the keel.

**MAST STEP** – Into which the heel of the mast is shipped when sailing.

**RIBS – Coming away from underneath** the keelson are the ribs.

BOTTOM BOARDS OR FOOTING – Which support the weight of equipment and persons over a large area as possible. Metal, thickness must be that it should weighs at least 18 ounce per square feet.

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**BUOYANCY TANKS** – Made of rustless yellow

THWARTS – Going across the boats or seats.

SIDE BENCHES - Going around the sides or seats round the boat.

KNEES - Curved metal brackets braced to the thwarts.

**EYEPLATES** – Use for securing the stays of the mast.

CRUTCH SOCKETS - Round holes with metal bush plate around the gunwale.

**DRAINING HOLE** – Passage for water.

**BREAST HOOK** – Connect the forward ends of the port and starboard gunwale is a fork shaped fitting of metal with its fork bolted into the gunwale and its narrower end bolted to the stem.

GUNWALE – Wooden framing that forms the top edge of the boat.

RUBBER - A rounded beading fore and aft.

WATER LINE - Marker between the gunwale and the keel.

FREEBOARD - Distance between the gunwale and the waterline.

MAST CLAMP - Use to hold mast when it is shipped.



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### SAFETY EQUIPMENTS ON BOARDSHIP









# LIFEBOATS STATION

#### Master in command of all operation

Stt	od. Lifeboat	DUTIES	F	Port Lifeboat
1.	2/0	In charge of Lifeboat no. 1 Take Nav. charts, logbook.	1. 2.	Chief. Officer 3/0
2.	Radio Officer	Radio transmitter/important documents		
3.	C/Engr.	In charge of lifeboat motor	3.	1A/Engr.
4.	4/Engr.	Provide air pressure to life boat winch.	4.	2A/Engr.
		Start the motor.		
5.	Fitter	In charge of emergency light and search light of boat Deck.	5.	Elect.
6.	Bosun	In charge of lowering the lifeboat.	6.	Pumpman
7.	A/B no. 1	Release Fwd lashing and Davit hook.	7.	A/B no.2
8.	O/S no. 1	Release Aft lashing and Davit hook.	8.	A/B no.3
9.	D/Cdt	Secure Fwd painter	9.	OS no. 2
10.	Oiler no. 2	Secure Aft painter	10.	Oiler no. 1
11.	C/Std	Bring extra provision blanket and drinking water	11.	2/Cook
12.	Messman	In charge of life boat ladder.	12.	E/cdt.

#### **General Life Boat Instruction**

ALARM SIGNAL: Continuous Sounding of Alarm Bell;

Seven short blasts followed by one long blast repeated on ship whistle.

Each crew should wear warm clothing, proper foot gear and life jackets and proceed to the respective Boat Station.

Immediately upon hearing life boat alarm, each should perform specified duties as stated in their respective station bill and extra effort to do other tasks unattended.

Order of abandoned ship should be given by the master of the officer in charge of the lifeboat. Note: This station serves as guidelines to other vessels.

#### **VESSEL POLLUTION TEAM**

The primary duties of the Pollution Emergency Team is to response to any Shipboard Pollution emergency with extreme caution must be exercised with respect to any action that has a remote potential for affecting the stability of the ship such as cargo, fuel or ballast transfer. Also the proper communication procedures from ship to owner party and port authority about the case incident.

#### Master: Overhaul in charge of operations on board

Chief Off: Leading oil spill response group

Chief Eng: In charge of fire prevention, bunker operation

- Radio Off: Secretary and communications
- Deck Off: Assist Chief Officer

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Eng. Off: Assist Chief Engr. prepare fire fighting

Deck Crew: Oil spill response groups

Eng. Crew: Fire prevention/repair groups

Cat. Crew: Assist oil spill response groups

In case of any oil spill pollution or other hazards the team shall be activated immediately.

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#### SECTION II

### TANKER SAFETY

The pollution of the marine environment is received more and more frequently. Among the biggest problems, in this respect, are oil spillages and petroleum residues, whether intentional or due to negligence. This does not take into account the enormous problems caused by the occasional oil tankers that sink, spilling crude oil and affecting marine fauna, flora and coasts. With regard to the effect of pollution, one of the most important factors to keep in mind is that the problem remains the same whether refined products or heavy oils are discharged. The spills of heavy products tend to be visible for a greater period of time. On the other hand, the spills of the lighter products, such as petrol (gasoline), tend to evaporate or dissolve rapidly but are just as harmful to marine life, even though their effects are not visible. Another problem to keep in mind is that the process of pollution due to oil products is cumulative especially when it is caused by spills of heavy oils, in such a way that the smaller spills are added to the pollution already existing in the water, without allowing sufficient time for the natural process of recovery to take place.

### **CAUSES OF POLLUTION**

Among the principal causes of pollution are discharges from the bilges in machinery spaces and the cleaning of cargo tanks.

It is important to point out that while the majority of the large oil spills are involuntary, the smaller oil spills are due to human error and not to breakdowns in equipment. These are the type of discharge that should be prevented and which is subject to many laws.

Today, this problem is covered and regulated by the International Convention for the Prevention of pollution from Ships, 1973, and its Protocol of 1978 (MARPOL 73/78) and subsequent amendments.

#### **DISCHARGES FROM BILGES**

In order for a ship to discharge water from the bilges at sea, there are a series of

conditions which have to be met. For this reason, before carrying out any type of discharge, the responsible officer must be consulted.

### **CARGO AND BUNKERING OPERATIONS**

Normal cargo and bunkering operations, lead to spills and drops of dirty oil which are picked up in collectors and transferred to spill tanks. Included in these operations are the emptying and cleaning of tanks containing oily mixtures. Since the law applies equally to these cases, the same precautions should be taken to prevent spills of cargo oil or accidental discharges as from tanks containing sludge and dirty ballast.

### **GENERAL RECOMMENDATIONS**

If during loading operations, discharge, or bunkering, leaks occur from a hose or any other connections, the operations must be stopped. Should one of the hoses burst, loading or discharging must stop immediately.

Spills should be avoided when connecting/disconnecting the hoses. If the ship does not have an appropriate system for picking up spills, a tray should be placed under the connections. It is advisable to have a container with sawdust or sand close to the hose connections to use for spreading around the spill if necessary.

During operations involving derivatives of petroleum and bunkering, all scuppers should be plunged to prevent spills getting into the sea.

Whenever the ship is bunkering, or when loading and discharging, regular inspections must be carried out of the ship's side discharges and of the surface of the water in the vicinity of the sea water intake, in order to detect and prevent any loss of oil.

At all times when discharging from the bilges, sludge tanks and other sources, the sea discharges should be inspected.

The oily water which it is permitted to discharge into the sea is recognizable because it does not leave visible traces on the water.

Stopping polution is a "moral duty" for all the crew on board, whatever their rank or rating, although some ranks must assume a greater responsibility than others.

A lot of the pollution produced is the result of negligence, or failure to observe the minimum precautions necessary for prevention with the result that:

- Valves are improperly closed or closed at the wrong moment.
- Joints are fitted incorrectly.
- Garbage is discharged in port without proper authorization.

### CONSTRUCTION, EQUIPMENT AND OPERATIONS OF OIL TANKERS

Hereunder follows a description of the construction, equipment and operational requirements for oil tankers, designed to enable the ship to comply with the discharge provisions and to minimize pollution in the event of collision and stranding.

As indicated earlier, the protection of the marine environment against pollution from oil tankers is approahced through:

- construction requirements
- equipment requirements

- operational requirements
- survey and certificate requirements
- control procedures
- the imposition of penalties.

The construction requirements reflect the desire to prevent ballast water from coming into contact with cargo oil and hence to limit the generation of oily-water mixtures and the discharge of oil into the sea. They also reflect the desire to give ships carrying oil a greater survival capability, to protect the oil tanks by providing void spaces and to limit the size of tanks in order to minimize the outflow of oil in the event of accident. The equipment requirements are aimed at enabling the ship to comply with operational requirements. The earlier pollution convention, OILPOL 54, also laid down operational procedures, but without specifying the means to comply with them; this was though to be unsatisfactory. MARPOL 73/78 therefore not only lays down requirements, but also requires provision of the means to operate in accordance with those requirements.

#### Segregated ballast tanks (SBT)

New crude oil tankers above 20,000 tons deadweight and new product tankers above 30,000 tons deadweight must be provided with segregated ballast tanks of sufficient capacity so that it will not be necessary to take ballast water into cargo tanks except in extraordinary circumstances. SBT reduce the need for washing and therefore reduce oily-water mixtures, but only if they are of adequate capacity. Segregated ballast tanks are defined as tanks which are completely separated from the cargo oil and fuel oil system and which are permanently allocated to the carriage of ballast. They are served by their own pumps and piping adequate for their purpose. The capacity should be such that at any time of the voyage,

- the draught amidships is not less than 2.0 + 0.02L metres (where L = length between perpendiculars);
- the trim by the stern is not more than 0.015L;
- full immersion of the propeller is obtained.

New tankers in this context are those built after 1 January 1980. Less stringent requirements apply to ships built before that date, in recognition of the fact that retro-fitting segregated ballast systems may be costly and impracticable. Ships falling into the latter category may instead choose to:

- operate with dedicated clean ballast tanks (CBTs), if product tankers;
- be equipped and operate with a crude oil washing (COW) system, if crude oil tankers.

#### Protective location of ballast tanks

In addition to providing sufficient ballast capacity resulting in the stipulated mean draught and trim, SBT should also be located so as to offer some degree of protection in the event of stranding or collision. Ideally, this would be a double skin and double bottom of specified width and depth. In practice this is not necessary and partial protection is accepted, provided the total area of the protected side and bottom complies with certain parameters. The regulations also stipulate a minimum width of 2 metres for the wing ballast

tanks and a minimum height of 2 metres of B/15, whichever is the lesser, for the double bottom ballast tanks (B = maximum breadth of the ship). There is no requirements for the ratio of side and bottom protection, provided the total area complies with Annex I. In practice this means that in the case of oil tankers the SBT are wing tanks, adjacent to the ship's shell plating.

#### Limitation of tank size

This requirement concerns the construction of cargo tanks and is applicable to all oil tankers. The provision aims to limit the quantity of oil which can escape into the marine environment when the cargo tanks of an oil tanker are damaged. The provision limits the length and width of cargo tanks and, for large tankers, limits the hypothetical outflow to less than 40,000 cubic metres in cases of assumed collision and stranding damage.

### Subdivision and stability

In order to ensure a certain survival capability in the event of collision or stranding, Annex I contains requirements for the subdivision and stability of oil tankers.

Collision or stranding damage of a given longitudinal, transverse and vertical extent is assumed for the purpose of determining subdivision and stability. Furthermore, using the ship's length as a parameter, a distinction is made between the location of the assumed damage in relation to the ship's length. For tankers above 225 metres in length, the damage is assumed anywhere along the length of the ship. For shorter ships, certain areas, such as machinery and peak tank space, or damage involving a transverse bulkhead, are not considered in the damage assumption.

Taking account of the above damage and the resulting sinkage, heel and trim, the condition of the ship should be such that the waterline should be below the lower edge of any opening through which progressive flooding might take place. In that condition the stability should also meet certain requirements.

### Slop tanks

Slop tanks must be of adequate capacity, in order to ensure that tank washings and other oily mixtures can be retained on board for oil and water separation and subsequent discharge of the water as part of the LOT procedures. Annex I requires at least one slop tank for ships of less than 70,000 tons deadweight and at least two slop tanks for larger ships. The capacity of the slop tank is expressed as a percentage of the cargo-carrying capacity, and depends on the tank washing mode used. For open cycle washing a larger capacity is required than for washing in the recirculation mode. SBT and COW tankers and combination carriers also may have smaller capacity slop tanks. Slop-tank arrangements must be such as to facilitate the separation of oil and water.

#### **Overboard** piping

All discharges from cargo and ballast tanks must in principle be made above the waterline so as to ensure that both discharge and water surface may be observed. Since

discharge above the waterline may pose hazards in port for persons working on lighters, jetties, passing small craft, etc., the discharge of clean and segregated ballast is permitted below the waterline when in port. Pipelines on board reflect these requirements.

On large oil tankers (i.e., from 20,000 tons deadweight upwards) it should also be possible to drain the pump and lines, if necessary by connection to a stripping device. A special small diameter line should be provided to discharge these drainings to the shore.

### **Operational measures in lieu of construction requirements**

It is difficult, and may be extremely costly, to modity an existing oil tanker so that it complies with the SBT requirements, and ways had to be found for such oil tankers to be exempted while posing no threat to the marine environment.

In the case of crude oil tankers, one method for dealing with this problems is crude oil washing (COW). It was not a novel concept when it was introduced into the rules and a number of tanker operators were already practicing COW as a matter of routine. Reports indicated that, when carried out effectively, COW could considerably reduce oily residues in cargo tanks, so much so that subsequently only a water rinse would be necessary to prepare the cargo tanks for clean ballast. The oily-water mixtures were reduced to such an extent that they were considered to pose little threat to the marine environment. As far as existing oil tankers are concerned, COW was therefore accepted as offering protection equivalent to that provided by SBT. In fact, COW was considered to be so beneficial for the marine environment, particularly with regard to the removal of sludge from cargo tanks, that the requirement for COW was extended to cover new crude oil tankers as well.

In the case of existing product tankers, other means had to be agreed upon to give a level of environmental protection similar to that provided by SBT. A solution was found in the dedicated clean ballast tank (CBT) concept. With this method, rather than provide the ship with SBT, a number of cargo tanks are dedicated solely to the carriage of ballast. The capacity and distribution of the clean ballast tanks are such as to fulfill the trim and mean draught parameters that apply to SBT and to ensure that the ship not be subject to excessive stress forces when ballasted. The main difference between SBT and CBT is that CBT shares the same piping and pumping arrangements as cargo tanks.

### Crude oil washing (COW)

COW offers the following advantages over water washing of cargo tanks:

- reduction in pollution potential
- increased cargo outturn
- less deadfreight
- less time required in subsequent tank cleaning
- less time needed to prepare a tank for repairs in dry-dock
- less corrosion because of less water washing.

The disadvantages of COW are:

- increased workload
- prolonged discharge time
- cost of COW equipment
- increased safety risks in port.

COW operations are usually carried out in the port of discharge, although it is also possible to implement COW on passage between ports, provided that there is still a parcel of crude oil in the ship. The source of the oil for COW may be the discharge line, in which case provisions have been made to bleed off oil for tank washing. Alternatively, the contents of the slop tank may be used in the recirculation mode. When the discharge line is the source of the washing fluid, special measures may be necessary to ensure sufficient pressure on the washing line, especially if backpressure from the terminal is low. It may be argued that the use of oil from the slop tank means re-using the sludge removed from the cargo tanks, for further washing. In either case, it is important that sufficient crude oil be available to complete the COW programme.

In order to obtain the desired washing results, COW operations during subsequent trading of the ship should take place under tha same parameters as those used during the tests. Conditions influencing the washing results are:

- the number and location of washing machines
- nozzle diameter
- duration of washing
- number and size of drainholes
- effectiveness of the stripping system
- stripping procedure
- trim of the ship.

It should be noted that too many machines in use on a branch line could lead to excessive fluid velocity in the line, causing a pressure drop over the line and reducing the effectiveness of the machines being served. It is therefore important for the correct number of tank washing machines to be used at all times.

#### Dedicated clean ballast tanks (CBT)

As with COW, the use of CBT is a measure aimed at reducing the generation of oil/ water mixtures. It must be practised on oil tankers without SBT, which carry oils other than crude oil and hence are unable to carry out COW. In principle, an oil tanker with CBT is the same as an SBT tanker. Because it carries its ballast water in tanks designated for that purpose, there is no need to change ballast while underway to the loading port. The capacity and distribution of the tanks should ensure that no additional ballast is needed on most occasions, and their location in the ship's sides (where possible) should offer some degree of protection against pollution arising from collision damage. In accordance with the requirements of MARPOL 73/78, CBT may be used as an alternative to SBT on product tankers of 40,000 tons deadweight and above built before 1980.

#### Oil discharge monitoring and control equipment

The discharge provisions limit both the total quantity of oil that may be discharged into the sea from the cargo tank area and the instantaneous rate of discharge of oil. Equipment should be provided for oil tankers to enable them to comply. The discharge provisions also stipulate that the equipment should be in operation when oil and water mixtures are being discharged into the sea.

International specifications for the equipment have been established and only

approved types may be used on board. The equipment must come into operation whenever a discharge takes place. The discharge of segregated and clean ballast (except that from CBT tankers) need not be monitored. The equipment must stop the discharge automatically when the permitted quantity of oil or the permitted number of litres of oil per mile are being exceeded.

An oil discharge monitoring and control system consists essentially of four systems:

- an oil content metre able to analyse the relative content of oil in the water stream, expressed in parts per million (ppm);
- a flow meter able to measure the flow rate of oily water through the discharge pipe;
- a computing unit able to calculate the oil discharge rate in litres per nautical mile and total quantity, together with date and time identification;
- an overboard value control system able to stop the discharge when the permissible limit is reached.

### **Oil/water interface detector**

When decanting slop tanks, an essential operation during LOT procedures, the height of the oil/water interface must be established in order to prevent the discharge of oil into the sea. Interface detectors are usually portable instruments, although permanently installed equipment is also used. International specifications have been established and only approved equipment may be used.

The equipment, in this case a portable instrument, consists of a metal measuring tape, an ampere meter, a zinc weight and an earthing clamp to connect the equipment to the ship's structure. When the weight is suspended in salt water, galvanic action between the zinc and the steel structure of the ship generates an electric current, which is indicated on the meter. No current is generated when the zinc weight is suspended in oil. By lowering the zinc weight and measuring the height at which the current begins to flow it is possible to determine the interface. In practice, the weight is lowered through the oil into the water first to clean the oil from it. The weight is then raised until the current ceases, when it will again be at the interface.

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### ENTRY TO ENCLOSED SPACES

An enclosed space by definition is "any space that has been closed or unventilated for some time; any space that may, because of the cargo carried, contain harmful gases; any space which may be contaminated by cargo or gases leaking through a bulkhead or pipeline; any store—room containing harmful materials; any space which may be deficient in oxygen."

An enclosed space should not be entered unless authority has been given by the Master of Officer in charge.

Before entering, find out if it is safe to do so. When it is known to be safe follow this procedure:

- 1. Obtain proper authority.
- 2. Ventilate the space.
- 3. Test the atmosphere for toxicity and oxygen deficiency.
- 4. Continue ventilation.

- 5. Have breathing apparatus standing by.
- 6. Have resuscitation equipment at the entrance to the space.
- 7. Have rescue equipment at the entry to the space.
- 8. Have a rescue team, properly led, readily available.
- 9. Have a man standing by at the entrance watching for trouble and ready to raise the alarm.
- 10. Agree a system of communication before entry is made.
- 11. Continue to ventilate and test the atmosphere frequently.
- 12. Have adequate illumination.
- 13. When you are in the compartment signal your condition at regular intervals. If you feel unwell, come out at once.

If you are instructed to come out, do so at once.

When the atmosphere is known or suspected to be unsafe, follow the safety precautions already listed and in addition follow this procedure when using breathing apparatus.

- 14. Ensure that the wearer is properly trained to use it.
- 15. Check the equipment thoroughly.
- 16. Check that face mask fits properly.
- 17. The stand-by man should check the time of entry and ensure that there is enough time to leave the space.
- 18. Check that air cylinders are fully charged.
- 19. When in the compartment, leave if the low pressure audible alarm sounds, but do not rely on it look at the gauge frequently.
- 20. Never take off your mask in an enclosed space.
- 21. Establish a communication system before entering the space.
- 22. Never attempt to effect a rescue alone.

### SAFETY CHECK LIST

Before entering any enclosed space all the appropriate safety checks listed below must be carried out by the master or responsible officer and by the person who is to enter the space.

### To be checked by the master or responsible officer

1. Has the space been thoroughly ventilated and, where testing equipment is available, has the space been tested and found safe for entry?

2. Have arrangements been made to continue ventilation during occupancy of the space and at intervals during breaks?

3. Are rescue and resuscitation equipment available for immediate use beside the compartment entrance?

4. Have arrangements been made for a responsible person to be in constant attendance at the entrance to the space?

5. Has a system of communication between the person at the entrance and those in the space been agreed?

6. Are access and illumination adequate?

7. Are portable lights or other equipment to be used of an approved type?

When the necessary safety precautions in SECTION 1 have been taken, this card should be handed to the person who is to enter the space for completion.

# To be checked \_\_\_\_ by the person who is to enter the space

1. Have instructions or permission been given by the master or a responsible officer to enter the enclosed tank or compartment?

2. Has SECTION 1 been completed as necessary?

3. Are you aware you should leave the space immediately in the event of failure of the ventilation system?

4. Do you understand the arrangements made for communication between yourself and the responsible person in attendance at the entrance to the space?

Where breathing apparatus is to be used, this section must be checked jointly by the responsible officer and the person who is to enter the space.

- 1. Are you familiar with the apparatus to be used?
- 2. Has the apparatus been tested as follows?
  - Gauge and capacity of air supply
  - Low pressure audible alarm
  - Face mask air supply and tightness
- 3. Has the means of communication been tested and emergency signals agreed?

Where instructions have been given that a responsible person be in attendance at the entrance to the compartment, the person entering the space should show their completed card to that person before entering. entry should then only be permitted provided all the appropriate questions have been correctly checked

### **HOT WORK PERMITS**

This form of permit is intended to ensure a high degree of control and supervision when it is required to carry out hot work in hazardous or dangeruos areas.

Before the issue of such a permit is authorised the following conditions must be met:

- The area and any equipment to be worked on must be free of flammable material and in a non-flammable atmosphere as well as being isolated from sources of hydrocarbons by means of disconnecting, blanking or inserting blinds. No reliance should be placed on closed valves.

- The work area must be clear of any combustible material such as oil soaked rags, wood, sediments etc.

- Welding or other equipment being used must be appropriately earthed.

- The degree of risk and potential sites of accidental release of hydrocarbons in the area should be fully assessed.

- Fire fighting equipment must be ready for immediately use.

- A gas free certificate must be issued.
- The frequency of atmosphere monitoring shoul be established and the possible use

of portable continuous gas detector alarms considered.

- There should be effective means of containing and extinguishing welding sparks and molten slag.

- Personnel involved must be briefed or trained as appropriate.

The above considerations apply in principle to both shipboard and shore work, but before permitting hot work on board ship, additional hazards such as entry into enclosed spaces may have to be considered.

#### Permit to Work on a Tanker Berth

No construction, repair, maintenance, dismantling or modification of facilities should be carried out on a tanker berth without the permission of the terminal manager. If a tanker is moored at the berth, the agreement of the master should also be obtained by the terminal representative.

In all cases, except for routine work of a non-hazardous nature, this permission must be given in the written form of a permit to work.

#### PUMPROOMS

#### **General Precautions**

Pumprooms, by virtue of their location, design and operation, constitute a particular hazard and therefore necessitate special precautions.

Pumproom bilges should be kept clean and dry. Particular care should be taken to prevent the escape of petroleum products and/or hydrocarbon vapour into the pumproom. All pump seals, valve glands, drain cocks and mud boxes should therefore be maintained in good condition. In the event of a serious spillage, the application of a layer of fire extinguishing froth will help to control the generation of hydrocarbon vapour until the situation is brought under control.

### Ventilation

The probable presence of hydrocarbon gas within the pumproom requires the use of ventilation. Regulations require the mechanical expulsion of air and any petroleum gas from the bottom of the pumproom.

Before anyone enters a pumproom, it should be thoroughly ventilated and the atmosphere checked for petroleum gas. Ventilation should be maintained until access to the pumproom is no longer required.

Special attention should be paid to levels below the lower platform where petroleum gas is liable to accumulate.

Isolation of the pumproom vent system in the event of fire requires the efficient operation of dampers in the vent trunking. They should therefore be well maintained.

#### Pumproom Entry

No one should enter a pumproom at any time without first obtaining the permission of

a responsible officer.

It is the duty of the responsible officer in charge of cargo operations to ensure that adequate ventilation of the pumproom has been accomplished, that the atmosphere within the compartment is suitable for entry, and that adequate communication procedures ar established and maintained.

Notices should be displayed at the pumproom entrance prohibiting entry without prior permission.

The pumproom life lines and harness should be rigged ready for immediate use. Where possible an unobstructed direct lift should be provided.

Approved breathing apparatus and resuscitation apparatus should be available in an accessible location.

#### **Opening of Pumps, Valves or Equipment**

Prior to any operation or repair involving the opening up of pumps, cargo valves, cargo piping or electrical equipment the following procedures should be observed:

The atmosphere must be tested for hydrocarbon and toxic gas

A responsible officer should ensure that there are safe working conditions at the work site.

A work permit should be issued detailing the safety criteria to be observed and the work to be performed. The permit should be limited to a period not exceeding 12 hours.

The cargo system should be flushed through with water prior to opening up. Sections should be water flushed when opened to clear any petroleum residue. Surfaces should always be cleaned before work is carried out on them.

#### **SUPERVISION AND INSPECTIONS:**

1. RESPONSIBLE OFFICER - who is familiar with the arrangement of lines, valves and venting system in the tanker should supervise and control all cargo handling, ballasting and bunkering operations.

2. INSPECTION OF TANKER BEFORE HANDLING CARGO OR BALLASTING OR AT SEA - before handling cargo or ballasting begins, the responsible officer should be satisfied, as appropriate, that;

- No unauthorized persons are on board the tanker.
- No unauthorized work is being carried out.
- No unauthorized craft is alongside.
- No naked lights are being used.
- Craft alongside are advised that cargo handling or ballasting operations are to begin and the necessary safety measures are to be observed.
- The agreed ship/shore communication system is working.
- Ship's portable Radio/Telephone sets are of approved design.
- Warning notice are displayed as required.
- Appropriate ship and shore personnel have been notified the cargo handling or ballasting is about to begin.
- When necessary adequate safe lighting is available.
- Fire appliances are in good order.
- Emergency towing-off lines are in place.

- Canvas covers are removed from ship's floodlights.
- There is no smoking on board except in places approved by the Master.
- Cargo tanks to be used are open to the atmosphere via designed venting system.
- All cargo lines which are not in use are isolated, if possible and appropriate valve are closed.
- All doors and ports required to be closed are closed and ventilators are suitably trimmed.
- All valves to cargo and bunker lines which are required for use are properly set.
- Scuppers are properly plugged.

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- All cargo tanks lids, washing openings, ullage openings, sighting ports and similar fittings are closed.
- Any necessary shore connections are properly made and supported.
- All sea and over board discharge valves connected to cargo system are closed when not in use. In port, the terminal may present a safety checklist for mutual agreement.

3. INSPECTION AFTER LOADING – As soon as practicable after completion of loading, a responsible ship's officer should see and check all valves in the cargo system to see that they are closed, all appropriate tank openings are closed and all pressure valves are correctly set.

# FIRE FIGHTING PROCEDURES ON TANKER

1. **General** – Personnel discovering an outbreak of fire should raise the alarm immediately meanwhile trying to give consideration to the following points:

a. Try to fight by himself with whatever extinguishing agent available at hand.

b. If fire is inside a compartment or enclosed space, he should try as much as possible to close all openings leading to the compartment or space, to exclude air from the compartment.

c. If the fire is in an enclosed space, no doors leading to such space be left open until help arrives.

d. mechanical ventilation to the space should be secured immediately, the principal aim being to:

Limit the area of the fire.

- Extinguishing the fire by denying oxygen.

- Prevent re-ignition.

2. Solid Fires – Usually associated with beddings, wood, clothing inside accomodations and storerooms. Speed in the proper application of extinguishing agent is very essential for speedy extinguishment of the fire. For this type of fire, water will be the most effective agent to use. However, if the fire is deep-seated, the water should be in the form of solid stream so as to enable it to penetrate deep into the burning material.

3. Liquid Fires – The most serious fire fighting problem in a tanker. Foam is the most efficient agent for this kind of fire. Foam to be most effective must be applied so as to flow evenly and progressively over the burning surface, avoiding undue agitation.

This can best be achieved by directing the foam jet against any vertical surface adjacent to the fire or by advancing the jet in an oscillating sweeps with the wind.

4. Liquefied Gas Fires – Fires involving LPG, should were possible, be extinguished

by stopping the gas flow. If the flow of gas can not stopped, it may be safer to allow the fire to continue to burn at the same time using water spray to cool and control the effect of radiant heat. Extinguishing the flame may result in re-ignition and a wider spread of flame due to continued flow of gas. In order to reach and close the fuel valve, it may be necessary to extinguish flames from small leaks in its vicinity. In this case, dry powder estinguishers should be used and not water jet.

5. Electrical Equipment Fires — These may be caused by short circuit, over-heating, or the spreading of solid and liquid fires. The immediate action should be to de-energize the circuit involved. When this is done, any appropriate extinguishing agent may be used. If the circuit cannot be de-energized, CO<sub>2</sub> or dry powder can be used.

6. Cargo Tank Fires – With fire in a cargo tank containing bulk petroleum, the smothering system must be immediately turned on, and all accessible tank hatches ullage and other openings should be closed. The smothering system to the tank on fire and more remote from the fire should be closed. Water in the form of a jet or spray should be used to cool the surrounding decks, bulkheads or other structure. In the case of cargo tank fires where the deck is ruptured or the hatch cannot be closed, foam injected into the opening may be effective method of control.

7. Packed Cargo Fires – If a compartment containing packed cargo cannot be extinguished by smothering agent, flooding should be attempted, provided that there is no risk that burning liquid will overflow.

8. *Pumproom Fires* – Fire and explosions in pumprooms are usually the result of a combination of three conditions:

- Malfunctions of machinery such as packing glands, hot bearings or other points of excessive friction creating temperatures high enough to ignite volatile gases or liquids.
- b. Leakage of petroleum products into pumproom and collection in bilges.
- c. Insufficient ventilation to keep volatile fumes below the lower flammable limit.

As pumproom are normally confined areas, fixed  $CO_2$ , water fog, high expansion foam system are very effective in extinguishing fires. Water fog has a cooling effect will help to protect anyone trapped in the area.  $CO_2$  has no cooling effect, it displaces oxygen and anyone remaining in the area will be asphyxiated.

9. Open Deck Fires – With fire on deck following a tank overflow, burst hose or leaking pipeline, the supply of fuel should first be shut off. Dry chemical, foam, water fog, or water spray should then be applied.

10. Nearby Fires – If fire occur on shore or on board another vessel in the immediate vicinity, the ship's fire fighting organization should be made ready. All cargo handling, ballasting, bunkering, gas-freeing, or tank cleaning should be stopped and all valves, openings should be closed. All canvas awnings and sun screens should be furled or wetted down.

### **INERT GAS SYSTEM**

The main reason for the installation of an Inert Gas system on board a tankship is to minimize the danger of fire or explosion in cargo tanks.

This danger is always existing, due to the fact that all three elements needed to start a fire or explosion will be present.

#### Three elements are:

- 1. A combustible element, fuel, represented by hydrocarbon vapours from the cargo.
- 2. Energy to start the combustion, represented by the sparks from various sources.
- 3. Oxygen to support the combustion, represented by the oxygen in the air, which contains roughly 21% oxygen and 79% Nitrogen.

To set off a fire or explosion all three elements must be present simultaneously.

If any of the three elements can be eliminated, the danger of explosion is also eliminated, and this is the philosophy behind the inert gas system.

### When looking for the simplest element to remove, one will find that:

1. The fuel part can never be eliminated, due to the nature of the cargo which in itself is highly inflammable.

The cargo will always evaporate explosive hydrocarbon vapours, which will fill and void spaces in the tanks, and mix with the air entering the tanks through open hatches, etc.

On the ballast voyage the empty tank is also filled with a mixture of air, drawn in when unloading and vapours from the cargo remain in the tank.

2. The energy spark to set off an explosion is also very difficult to eliminate completely.

Exhaustive studies have been made by maritime bodies worldwide. No exact conclusion has been drawn, but it is a recognized fact that the most dangerous source of ignition is that of static electricity, which may be created in various ways inside the tank.

The nature of this static electricity is such that it is difficult to recognize, and therefore almost impossible to eliminate.

3. The only element left is the oxygen to support combustion. This is always present as 21% of the earth's atmosphere.

However, the percentage of oxygen inside the cargo tanks can be controlled, by replacing the air with an inert gas, namely, a gas with an oxygen content too low to form an explosive mixture regardless of the amount of petroleum gas on the atmosphere of the tank.

### EXPLOSIVE LIMITS

The chemical composition of air is basically:

Oxygen - O2 = 21% volume Nitrogen - N2 = 79 volume

A mixture of hydrocarbon gas and air has two limits of explosivity.

- The lower explosive limit (LEL), is 2% of gas -(98% of air).

- The upper explosive limit (LEL), is 10% of gas-(90% of air).

Within these two limits, the mixture is inflammable. Below the lower explosive limit, the mixture is too lean to burn. Above the upper explosive limit, the mixture is too rich too burn.

- A. Hydrocarbon gas in a haseous mixture containing oxygen will only burn if the content of hydrocarbon gas in the mixture lies between the upper and lower limits of inflammability. These limits which are, respectively, 10% and 2% in air, vary according to the oxygen content of the mixture. The gaps between then narrows progressively as the oxygen content diminishes.
- B. If the oxygen content of the gaseous mixture is BELOW 11%, the hydrocarbon gas contained in the mixture CANNOT BURN WHATEVER ITS CONCENTRA-TION MAY BE. An atmosphere containing less than 11% of oxygen is considered to be THEORETICALLY INERT.

#### Quantity and Rate of Supply of inert Gas

The most critical demand for Inert Gas is during cargo discharge, when the supply must at least equal the cargo discharge rate. Centrifugal cargo pumps have a rated capacity against a nominal head, but on some occasions it is possible to exceed the rated capacity when discharging against a lower head.

To cater for such variations in discharge rate, the Inert Gas System capacity has been sized on the nominal pumping rate multiplied by at least 1.25

IF THE CARGO DISCHARGE CAPACITY EVER EXCEEDS INERT GAS CAPACITY, THE DISCHARGE RATE SHOULD BE REDUCED IN ORDER TO MAINTAINE A POSITIVE INERT GAS PRESSURE.

#### Safe Oxygen Levels

During inert gas plant operations, it is of utmost importance to keep the oxygen levels as low as possible, in order to have the greatest possible safety margin.



### **Oxygen Levels:**

- 11% Oxygen: MINIMUN OXYGEN LEVEL necessary to support combustion/ explosion, this level, however, is not considered safety, since there is no margin left for measurement errors.
- 8% Oxygen: MINIMUN OXYGEN LEVEL ALLOWED during inert gas plant operations. However, all necessary steps must be taken to ensure oxygen level below 8%.

5% Oxygen: SATISFACTORY OXYGEN LEVEL. This is considered the normal maximum level that a good operating vessel shall maintain, even with the worst boiler load condition.

Less than

3% oxygen: BEST OXYGEN LEVEL for a good operating vessel. The I.G.S operations in the following sections refer to this level.

BASIC FUEL GAS COMPOSITION

02	– content:	Approx. 3% by volume
ĊŌ,	- content:	Approx. 13% by volume
SO,	- content:	Approx. 3000 ppm
NO	- content:	Balance

This means that during normal operation of oil tankers the following operational modes frequently take place:

- Inerting of empty tanks
- Inening during loading and simultaneous discharge to ballast
- Inerting during loaded sea voyage
- Inerting during discharging and ballasting
- Inerting during tank cleaning
- Purging prior to gas freeing and used of the IGS during gas freeing.



**SCHEMATIC DIAGRAM OF INERT GAS PLANTS:** 

# **PARTS:**

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1.	Boiler gas uptake	4.	Suction valve	9.	Back flow valve	14.	O <sub>2</sub> – analyser or gas generator
2.	Gas uptake valve	5.	Fan	10.	Isolating valve	14a	.O <sub>2</sub> – analyser and recorder
3.	Scrubber	6.	Supply valve	11.	Tank Isolating valv	e15.	Pressure indicator
3a.	Cooling water inlet	7.	Pressure control	12.V	entilation (Riser)	15a	Pressure indicator valve and recorder
3b.	Cooling water outlet	8.	Water seal	13.	P/V breaker		

### MAIN FUNCTION OF EACH COMPONENT IN INERT GAS SYSTEM

1.		Gas uptake or gas generator	Stack gas supply
2.		Gas uptake isolating valves	Isolation of inert gas plant from bollers/generators.
3.		Inert gas scrubber	Cooling of gas and removal Sulphur dioxide and solid particles.
34	a.	Seawater inert	Cooling and washing water inlet to scubber.
31	b.	Seawater outlet	" " " outlet from scubber.
4.		Isolating valve suction side	Fan isolating valve suction side.
5.		Fan	Fan for transport of inert gas to tanks.
6.		Isolating valve	Fan isolating valve pressure side.
7.		Deck water seal	Prevent backflow of hydrocarbon gases from tanks to engine room during shutdown.
8.		Non return valve	Prevent backflow of hydrocarbon gases or crude oil in the event of overfilling.
9.		Tank isolating valve	For isolation of tanks from inert gas system in case of gas freeing, or if tank has to be opened.
10	0.	Mast ventilation	For ventilation or relieving of gas pressure from tanks.
1'	1.	Pressure/vacuum breaker	A common pressure/vacuum valve in addition to individual breaker p/v-valves on tanks. Prevention of damage to tanks in case of overpressure or under- pressure in tanks.
1:	2.	Gas analyser	Control of the inert gas with respect to high oxygen content.
12	2a.	Gas analyser	Oxygen content meter with recorder
1:	3.	Pressure meter	Pressure meter with indicator and recorder in deck main line.

# MAINTENANCE ROUTINE CHECK

Component	Preventive maintenance	Maintenance interval	
Flue gas isolating valves	Operate the valve	Before start-up and one week	
	Cleaning with compressed air or steam	Before operating valve	
	Dismantling for inspection and cleaning	Boiler shut-down	
Flue gas	Water flush	After use	
scrubber	Cleaning of demister	Three months	
	Dismantling of level regulators and temperature probes for inspection	Six months	
	Opening for full internal inspection	Dry-docking	
Overboard pipes and valve	Flushing with scrubber water pump for about one hour	After use	
scrubber	Dismantling of the valve for overhaul, inspection of pipeline and overboard end	Dry-docking/repair period	
Blowers	Vibration check	While running	
	Flushing	After use	
	Internal inspection through hatches	After flushing and six months	
	Dismantling for full overhaul of bearings, shaft tightenings and other necessary work	Two years or more frequently if required/dry-docking	
Deck water seal	Dismantling of level regulators/ float valves for inspection	Six months	
	Opening for total internal inspection	One year	
	Overhaul of auto-valves	One year	
Deck mechanical nonreturn valve	Moving and lubricating the valve if necessary	One week and before start	
	Opening for internal inspection	One year/18 months	
Pressure-vacuum valves	Operating and lubricating the valves	Six months	
	Opening for full overhauland inspection	One year	
Deck isolating valve	Opening for overhaul	One year	

Gas pressure regulating system	Removal of condensation in instrument, air supply	Before start
	Opening of gas pressure regulating valves for overhaul	As appropriate
Liquid-filled pressure-vacuum breaker	Check liquid level when system is at atmospheric pressure	When opportunity permits and every six months

# **STARTING PROCEDURES:**

### Starting up (engine room)

1. Open gas valves on blower uptakes.

2. Shut blower discharge valve.

3. Switch gas regulating valve (if any) on "manual" and reduce diaphragm pressure to abt. 6 psig until indicator that shows "closed".

4. Open cooling water supply to scrubber. The pressure at scrubber inlet should be abt. 5 kg/cm<sup>2</sup>. Drain the main and auxiliary blowers. Start the main blower and recirculate the gas to scrubber. The blower discharge pressure should be 0.22 - 0.25 kg/cm<sup>2</sup>.

5. Observe temperature on blower housing and reduce discharge pressure if the blower temperature exceeds 65°C. The discharge pressure is reduced by reducing the lever length on recirculating valve.

6. Observe the water level in the scrubber. If all is in order, inform the deck department, that the plant is ready supply gas.

### Starting up (deck)

1. Open drain cocks in gas lines and drain off condensate which may have accumulated.

2. Drain non return valve (if fitted).

3. Check pressure/vacuum valves and ensure that the valves move freely and are correctly adjusted.

4. Check oil level in vacuum breaker (oil seal, if fitted), and drain off water.

5. Check water level in water seal on deck (if fitted) and that the water is discharging overboard. When all is in order, open non return valve (or manual) isolating valve, if installed).

The whole piping system in engine room and on deck under pressure corresponding to the recirculating gas quickly from blower to scrubber. Check gas  $0_2$  (or  $C0_2$ ) content in deck lines by using portable  $0_2$  (or  $C0_2$ ) indicators.

The gas quality in gas lines on deck should be almost the same as can be indicated in boiler uptakes.

If the gas qualities are the same and 0, content is high/adjust air/fuel ratio to burners.

## **GENERAL MAINTENANCE**

If the equipment shall give the protection of the tank system is the intention with the installation, all components must be systematically maintained in order to give the highest possible reliability and efficiency.

### Mechanical components

Daily

- 1. Turn the main blowers.
- 2. Turn the auxiliary blower (if any).
- 3. Turn the stationary cooling water pumps.

4. Blow soot from boiler uptake valves and scoops. (If purge air is not used). The upper sootblowing connection should preferably bonded. Be sure that steam pressure does not build up in the scrubber.

- 5. Drain off water from gas line in engine room.
- 6. Drain off water from blower housing.

### Weekly

- 1. Move boiler uptake valves and preferably in connection with sootblowing.
  - N.B. DO NOT SOOTBLOW FLUE GAS LINES TO SCRUBBER WITH IDLER UPTAKE VALVES CLOSED.
- 2. Check oil level in gas line vacuum breaker on deck if any.
- 3. Check water level in water seal tanks through sight glass.

# After each cargo voyage

1. Inspect one gas filter/demister at top of scrubber. Flush with fresh water if necessary.

2. Flush the upper (2nd) wet filter in scrubber with fresh water after conclusion of tank cleaning.

3. Inspect the non return value on deck through inspection opening. The value disc shall move freely.

# Control and safety system

### Daily

1. Check air pressure to air valves for automatic washing and maintain the correct pressure required.

2. Drain off water from air pressure reducing valves to the instruments.

### Weekly

1. Close non return valve on deck. This valve should always be closed when the inert gas system is not operated.

2. Open at least one boiler uptake valve. The blowers should *never* be started with boiler uptake valves closed.

3. Open cooling water supply to scrubber.

4. Start one blower and be sure that the gas recirculation to scrubber. (Observe blower temperature and auto-water seal is drained).

- 5. Open blower discharge valve and gas regulating valve.
- 6. Shut off water supply to scrubber. If all is correct, the following should happen:
  - a) Visible and audible alarm for low water pressure
  - b) The blower stops.
  - c) The blower discharge valve closes.
  - d) The gas regulating valve closes.
  - e) The drain valve on water seal closes and drop valve opens.
  - f) The auto-water seal is filled.

The same test is described in 1 through 6 should be carried out once a month for the thermostats in top of scrubber. The thermostat sensor can be tested in water of 60 - 65°C, and the effect of this test should be the same as described above

The same effect has also breaking of the contact in the water level switch in scrubber shell.

### Every 6 months.

- 1. Inspect internal parts of scrubber for:
  - a) Condition of spray nozzles and water pipings.
  - b) Wet filter condition.
  - c) Corrosion on scrubbershell and inlet chamber.

d) If filter mass has fallen to the bottom of scrubber to drain pipes or water

seal in scrubber water drain line.

- e) Corrosion in scrubber bottom, especially in weld seat.
- 2. Inspect internal parts of water seal for: (both auto-water seal and 2nd water seal, if fitted)
  - a) Corrosion on water seal shell.
  - b) Corrosion on the submerged pipe.
  - c) Corrosion on valve seats for drop and drain valve.

If corrosion is observed on the cold parts of scrubber in water seal shell, the corroded parts should be dry cleaned with steel brush and painted with tar epoxy.

Corrosion in the stainless steel parts of the scrubber be the result of insufficient flushing of the part corrosion occurs. It is therefore important that nozzles both in inlet chamber and in the main scrubber are in good condition.

The flushing of the inlet chamber can be checked the inspection covers.

IT IS IMPORTANT THAT THE SCRUBBER IS FLUSHED FOR SEVERAL HOURS WITH COOLING WATER BEFORE CLOSING DOWN THE PLANT.

### INERTING OF TANKS

### Inerting of empty gas free tanks

Start up the inert gas plant according to instructions. Close all tank hatches and check proper function of O<sub>2</sub> – analyser. Open lids or hatch covers on stand pipes or purge pipes on tanks to be inerted.

Open fan discharge valve (6) and main isolating valve (10) (see Fig. 1)

If the gas pressure control valve (7) is on "automatic", there is now a risk of "overload" of the scrubber due to a limited pressure drop in pipes and tanks. The "overload" of the scrubber may result in "carry over" of water or high temperature trip of the plant.

Because of the above, it is therefore sometimes necessary to control the pressure manually to reduce the gas flow during the first part of the inerting, until a minimum gas back pressure is established in the tanks. When this minimum gas pressure for stable operation is established, the inert gas plant can be operated automatically at full capacity.

Fig. 1 indicates the plant in operation



Figure 1 Condition: Inerting of tanks filled with air

- inert gas generator 2. Gas uptake valves
- 3. Scrubber
- 4. Fan isolating valves suction side
- 4a. Fresh air intake valve
- 5. Fans

- pressure side
- 7. Pressure control valve
- 8. Deck water seal
- 9. Non return valve
- 10. Deck line isolating valve
- 11. Tank isolating valves
- 12. Ventilation mast (riser)

- breaker (common)
- 14. P/V valves (individual)
- 15. P/V valve in ventilation line
- By-pass valve 16.
- 17. Tank hatch
- Level indicator 18.
- 19. Purge pipe

The oxygen-content in the tanks should be checked frequently, at least every half hour. The inerting should be continued until the gas leaving the tank has had a  $O_2$ -content of less than 8 percent for a minimum of 30 minutes. This is because of the possibility of local air pockets in the tanks.

When all tanks are satisfactorily inerted the tanks should be put under a slight overpressure, normally 300-600 mm W.G., and the plant closed down according to instructions and the tank isolating valves closed.

### Inerting during loading and simultaneous discharge of ballast water

The vessel is supposed to arrive at the loading port with all cargo tanks inerted.

If the ship is fitted with a central gas vent outlet, all tanks to be loaded are connected to the vent system.

In case only the local P/V – valves are fitted, the valves are checked and adjusted for gas evacuation through the high speed valves.

It should be checked that all tank hatches are closed and possible float level indicators are operable.

#### Discharge of ballast

Discharge of ballast can be done either before or during the loading. During discharge of ballast, before loading is commenced, the inerting procedure is the same as during discharge of cargo. See next chapter.

At simultaneous loading of cargo and discharge of ballast the loading capacity is normally higher than the ballast water discharge capacity. This means that the inert gas volume available in the ullage space above the oil level in the tanks being loaded is more than sufficient for the inert gas needed in the ballast tanks during discharge. By simply connecting the ballast tank to the cargo tanks with the inert gas lines on deck, inert gas will flow from the cargo tanks to the ballast tanks.

The inert gas system can be operated if required, but will normally not deliver any gas to the deck lines.

If by chance the ballast discharge rate is higher than the loading rate, the inert gas system must be in operation and the deck pressure adjusted sufficiently high to give a positive outflow of inert gas through the ventilation mast (or the individual P/V – valves onthe tanks). This is to avoid air being sucked into the tank system by a possible underpressure in the ballast tanks.

In order to start the loaded voyage with positive pressure in the tanks, the IGS has to be started and tanks purged to a pressure of 300-600 mm W.G.

#### Loaded sea voyage

During the loaded voyage the cargo tanks should as far as possible be kept inerted with a positive pressure.

This positive pressure may, however, be disturbed by several factors. The most common are:

leakages in valves and hatch covers

- change of pressure in the tanks due to temperature variations (i.e. day and night and sea/air temperature changes)

rolling and heaving in rough sea.

The effect of the different conditions as mentioned above is partly a pressure drop in the tank (escape of inert gas) and partly the risk of ingress of air into the tanks (temperature aspiration and local underpressure in tanks due to rolling and heaving).

Consequently, the oxygen content and the tank pressure should be frequently checked during the sea voyage. The frequency should depend on weather and deck equipment conditions.

"Topping up" of the tank inert gas pressure may be done by starting up of the inert gas system, or by using a special "topping up" inert gas generator, if fitted, or by starting up the IGS. The volume needed for this topping–up operation is normally small in loaded condition. "Topping up" is demonstrated in Fig. 4.



Figure 4. Condition : "Topping up" of tanks

- 1. Boiler gas uptake or inert gas generator
- 2. Gas uptake valves
- 3. Scrubber
- 4. Fan isolating valves suction side
- 4a. Fresh air intake valve
- 5. Fans

- 6. Fan isolating valves pressure side
- 7. Pressure control valve
- 8. Deck water seal
- 9. Non return valve
- 10. Deck line isolating valve
- 11. Tank isolating valves
- 12. Ventilation mast (riser)

- 13. Pressure/vacuum breaker (common)
- 14. P/V valves (individual)
- 15. P/V valve in ventilation line
- 16. By-pass valve
- 17. Tank hatch
- 18. Level indicator
- 19. Purge pipe

#### Discharging and ballasting

*Discharging.* When the vessel arrives at the discharge port, the inert gas system should be tested and ready for operation in due time for discharge.

Before cargo oil pumping is started the inert gas system should be in operation and connected to the deck line, with the pressure control in the automatic position.

Since the ullage volume is normally small in loaded condition, the desired overpressure is reached in a short time (minutes).

All decks openings and hatches should be closed, all P/V-valves in the operating position and by-pass valves closed.

When the pumping (discharge) starts the pressure in the ullage volume will drop. Now the control valve (7) will start operating and open for inert gas to compensate the pressure drop and keep a constant preselected pressure in the tanks. After some time the required pressure is established. At this moment the volume delivered from the inert system is equal to the cargo pump delivery. This condition is illustrated in Fig. 5.



#### Figure 5. Condition : Discharge

If for any reasons access to the cargo tanks is necessary during discharge the following procedure should be followed:

1. Reduce the inert gas pressure by adjusting the pressure control valve set point.

2. When the tanks' inert gas pressure is reduced to near atmospheric pressure, a suitable ullage hatch has to be opened carefully.

3. When reading is finished, the hatch may be closed and pressure raised if desired.

When discharge and stripping are finished, the tanks should be put under the desired positive pressure.
### Ballasting during discharge of cargo

Normally, time may be saved by taking in ballast while discharging. This is normally done in the last period (during stripping) of the discharge.

This means that some tanks displace inert gas while some consume inert gas. During the stripping of the last tanks, the discharge rate is normally less than the ballast rate. In this case there is surplus of inert gas, and the inert gas system may, if desired, be stopped. In case of the reverse, the inert gas system must be in operation to prevent air from being sucked into the tanks. See Fig. 6.



### Figure 6. Condition : Simultaneous discharge and ballasting

- 1. Boiler gas uptake or inert gas generator
- 2. Gas uptake valves
- 3. Scrubber
- 4. Fan isolating valves suction side
- 4a. Fresh air intake valve
- 5. Fans

- 6. Fan isolating valves pressure side
- 7. Pressure control valve
- 8. Deck water seal
- 9. Non return valve
- 10. Deck line isolating valve
- 11. Tank isolating valves
- 12. Ventilation mast (riser)

- 13. Pressure/vacuum breaker (common)
- 14. P/V valves (individual)
- 15. P/V valve in ventilation line
- 16. By-pass valve
- 17. Tank hatch
- 18. Level indicator
- 19. Purge pipe

The procedure for these operations is the same as for discharging cargo. In case the ballasting rate exceeds the stripping rate, however, the bypass valve in the ventilation must

be open (or in the case of individual P/V-valves, the valves must be opened). The inert gas pressure will in this case be reduced to atmospheric pressure.

Fig. 6 indicates the positions of the different main valves in the system during this operation mode. The capacity of the inert gas system should always be adjusted to give positive outflow of inert gas through the ventilation mast. This is done to prevent air from being sucked into the tanks.

When the vessel is ballasted the by-pass valve should be closed and the tank inert gas pressure raised to the desired pressure before the main isolating valve is closed and the inert gas plant stopped.

#### Ballast voyage

After the vessel has left the discharge port, the inert gas system should be in operation for purging of all cargo tanks to reduce the HC-gas concentration. The operation should be controlled by checking the HC-gas concentration in gas leaving the purge pipes, or with tests taken at different levels in the tanks.

When the tanks have been purged and the HC-gas concentration checked to be below ab. 2.5 per cent by volume, the tanks should be pressurized and the inert gas system closed down.

The tank pressure and oxygen concentration should be monitored during the voyage as discussed in chapter 4, and new purging or "topping up" should be done when necessary.

#### Tank cleaning

The oxygen content in the tank atmosphere should always be checked before any tank cleaning is started. No tank cleaning, either with the cargo oil – Crude Oil Washing (COW) – or with water, should be started unless the oxygen content is 8 per cent by volume or less measured in the tanks.

For tankers with Crude Oil Washing Systems the following procedure is to be complied with.

Before each tank is crude oil washed, the oxygen shall be determined at a point 1 metre from the deck and at the middle region of the ullage space and neither of these determinations shall exceed 8 per cent by volume. Where tanks have complete or partial wash bulkheads, the determinations should be taken from similar levels in each section of the tank. The oxygen level of the inert gas being delivered during the washing process shall be continuously monitored. If during crude oil washing:

(1) the oxygen level of the inert gas being delivered exceeds 8 per cent by volume; or

(2) the pressure of the atmosphere at the tanks is no longer positive, then the washing must be stopped until satisfactory conditions are restored.

In Fig. 7 the conditions during tank cleaning are shown.





### Gas freeing

When acces to the cargo tanks is necessary to inspection, repair a.s.o. the inert gas or inert gas/HC-gas mixture has to be replaced with fresh air. This replacement is called "gas freeing".

The gas freeing is normally carried out by one or more of the following three methods:

1. By portable tank ventilators

2. By permanently installed tank ventilators blowing air to tanks through the cargo oil piping system.

3. By using the inert gas system fans with suction from fresh air instead of the scrubber.

Whenever a method is being used for gas freeing the following steps should be taken:

1. Hydrocarbon gas concentration to be measured in each tank to be gas freed.

2. If the HC-gas concentration is 2.5% by volume or less ventilation with fresh air may start immediately.

Part VIII

Section I

# **MACHINE SHOP**

Section II

**PUMPS** 

Section III

# **CONTROL AUTOMATION**

**Section IV** 

ORGANIZATION OF ENGINE DEPARTMENT

**Section V** 

**CODE OF ETHICS** 

# Section I

# **MACHINE SHOP**

### Q. What is a machine shop?

A machine shop is a place in which metal parts are cut to the size required and put together to form mechanical units or machine, the machine so made to be used directly or indirectly in the production of the necessities and luxuries of civilization.

### Q. What are the standard machine tools and safety operation?

**LATHE** – is a metal turning machine tool in which the work, while revolving on a horizontal axis, is acted upon by a cutting tool which is made to move slowly in a direction more or less parallel to the axis of the work, or in a direction at right angles to the axis of the work operated by hand or by power as desired.

### Safety Procedure:

- 1. Before turning on the power, check to see that the tailstock tool holder, and job are properly clamped.
- 2. Use hand power only when putting on a removing check or faceplate.
- 3. Do not leave chuck wrench or any other tool in the chuck.
- 4. Do not use wrench or revolving work or parts.
- 5. Never try to measure work or feel the edge or adjust a cutting tool when lathe is running.
- 6. Do not take heavy cut on long slender work.
- 7. As a general rule, do not shift or change gears while lathe is running.
- 8. Stand erect. This keeps head away from flying ships.

**DRILLING MACHINE** — or drill press is a machine tool used mainly for producing holes n metal. In this machine, the work is securely held while a revolving cutting tool is fell nto it.

### afety Operations:

- 1. Use drills properly sharpened to cut to the right size.
- 2. Small drills should revalue at high speed, large drills at low speed.

- 3. Chuck wrenches must be removed from drill chuck before starting the machine.
- 4. Never attempt to hold work under the drill by hand. Always clamp work to table.
- 5. If drill stops in work, shut off motor and start drill by hand.
- 6. Keep your head back and well away from any moving parts of the machine.

**SHAPER** – is ordinarily used for finishing flat or partly curved surfaces of metal pieces few in number and not usually over a foot or two long. Cutting tools used in the shapes are similar to the turning tools used in the lathe.

### Safety Operations:

- 1. Be sure ram, tool head, work, etc. are properly secured in place.
- 2. After setting the stroke length and position, check to see that adjusting nuts are tight.
- 3. Remove all wrenches from machine after completing set-up.
- 4. Stand parallel to direction of stroke of machine when running.
- 5. Never remove chips while ram is in motion.

**PLANER** – is a machine tool used in the production of flat surfaces on pieces too large or too heavy or awkward to hold in a shaper. Cutting tools used in planer work are the same as those used in the shaper.

### Safety Operations:

- 1. After work is fastened, check to see that it clears crossrails, and served clamps in position.
- 2. See the feed rod and its attachment are properly located and in proper order.
- 3. Do not reach over a moving job and never ride the bed or platen.
- 4. Do not leave any tools of any kind between ways.

MILLING MACHINE – is a machine tool in which metal is removed by means of a revolving cutter with many teeth, each tooth have a cutting edge remove share of the stock.

# Safety Operations:

- 1. Make sure cutter and arbor are secured to clear the work.
- 2. Use only cutters that are correctly ground in good condition.
- 3. To avoid striking hands on cutter while setting up, move table with work as far away from cutter as possible.
- 4. Check speed and feeds, works against direction in which cutter is rotating.
- 5. Keep hands away from work when machining.
- 6. Use a brush not the hands to remove chips.

**GRINDING MACHINE** – is a machine tool in which an abrassive wheel is used as a cutting tool to obtain a high degree of accuracy and smooth finish on metal parts.

### Safety Operations:

- 1. Stand to one side out of line of wheel when starting it up especially wheel is new.
- 2. Work should be fed slowly and gradually.
- 3. Never use grinding wheel that is loose on the shaft.
- 4. Stop wheel if it chatters or vibrate excessively.
- 5. Use clamp or other suitable holding devices for grinding short pieces.
- 6. Always use goggles any time.

**BORING MILL** – consist of two types: the vertical and horizontal and method of operation of enlarging a hole, usually by means of a single cutting tool and designed primarily for the purpose of finishing holes that are not possible to other machines.

### **GENERAL SAFETY PRECAUTIONS IN SHOP:**

- 1. Be sure that all machines have effective and properly working guards that are always in place when running.
- 2. Replace guards immediately after any repairs.
- 3. Do not attempt to oil, clean, adjust or repair any machine while it is running. Stop the machine and lock the power switch in the off position.
- 4. Do not operate any machine unless authorized to do so by the teachers or under his supervisions.
- 5. Don't try to stop the machine with your hand or body.
- 6. Always see that work and cutting tools on any machine are clamped securely before starting.
- 7. Keep the floor clean of metal chips or curls and waste pieces.
- 8. Get help for handling long or heavy pieces of material. Follow safe lifting practice lift with your leg muscles, not your back.
- 9. When working with another student, only one should operate machine or switches.
- 10. Don't lean against the machine.
- 11. Do not run in the shop no fooling around.
- 12. Concentrate on the work and not talk unnecessarily while operating the machine.
- 13. Get first aid immediately for any injury.
- 14. Be sure you have sufficient light to see clearly. Check with the teacher if you do not have enough.

# SHOP TOOLS AND THEIR USES

- BELT (HOLE) PUNCH-used for cutting the bolt holes in gasket materials or in leather belting.
- BOLT CUTTERS made in several sizes from 18 36 inches used for heavy duty cutting jobs. It has special replaceable jaws of extra hard metal alloys-to avoid twisting motion when material is brittle.
- **CALIPERS -** are used for measuring diameters and distance or for comparing distances and sizes. Types are:

Outside Calipers - used for measuring outside dimension. Example: Diameter of a piece of round stock.

Inside Calipers - have inward curving legs for measuring inside diameters. Example: diameter of holes.

Hermaphrodite calipers - are generally used to scribe arc or marking gage in layout work.

- CENTER GAGE edge of this gage have 60°, use to check the grinding of thread cutting tools.
- CHISELS cold chisels are tool used for chipping or cutting cold metal. Classified according to their shape: Flat, Cape, Diamond and Round nose point.

Flat chisels – used and determined by the width of the cutting edge.

Cape chisels – used for cutting keyways where square corners on the slot are necessary.

Round nose chisels - usually used for cutting oil grooves in bearing.

Diamond pt. chisels – used for cutting "V" groove and inside sharp angles.

- CLAMPS when a vise not available, a clamp may be used to hold pieces of material tag while they are being worked on. Types: hand screw, toolmakers, carriage screw and beam clamps.
- COMBINATION CALIPER RULE has jaws designed to make either inside or outside measurements.
- COUPLING & GEAR PULLER a three jaw puller suitable for removing coupling, gears, etc., from shafts which shows strong, uniform full to remove gear bearing for convenient way.

- CUTTING & FLARING TUBES consist of a small tubing used for refrigeration lines and similar purposes by using tubing cutter. Flaring tubing used to expand the end of the tubing connections.
- CUTTING PIPE usually cut with a hand hacksaw, a power hacksaw or a pipe cutter. Pipe cutter most popular used on most ship, these are only adjusted and tightened by turning the handle.
- DEPTH RULE has narrow blade which slide through a slotted locking arrangement, used to measure the depth holes, slots, keyways, etc.
- DIES consist die and stock, before threading a piece of round stock its end should be tapered or chamfered slightly with a file or by grinding, so that die will start cutting more easily.
- DRILLS made of carbon steel or high speed alloy steel used for general purposes, making a smaller to larger holes. Types: hand dries, and breast drill and can use clamp block to the piece of metal.
- FILES are used for cutting smoothing or removing small amounts of metal, made in various shapes, cut of teeth and length.
- FUSE FULLERS is designed for easy and safe removal of electric fuses.
- HACKSAW used for cutting metal. Types are solid and adjustable. Solid hold only one side of blade while adjustable type can be fitted with different length blades. Hacksaw blade come in two forms hard back and flexible back.
- HAMMERS -- consist of: Ballpen or machinist hammer used for general purposes:
  - Soft hammers used for hammering or working on a finished surface in order not be marked.
  - Sledge hammers made of heavy weight between 5 25 pound used for producing heavy blows.
  - Scaling hammers more often used as chipping hammers for removing scale, point, etc.
- HANDSNIPS -- used for cutting sheet metal or other thin pieces of metal, also for cutting out circular pieces.

**MICROMETER CALIPERS** – is the most commonly used adjustable gage, and it is important that the mechanic understands its mechanical principles, construction use and care.

### **Types:**

- Outside micrometer used to measure outside dimension, such as diameter of a piece of round stock.
- Inside micrometer used for measuring inside dimension, example, inside diameter of a tube or hole, bore a cylinder.

NUTS, BOLTS AND SCREWS – used for fastening or holding metal parts together in assembly and disassembly, and that on occassion must be removed in taken part. Cap screw and machine screw are always used without nuts.

OFFSET SCREWDRIVER - used for screws located in accessible places.

**PACKING TOOLS** – are used to remove soft packing from the packing gland of values and pumps.

**PHILIP SCREWDRIVER** – used for Phillips type screws only.

PLIERS – used generally for general purposes, electrical work and for better gripping. Types are combination, side cutters, needle nose round nose, flat jaw pliers.

Combination – has one arm of the slip joint slotted, can be slipped from one position to another.

Side cutting plier – used to a electrical work in stripping the wire insulation. Needle nose plier – used to get into tight spaces or corners.

Flat jaw - used teeth for better gripping of nuts and measure overall length.

**PROTRACTOR** – used in measuring or laying out angles, usually made of a transparent substance such as celluloid, semi circular shape up to 180°.

PUNCHES - consist of several types depend on used for a variety of jobs done.

Center punch – used to make a starting mark for a drill when holes are to be drilled in metal.

Prick punches – usually used for marking centers and lines in a layout work.

Starting punches – have long tapes from the tip to the body and can stand heavy blows used for knocking out rivets, bolts, etc.

Pin punch - designed to follow through the hole without jamming.

Alining punch – used to line up corresponding holes in adjacent parts of the engine.

- **RATCHET SCREWDRIVER** a very handy tool, that can handle in firm grasp and does not turn continually called standard screwdriver.
- **REAMERS** used in precision work to smooth and enlarge holes to exact size. Types are expansion reamer, and taper reamer.
- **RIVETS** not threaded form, are used for metal fasteners for permanent and not subject to disassembly or taken apart.

SCRAPERS – made in many forms, used for scraping or removing high spot from flat surfaces, to refit a bearing. Scraper design for flat scraper top and sides blades while bearing scraper and three corner scraper for delicate parts.

SCREWDRIVERS – generally has one purpose, to tighten or loosen screws. Types are regular, offset, rachet and Phillips screw drivers.

**SCREW GEARED CHAIN HOIST** – a handy portable hoist which is light and powerful, that hold securely and will not lower unless the chain is pulled.

- SCREW PITCH GAGE used to check the number of threads on bolt, screw nut, etc. Each blade or finger is stamped with the number of threads cut on it.
- SCRIBER used to make clean narrow lines on metal, made up of tool steel have single and double end.
- SHEET METAL SCREW used to hold together section of sheet metal, fiber, plastic etc., especially on board for insulation purposes.

**SPEED INDICATOR** – indicate the number of revolutions per minute made by an electric motor, turbine rotor, and other revolving equipments.

SQUARE & COMBINATION SET-used to scribe, measure and check angles, to construct line at right angles to the edge of a piece of material, to establish points for lines parallel to the edge, and guide for other instrument.

**TACHOMETER** – differs from speed indicator, it directly registered revolutions of the rotating shaft, no timing or computation being necessary.

- **TAPS** usually in sets of three for each diameter and thread series, set contain a tapes, plug and bottom tap. Usually used for making an exact hole thread each job.
- THICKNESS GAGE or feeler gage is used for measuring distances or clearances between two surfaces. The number stamped on each blade is the thickness of that particular blade in thousandths of an inch.
- WIRE AND SHEET GAGE used to measure cross sections of wire and sheet gage and to determine the thickness of metal sheets.
- WRENCHES are tools for tightening or removing bolts, nuts, studs, etc. or for gripping round material such as pipe, stud, round rod, classified in three heading – adjustable, solid and open end. Also for their shape like S-wrench, angle, pipe, monkey, tap wrenches.



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**MILLING MACHINE** 

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SHAPER

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# READING PIPING AND INSTRUMENT DIAGRAM IN ENGINE ROOM



F. O. MAIN SERVICE SYSTEM

#### Symbols of Instruments:

8	-	Screw Pump	IL.	-	Indicating Lamp
Ā	-	Duplex Strainer	ZS	-	Limit Switch
	-	Simplex Strainer (angle)	CP	-	Compound Gauge
-	-	Simplex Strainer	PI	-	Pressure Indicator
<b>N</b>	-	Globe Stp. Valve	PS	-	Pressure Switch
N	-	Screw down Stp. Check v/v	PT	-	Pressure Transmitter
D.	-	Quick Closing Angle v/v	XS	-	Aux. Unspecified Switch
	-	Globe Stp. Angle v/v	XA	-	On-Off Card
2	-	Sight Glass	ТІ	-	Temperature Indicator
<u>+0</u> +,		Control Air Pipe Line	DPS	-	Different Pressure Switch
	• _	Electric Cable Line	PAH	-	Pressure Alarm High
		Insulation	VT	-	Viscosity Transmitter
0	-	Local Indicator	VI	-	Viscosity Indicator
Ă	-	Inside of Panel Mounted	VAH	-	Viscosity Alarm High
U			VAL	-	Viscosity Alarm Low

# MARKING FOR IDENTIFICATION OF PIPING SYSTEM

Piping System		Colours	<b>Distinctive Marking</b>
Feed Water		Blue	
Sea water:	cooling water	Green	
	Ballast	Green	
Fresh water:	Cooling water	Blue	
	Domestic Water	Blue	
Compressed /	Air	Gray	
Bilge		Black	
Fuel oil: Heavy fuel oil		Red	
D	iesel oil	Red	
CO2 Fire Fighting		Red	
Refrigeration		White	
Hydraulic Line	<b>)</b> .	Brown	
Air & Sounding		Brown	
Lube Oil		Yellow	
Steam		Silver	
Condensate		Orange	
Sanitary		Black	

# POINTS TO PONDER:

# Arrangement, Numbering of Fittings, Aux. Equipments, Engine:

1

		counter clockwise/left turn direction				=	OPENING
Valves operation:		clockwise/right turn direction				=	CLOSING
Port 🤟		Bottom		Aft	_	are	No. 3
Midship		Middle		Midship	—	are	No. 2
Starboard side		Тор		Forward		are	No. 1

# II. BASIC WELDING SYMBOLS



# III. GAS/ELECTRIC WELDING RECOMMENDED METHOD OF PROCEDURE:

# **TABLE FOR CUTTING:**

Thickness of material – mm	2-6	6-13	13-25	25-50	50-75	75-100
Distance for tip of flame core	2	3	4	4	5	5
Acetylene press kg/cm <sup>2</sup>	0.2	0.2	0.2	0.2	0.2	0.2
Oxygen press kg/cm <sup>2</sup>	1.7	2.3	3.5	4.3	5.1	4.0
Cons. of gas L/Hr Acetylene	460	520	690	690	690	810
Oxygen	1300	2150	4800	4900	6500	7800

# TABLE FOR WELDING (BRAZING/WELDING JOB)

Thickness of material in mm	0.5-1	1-2	2-4	4-6	6-9 Brazing/ Welding Job
Size of welding torch	50	100	225	400	650 1000- 1300-1680
Acetylene & Oxygen press kg/c		BOTH (	).3 kg/cm <sup>2</sup>		

# **IV. FLAME TORCH CHARACTERISTICS:**



OXYGEN SURPLUS – deposit brittle & burnt

ACETYLENE SURPLUS - deposit brittle & hard

NEUTRAL FLAME - deposit normal

V. DISTANCE OF FLAME AND MATERIAL



### VI. METHOD OF WELDING:





LEFTWARD WELDING: use on material up to 4 mm. The welding rod precedes the torch in the welding direction.



**RIGHTWARD WELDING:** use on material thicker than 4 mm. The welding rod follows the torch in the welding direction. During pre-heating the torch should be removed in such away time use correct temperature.



VERTICAL-UP WELDING: Also used for material thicker 4 mm.



OVERHEAD BUTT or FILLET WELD

#### **VII. POSITION ELECTRIC WELDING**



### Section II

# PUMPS

### THEORY, OPERATION AND MAINTENANCE

#### **DEFINITION OF PUMPS IN GENERAL:**

A pump is a device which adds to the energy of a fluid causing an increase in its pressure and movement. Also in Theory — Pump does not draw up a liquid, but rather creates a vacuum on the suction side allowing atmospheric pressure to push the liquid into the pump.

#### **Two Main Categories:**

Pumps can be divided into two main categories

- 1. Positive Displacement pumps and
- 2. Rotodynamic pumps.

### **Basic difference between the categories:**

Positive displacement pumps are self-priming pumps whereas the rotodynamic pumps are not.

#### **Positive Displacement Pumps and their classification:**

- A. Reciprocating pumps.
- B. Rotary pumps
  - Types:
    - 1. Gear3. Screw2. Vane4. Lobe
- C. Rotary Reciprocating pumps.

Types:

- 1. Radial Piston Pumps Heleshaw pumps
- 2. Axial Piston Pumps Swash plate pumps

#### **Rotodynamic Pumps and Their Classification:**

- A. Centrifugal pumps volute and diffuses types. Dynamo pumps with radial, axial and mixed flow
- B. Regenerative turbine pumps all turbine pumps.
- C. Special Effect pumps ejector, eductor, gas lift, jet pumps

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### I RECIPROCATING PUMPS

**Construction:** 



### **General Characteristics:**

They are suitable and efficient for dealing with small volumes, can develop high differential pressure and can handle any viscosity. Also Positive displacement and self priming.

Used on board tankers as stripping pumps for definite reasons and also used as bilge pumps on many ships.

#### Maintenance and trouble shooting

Maintenance:

Steam side: Shuttle valve

- 1. Aux. slide valve adjusted by liners for smooth light movement.
- 2. Shuttle smooth movement inside bells.
- 3. Bells axial movement about 0.07 mm.

Liquid side: Bucket rings

- 1. Suction/Delivery valve chest.
- 2. Pet cocks and Snifting valves.

Trouble shooting:

- 1. Pump vibration;
- 2. Does not deliver;
- 3. Pump short strokes, Pump hits cylinder cover;
- 4. Pump runs too fast, Pump stops;
- 5. Low discharge pressure, Discharge pressure fluctuates;

# **II ROTARY PUMPS**

### Types:

- 1. Gear 3. Vane
- 2. Screw 4. Lobe
- 5. Other Geometric form pumps.

### **General Characteristics:**

- 1. Suitable and efficient for handling, intermediate range of pressure, volumes and viscosities like fuel, lube oil, diesel, and other commercial liquids.
- 2. Due to rotation and close clearances a time-continuous liquid seal is maintained. Hence, these pumps do not require suction/delivery valve chest arrangements like reciprocating pumps.

### **GEAR PUMPS : Types**



Internal Gene Internal Conservert

**INTERNAL GEAR PUMP** 

# **SCREW PUMPS: Types**



### SINGLE SCREW PUMP











VANE PUMPS

### LOBE PUMPS



### Part lists:

520	Mechanical Seal	106	Key
305	Coupling Bolt & Nut	105	Key
304	Coupling Ring	104	Driven Gear
302	Coupling	103	Drive Gear
301	Coupling	102	Driven Shaft
201/2	Bearing Metal	101	Drive Shaft
201/1	Bearing Metal	003	Side Cover
107	Key	002	Side Cover
	-	001	Casing

### SECTIONAL VIEW OF HORIZONTAL GEAR PUMP
#### III ROTARY-RECIPROCATING PUMPS-

#### Types:

- 1. Radial Piston Pumps Heleshaw pumps.
- 2. Axial Piston Pumps Swash Plate pumps.

#### **RADIAL PISTON PUMPS**

These pumps are so called because their plungers or pistons are positioned radial to the main axis of the pump. Each pump consists of a fixed shaft which is stationary and has a port at the top and a port at the bottom. Around this shaft is a hollow shaft which is coupled to the prime mover and carries the radially placed bores as shown in the diagram. Inside each bore fits a lapped plunger with gudgeon pins which can move in and out restricted by the slot in the bore.

The gudgeon pins fit into segment shaped slippers which in turn are carried in the annular grooves of circular floating rings. The floating rings are connected to an actuating rod and its radial movement controls the stroke of the plungers.

### **AXIAL PISTON PUMPS**

This type is so named because the plungers are positioned parallel to the axis of the pump. Here the shaft which is coupled to the motor carries and rotates a cylindrical block which is kept pressed against a stationary valve plate. The stationary valve plate has two segmental ports which end in circular openings for the fitting of the suction and delivery pipes.

The cylindrical block has axial bores in which slide lapped plungers. Each plunger ends in a ball joint which fits in a socket ring, which in turn is held by a tilting box or "Swash Plate" as shown. The shaft carries the socket ring and the swash plate on a double universal joint and the tilt of the swash plate determines the stroke of the plungers.

#### **ROTODYNAMIC PUMPS**

Types:

- 1. Centrifugal Pumps,
- 2. Turbine Pumps,
- 3. Special Effect Pumps.

#### **General Characteristics:**

Most suitable and efficient for handling large volumes with medium to low heads and viscosities.

# Factors affecting slip Rotary pumps:

- 1. Clearances,
- 2. Pressures,
- 3. Speed,
- 4. Viscosity.

# Rotary pump performance:

- Displacement Slip = Capacity
- Volumetric Efficiency =
  - <u>Capacity</u> x Displacement

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- Brake Horse Power = Frictional HP + Hydraulic HP
- Mechanical Efficiency = <u>Hydraulic HP</u> Brake HP

# **Clearances** measured:

- 1. Between two meshing teeth at pitch point. (Backlash)
- 2. Between teeth and casing.
- 3. Between gear wheel and end plate/cover.

# Sectional View of One Rotor Screw Pump



# Parts list:

001	Stator
002	Pump Stand
003	End Piece
004	Bearing Case
005	Bearing Cover
101	Rotor
102	Shaft
103	Connecting Rod

104	Кеу
110	Pin
112	Snap Ring
113	Sleeve (A)
114	Sleeve (B)
150	Bearing Nut
201	Bearing
202	Bearing

501 Gland Packing
504 Gland
515 Oil Seal
516 Oil Seal
530 "O" Ring
531 "O" Ring
532 Seat Packing
533 "O" Ring



**IV CENTRIFUGAL PUMPS** 

**Construction:** 



# **Two Main Classes:**

- 1. Volute Pumps,
- 2. Diffuser Pumps,



Impeller Classification:



#### 1 CONSTRUCTION

The model GVC pump is of the vertical single-stage single-suction centrifugal type. Its rotating element is connected to an electric motor shaft through a flexible coupling and constructionally its disassembling and assembling are easy.



# PARTS LIST:

- Volute Casing 1
- 2 Volute Cover
- 4 Pump Bed
- 5 Motor Bed
- 7 Bearing Housing
- 9 Bearing Cover
- 14 Bearing Inner Case
- 16 Impeller
- 18 Impeller Shaft
- 19 Impeller Key
- 20 Coupling Key
- 22 Sleeve
- 29 Washer
- 30A Washer
- 30B Washer

- 34 Ball Bearing
- 38A Mouth Ring
- 38B Mouth Ring
- 41 Line Bearing
- 47 Gland
- 49 Coupling
- 50 Coupling
- 54 Gland Packing
- 55 Packing Ring
- 56 Packing Ring
- 318 Coupling Bolt Nut & Washer
- 319 Coupling Ring
- 351 **Impeller** Nut
- 353 Bearing Nut
- 354 **Bearing Washer**

31 Packing

# SECTIONAL VIEW OF CENTRIFUGAL PUMP

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# A. PUMP CASING

The volute casing is split into two halves along the vertical plane containing the axis, and the removal half casing can be removed easily without disturbing the suction and discharge pipes, both of which are provided in the stationary half casing.

# **B.** IMPELLER

The impeller is of the single suction type and the balance holes provided near the center of the back should serve to cancel the axial thrust due to the pressure water on the back of the impeller.

### C. BEARING

- (1) For the upper ball bearing is furnished to support the rotating element. Although it is fitted into the solid inner case, it can be taken out together with the rotating element if the bearing housing cap is removed. It is grease lubricated.
- (2) The lower bearing is a line bearing fitted in the volute casing. For the bearing material, good self-lubricating ability is used and lubrication is effected by means of the pump's discharged pressure water.

# D. STUFFING BOX SEAL

This pump can be provided with either mechanical seal or gland packing for stuffing box sealing, which is its most important part.

1. Gland packing

Gland packing of carbon fiber is provided and sealed by pressure water from discharge side.

2. Mechanical packing Unbalanced type mechanical seal is fitted and flushed by pressure water from discharge side same as gland packing.

# E. SELF PRIMING PUMP (If required)

The vacuum pump unit is provided for priming on starting pump. Vacuum pump is driven by pump motor through the clutch.

During the pump operation vacuum pump is stopped automatically by taking off clutch reflected by the pressure of handling water.

#### II. DISASSEMBLING AND ASSEMBLING

#### 1. Disassembling

In order to replace impeller, sleeve, ball bearing, etc., disassembling of pump is carried out as follows.

#### 1.1 Removal of volute cover

- 1. Remove pipe connecting volute cover (2) and volute casing (1).
- 2. Raise gland (47) or mechanical seal cover (146) after loosing gland nuts or fixing bolts of mechanical seal cover.
- 3. Remove volute cover (2) forward by using two liftings bolts after loosing fixing nuts for volute cover.

#### 1.2 Removal of rotating element

- 1. Remove the coupling bolts (318).
- 2. Next, remove the bearing housing cap and take out the rotating elements together with the inner case (14) and bearing cover (9) with paying attention to the mouth ring (38).
- 3. In this case, support the lower mouth ring together with the rotating elements by hand test they should drop off and get injured.

#### 1.3 Removal of impeller and sleeve

- 1. Remove the impeller nut (351) by turning it counterclockwise.
- 2. Then remove impeller (16) and sleeve (22A) successively.

# 1.4 Removal of mechanical seal

- 1. Remove rotating elements together with sleeve (22A).
- 2. Remove setscrew on stopper ring (54-7).
- 3. Remove floating seat (54-1) (carbon) by pushing it endwise by hand. If it sticks remove scale by washing with kerosene, never hit with hammer.

#### 1.5 Removal of coupling

Remove the coupling (49) by pulling tool.

#### 1.6 Removal of ball bearing

- 1. Remove the bearing cover (9), unbend one of the teeth of the bearing washer (354) which is bent into one of the slots on the periphery of the bearing nut as a rotation preventing device and remove the nut (353).
- 2. Shift the bearing inner case (14) toward the impeller side. Since the ball bearing (34) is lightly pressed onto the impeller shaft it can be drawn off when the inner race is hit lightly.

3. When replacing the old ball bearing with a new one it can be drawn out of the shaft by hitting the outer race or together with the inner case (14), but if in case is used again never hit on the outer race, a strong shock given to the outer race will deform the balls and rolling face, thus making the bearing unusable.

#### 1.7 Motor

Since the motor is aligned with the pump axis and dowelled to the motor bed it is desirable not to remove it except troubles being happened.

#### 2. Assembling

Assembling can be carried out by reversing order of disassembling and attention must be paid to the following:

- 1. Cleanse each part thoroughly to remove rust and scale, and be sure there are no injury and burr in fitting parts.
- 2. Assemble fitting parts according to match marks if any.
- 3. Turn nuts for rotating parts securely and fix anti-rotation device without fail.
- 4. Be sure to thoroughly cleanse the ball bearing with pure kerosene taking care to keep off dust and foreign matter.

#### CAUTIONS FOR INSTALLATION AND PIPING

#### **CLEARANCE AND LIMIT OF USE**

The bigger the clearance between impeller and mouth ring becomes, the more the counter-flow discharge side to suction side becomes, and consequently pump capacity decreases.

In general, pump capacity decreases by 15-20% at the clearance of limit of use compared with the clearance of new pump, even if the quantity of the counterflow is different at various discharge pressure.

Furthermore, increase of the clearance between sleeve and line bearing makes vibration and more leakage from stuffing box, besides damage of seizure caused by impeller contacting with mouth ring is expected, so that the parts are necessary to be replaced.

#### Suction Piping

The piping on the suction side affects pump efficiency to a great degree and to avoid troubles arising therefrom the following points must be noted.

1. No air pocket must be formed in the piping.

- 2. All fittings in the piping must be perfectly tightened to prevent air invasion.
- 3. Care must be taken to prevent air leakage through glands of all valves in the piping.
- 4. The suction piping must be thoroughly cleansed so that pipe scale, welding beads and other foreign matters do not remain, otherwise seizure and other troubles may result.

# Alig ment of Coupling – Centrifugal Pump:

- 1. Measurement of parallel misalignment connect the pump and motor together, fix a dial indicator on the coupling half on the motor side so that its spindle rests on the periphery of the coupling turn to both coupling halves at the same time, and read the difference between the maximum and minimum readings on the indicator.
- 2. Measurement of angular misalignment, in the same way as above, give one complete turn to both coupling halves at the same time, measure the gap between the coupling faces (e.g. at each 90 deg.) using a feeler gauge, and read the difference between the maximum and minimum measurements.

# CHECKING

# Cl ecking of alignment – Rotary pumps:

- a. After removing coupling bolts as shown in Fig. 1 or Fig. 2 check alignment by measuring and angular misalignment at 4 points, 90° apart, on the coupling peripehry.
- b. For measurement on the shaft coupling periphery, a dial indicator is fixed, motor end coupling and the pump end coupling periphery.
- c. For comparing the distance between coupling faces at four points using a thickness gauges, as shown in Fig.1 give the shaft one complete turn by hand.
- d. Ensure the direction of the motor rotation is correct.
- e. Fit the bolts to the coupling.
- f. Rotate by hand to check for smooth movement.
- g. On completing the adjustment of alignment, insert dowel pins. Coupling periphery and end faces should be protected against rust damage.
- h. For V-belt Drive, apply a scale to the end face of the V-pulleys and eliminate vertical and horizontal discrepancies. (The scale should be applied obliquely). Most proper tension of the V-belt will be obtained when it is loosened up to the maximum before getting to slip on the pulleys.

i. At the proper tension, the belt is flexible up to an amplitude equivalent to the height of the belt when perpendicularly pressed at the middle of the span. See fig. 3



# **III. CHECK BEFORE OPERATION**

A. When operating for the first time after installation or overhaul and assembly, it is necessary to do as follows.

- 1. Take off dust preventing tape placed on the part where the pump shaft passes through. Take care so that no foreign matter enters the clearance around the shaft.
- 2. Give a few turns to the coupling by hand and see if it turns easily.
- 3. Confirm the turning direction of the motor, and if it is not correct change the wiring.
- 4. See if the valve in the suction piping is fully open.
- 5. If the pump is of the self-priming type with the attached vacuum pump, see if the supply tank contains the specified amount of water.
- 6. When the pump is operated for the first time after being overhauled and reassembled, pour required amount of grease into the ball bearing except the sealed ball bearing.

# **B.** Cautions During Operation

- 1. Never throttle the suction valve during operation, otherwise troubles may occur due to dry operation.
- 2. Never operate over 15 minutes with the discharge valve completely closed. When a centrifugal pump is operated without discharge, most of the power

changes into heat and as a result water temperature rises to the boiling point causing seizure of the interior of the pump.

- 3. Avoid dry operation of the pump. In the case of a self-priming pump it can stand dry operation when starting about 10 minutes before air is completely draw off, but it is not good to continue dry operation longer.
- 4. During operation keep the gland lightly tightened so that there is a slight leakage from the gland. This is the best condition. If the gland is tightened too much in order to minimize leakage the shaft or sleeve may wear rapidly and the service life of the packing may be shortened.

#### C. Starting

- 1. Close the discharge valve completely.
- 2. Open the suction valve completely.
- 3. Open the air vent at the top of the volute casing and if water comes out from it close it and fill the pump with water.
- 4. If the pump is of the self-priming type with the attached vacuum pump, keep the air vent close and open the check valve on the attached vacuum pump line.
- 5. Start the motor.
- 6. When the discharge pressure has risen, open the discharge valve gradually and, if the pump is of self-priming type with the attached vacuum pump, close the check valve on the attached vacuum pump line.

#### **D.** Stopping

- 1. Close the discharge valve.
- 2. Stop the motor.

# MAINTENANCE CHECK LIST

item	Inspection Procedure	Remedy in case of trouble
Suction pres-	Check everyday if there is no abnormal pressure drop andtake record.	Stop pump immediately and check suction line.
Bearing temp.	Check and record every three days.	In the case of ambient temp. plus 40°C stop the pump and eliminate the cause.
Grease	Renew grease every 6000 hours. (or supply every 3000 hours)	When deterioration occurs earlier confirm if specified grease is used.
Lubricating oil	Check oil level by oil level gauge once a week.	Supply oil if level is low.
	Renew oil every 3000 hours.	When renewing oil stop pump.
Ball bearing	Check for abnormal noise once a month.	If abnormal noise occurs and besides there is heating stop the pump, eliminate the cause, renew the ball bearing if necessary.
Stuffing box seal	Check for leakage, heating ab- normal noise every three days.	Stop the pump immediately and remove cause
Line bearing	Check for heating in the perti- nent part, great vibration in the whole pump and heating in the ball bearing every three days.	Stop the pump and check if the lubricating water is pass- ing and if the line bearing clear- ance has become too great.
Vibration	Check for vibration once a week.	Check for pump alignment and line bearing clearance.
Cooling water	Make sure whether cooling water is supplied and water tempera- ture is not abnormal in every two days.	Stop the pump and check the cooling water pipe line.

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Maintenance and check for the following can extend a life of the pump.

### **TROUBLE SHOOTING**

#### A. Pump cannot discharge – causes:

- 1. Pump not completely or insufficiently filled with liquid.
- 2. Much air leakage in suction line.
- 3. Air pocket in suction line.
- 4. Suction lift too high.
- 5. Wrong direction of rotation.
- 6. Suction strainer and suction line clogged.
- 7. Speed too low.
- 8. Impeller clogged.

#### **B.** Insufficient discharge

- 1. Air leakage.
- 2. Speed too low.
- 3. Discharge head too high.
- 4. Suction lift too high.
- 5. Suction pipe end not sufficiently submerged.
- 6. Suction strainer and suction line clogged.
- 7. Impeller clogged.
- 8. Wrong direction of rotation.
- 9. Clearance between impeller and mouth ring due to latter's wear down
- 10. Cavitation due to high liquid temperature.

### C. Prime mover overload

- 1. Speed too high (power frequency too high)
- 2. Impeller touches mouth ring.
- 3. Rotating elements touch due to bent shaft.
- 4. Casing deformed.
- 5. Liquid specific gravity is greater than designed one.
- 6. Voltage too low (constant input, but increase in current)

## D. Overheating of bearing

- 1. Grease is too little.
- 2. Grease is too much.
- 3. Grease or oil has improper consistency or it is deteriorated.
- 4. Misalignment is great.
- 5. Shaft is bent.
- 6. Injury or too much wear in ball bearing.
- 7. Too much thrust force.

### E. Abnormal noise in ball bearing

- 1. Injury in balls or rolling face.
- 2. Too much clearance due to abnormal wear.
- 3. Abnormal wear in retainer.

### F. Vibration in pump

- 1. Misalignment.
- 2. Shaft bent.
- 3. Impelier partially clogged with foreign matter.
- 4. Incorrect installation.
- 5. Weak foundation.
- 6. Suction and discharge pipings not sufficiently secured.
- 7. Rotating elements touch stationary elements.

#### G. Leakage in Mechanical Seal

- 1. Injury or excessive wear down in rubbing faces.
- 2. Foreign matter in rubbing faces.
- 3. Insufficient tightening of mechanical seal cover.
- 4. Break down of "O" ring.
- 5. Insufficient tightening of screws for stopper ring (54-7).
- 6. Injury or wear down of part of shaft or sleeve where rotary-ring's "O" ring (54-5) contacts.
- Scale sticks in groove for "O" ring (54-5), causing rotary ring to stick and rubbing faces to open.

# **CAVITATION IN PUMPS:**

We know that all fluids generally contain some air in a dissolved state in them. Also, fluids will vapourise when their pressure is reduced to the level of their vapour pressure.

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# The process or phenomenon of cavitation can be summarised as:

- 1. Creation or formation of low pressure.
- 2. Air coming out of solution or liquid vapourising.
- 3. Bubbles evolving, growing in size and then bursting.
- 4. Rattling noise, vibration, increase in temperature & pressure.
- 5. Disintegration of metal by erosion and fatigue.

### Therefore circumstances favouring cavitation:

1. If pressure is too low in relation to the liquids vapour pressure at the prevailing temperature.

Could be due to:

- a. High/big suction lift,
- b. Throttling of Suction valve,
- c. Low submergence head.
- 2. If discharge rate is exceeded.
- 3. Incorrect angle of entry of fluid into the impeller eye.
- 4. Sudden expansions of pump passages.
- 5. Poor approach conditions for fluids entry into impeller.
- 6. NPSH available < NPSH required.

#### Distinguishing characteristics of a pump running under cavitation:

- 1. Rattling noise and vibrations.
- 2. High pressure surges.
- 3. Sudden "Drop-off" in pump capacity.

#### **Effects of cavitation:**

- 1. Vibration can cause bearing failure, shaft breakage and fatigue failures of the pump.
- 2. Collapsing of bubbles forces liquid to enter the void so created at a high velocity (surge pressures) blasting out particles of material.

#### **Regions attacked by cavitation:**

- 1. Impeller vane inlets where the change of direction takes place.
- 2. Impeller vane tips.
- 3. Impeller back face.
- 4. Diffuser ring.
- 5. Volute casing.
- 6. Sometimes carried over to the next stage.

# Essential properties of materials to resist cavitational erosion:

- 1. High tensile strength.
- 2. High hardness.
- 3. Good fatigue properties.

# Conditions to be avoided to prevent cavitation occuring:

- 1. Suction lift greater than that recommended.
- 2. Throttling of suction valve.
- 3. Liquid temperature higher than that designed for.
- 4. Pump speeds higher than that recommended.
- 5. NPSH available less than NPSH required.

# Other circumstances favouring cavitation:

- 1. Cavitation due to internal recirculation (vane inlets & outlets).
- 2. Cavitation due to separation of liquid from vane walls.

# Methods used to counter cavitation & Improve NPSH available:

- 1. Use an Inducer, fitted before the main impeller.
- 2. Raise the liquid level.
- 3. Subcool the liquid.
- 4. Use slower speeds.
- 5. Use an oversized pump.
- 6. Use a double suction impeller.
- 7. Use an impeller with larger eye area.
- 8. Use a booster pump.

# **EFFICIENCY OF PUMPS & THROTTLING OF VALVES:**

# Basic Pump Terms:

HEAD – is the energy per pound/kg. of liquid.

**POTENTIAL ENERGY** – is the energy due to its position.

STATIC PRESSURE HEAD - is the energy per pound/kg. due to its pressure.

**VELOCITY HEAD** – is the kinetic energy per pound/kg. of liquid.

**BERNOULLI'S THEOREM** – is the energy that cannot be created or destroyed. The sum of the three types of energy (heads) at any point in a system is the same as at any other point in the system.

**STATIC SUCTION HEAD.** Vertical distance from free surface of liquid to pump datum, when supply is **above** the pump.

**STATIC SUCTION LIFT.** Vertical distance from free surface of liquid to pump datum, when supply is below the pump.

**NET SUCTION HEAD.** Static suction head **plus** pressure on the surface of the liquid **minus** friction losses. (Could be + ve or - ve).

NET SUCTION LIFT. Sum of static suction lift plus friction losses. (Always - ve)

**STATIC DISCHARGE HEAD.** Vertical distance from pump datum to free surface of liquid in discharge tank or point of free discharge.

**NET DISCHARGE HEAD.** Sum of static discharge head **plus** pressure on the surface of the liquid in the discharge tank **plus** friction losses.

**TOTAL HEAD. (TH)** The net difference between total suction and discharge heads. It is a measure of energy increase imparted to the liquid by the pump.

For suction above pump: TH = Discharge head - Suction head. For suction below pump: TH = Discharge head + Suction head.

**SPECIFIC SPEED** – is defined as the speed in rpm at which an impeller would operate if reduced proportionally in size so as to deliver a unit capacity against a unit total head.

(There is no direct connection between the rotational speed of a pump and its specific speed; e.g. a large pump of high specific speed may have a low shaft speed whereas a small pump of low specific speed could have a high shaft speed.)

**DESIGN POINT.** It is a point at which, when running at a particular speed, the pump works at its maximum possible efficiency.

**DUTY POINT.** When a pump is regulated so that its performance confirms as nearly as possible with the desired/specified conditions, it is said to be working at its duty point.

**NET POSITIVE SUCTION HEAD. (NPSH)** It is the amount of energy in the liquid at the pump datum. To have any meaning it must be defined as either available or required NPSH.

**NPSH REQUIRED. (NPSHr)** It is the energy needed for a pump to operate satisfactorily i.e. to fill the pump after overcoming friction and flow losses so that the pump can next add more energy. NPSHr is a characteristic of a pump and is supplied by the manufacturer in terms of 'feet' or 'metres'.

**NPSH Available. (NPSHa)** It is the energy available in a liquid at the suction of a pump (regardless of the type of pump) over and above the energy due to its vapour pressure. NPSHa is a characteristic of the system and has to be calculated.

NPSH available must always be equal to or greater than NPSH required for a pump to work satisfactorily and prevent cavitation.



NPSH = Pot. hd. energy + Static Pr. hd. energy + Vel. hd. energy.

$$= Z_1 + P_2 + V_1^2$$

Since area of liquid surface compared to suction pipe area is very large:

NPSH =  $Z_1 + P_1$ 

Since P is atmospheric pressure at liquid surface; we do not want the liquid to vapourise in the suction line, hence we must substract the vapour pressure of the liquid (P<sub>v</sub>).

NPSH = 
$$Z_1 + (P_1 - P_y) \times 2.31$$
  
Sp. gr.

This NPSH is at present at point 1, but since we want it at the pump datum or point 2, therefore we have to subtract the friction losses:

NPSH =  $Z_1 + (P_1 - P_v) = x = 2.31 - h_f$ Sp. gr.

# **PRIMING OF CENTRIFUGAL PUMPS:**

Since centrifugal pump are NOT self-priming pumps, they need to be primed to function satisfactorily. They could either be provided with a positive suction or be fitted with a priming device.

Priming devices used:

1. Ejectors

- 3. Wet Vacuum Pumps,
- 2. Dry Vacuum Pumps,
- 4. Central Priming System.

# Section III





# BASIC CONTROL LOOP

# A. THE BASIC CONTROL LOOP CONSIST OF THE FOLLOWING PARTS:

# I. System or Process:

- a. level c. temperature
- b. pressure d. flow

### II. Transmitter or Transducer - signal generating unit

- a. Pneumatic Flapper Nozzle
- b. Electronic potentiometer, magnetic flux, capacitance
- III. Controlling unit comparator (setpoint) + controlling element
- IV. Controller valve divided in two: controller output and final correcting unit. (actuator control mode)

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**NOTES:** Points to Ponder?

- 1. What is the parameter that you wish to control?
- 2. Why does this parameter (variable) change?
- 3. Set up a control loop and clearly.
- 4. Identify the components comprising the loop.

# **B. CALIBRATION OF AN INSTRUMENT:**

A transmitter is often designed to accept different ranges of input signals and in response to any one of these ranges produces either one of standardized output signal ranges. Before fitting any instrument in a given application, it is, therefore, necessary to calibrate that instrument for the specific application. Standardized output signal ranges that have been Internationally agreed are: Pneumatic signals 0.2 to 1.0 bar; and, Electronic signals 4 to 20 mA dc. Calibration of an instrument entails three steps:

**ZERO ADJUSTMENT** – which means that when the sensor of the instrument is exposed to one end of the input range, the output signal produced should be the lower value of the output signal range. If that be not so, adjustment need be made on Zero Adjustment knob or potentiometer or whatever form provided on the instrument, until the signal attains the desired value.

SPAN ADJUSTMENT – which means that when the sensor of the instrument is exposed to the other extreme of the chosen input range, it produces the higher end value of the standard output signal range. If not, adjustment need be made on provided Span Adjustment device until the desired value of the output signal is achieved.

Because of the interaction between the above two adjustments, it is likely that Zero adjustment may have gone out by a small amount. Therefore, one may have to go back and forth a few times between Zero and Span adjustments, at each step making finer and finer adjustment, until such time that when the sensor is exposed from one extreme end to the other, the output signal produced shows the minimal deviation from the desired values.



#### **Proportional Band:**

It is that range of values of the controlled variable which operates the correcting unit over its full range. It is usually expressed as a percentage of the scale range.

From the diagram it is to be noted that within the Proportional Band there is a unique position of the correcting element for every value of the controlled condition.

This band is adjustable in order to obtain stable control under differing process conditions. The PB setting required for any given application will depend on plant characteristics and the various lags in the control loop. There is an optimum value which will give stable control. If the PB is made too narrow, the process will become unstable, whereas if it is made too wide, the process will be sluggish.

Usually, correcting element is 50% open when the process is at the normal condition and the controlled condition is at the desired value.

#### Gain:

Gain of a component is defined as the ratio between the change in output to change in input.

Applying this definition to a controller and comparing it with that for Proportional Band, it can be easily shown that one is the reciprocal of the other.

Expressed mathematically, Gain = 100PB

LINEARITY CHECK – Once Zero and Span have been adjusted, all that remains is to make sure that the two end points are connected in linear fashion, which is easily established by exposing the sensor to one or more intermediate input values and checking whether the produced output signal lies on the straight line joining the Zero and Span points.

It is to be noted that of the above three steps, the first two are adjustments whereas the third is merely a check. The reason for this is that every instrument has provision for Zero and Span Adjustments, but because practically all modern instruments are designed on Force balance principle which inherently takes care of linearity requirement between Zero and Span, there is no need for any linearity adjustment. However, linearity check is essential since most of the time the instrument operates somewhere in the middle of the range for which it has been calibrated. The control system that we commonly come across are those that can mostly deal with linear signals only.



Proportional only mode of control is suitable for only those applications where the process load is fairly constant and the requirement for accuracy is not stringent. It is so because of the inability of proportioanl control to accommodate load changes without sustained deviation.

Offset is defined as sustained deviation or steady state error.

From the diagram, it can be seen that the magnitude and direction of offset is related to the magnitude and direction of load change.

Narrow-band, proportional only controllers are often used- in non-critical single temperature loops, such as in maintaining a temperature in a tank to prevent boiling or freezing.

Non-critical level control applications having long time constants can also make use of proportional only controllers. A float operated controller maintaining level in a tank is an obvious simple example of the principle.



# C. CONTROLLER ADJUSTMENTS

I. **Proportional Band or Gain** – Time independent, error actuated, percentage % (P.B)'

Changed mode: To increase proportion action, decrease proportional band.

II. Integral Action Time (IAT) or Reset - repeat per minute, time dependent, Error actuated.

Changed mode: To increase the integral action, decrease integral action time setting.

III. Derivative Action Time (DAT) or Rate - constant, time dependent, anticipatory.

Changed mode: To increase derivative action increase derivative action time setting. PB Increase, IAT decreases, DAT increases

Controller Gain (Loop) =  $\underbrace{\text{output}}_{\text{input}}$  =  $\underbrace{100}_{\text{PB}}$  = 2

Proportional Band = input output

# D. PERFORMANCE

#### **Proportional Action**

When measured value becomes higher than the set value (deviation), the upper end of proportional lever shifts to the right. Thus the flapper approaches to nozzle and the back pressure of nozzle i.e., the pressure charged upon pilot really increses. Consequently valve in pilot relay opens and supply pressure flows into control side to increase the pressure. At the same time, this pressure in charged upon proportional bellows and lifts up proportional lever an thus flapper is detached from the nozzle and control pressure is set in proportion to such deflection. All of the aforesaid actions occure simultaneously in the actual operation. When both pointers overlap (deviation "O") control pressure becomes 0.6 kg/cm<sup>2</sup> (intermediate point of 0.2 - 1.0 kg/cm<sup>2</sup>)



**PROPORTIONAL - ACTION** 



FRONT VIEW OF CONTROLLER

Controller can be applied to all possible fields of process control such as pressure, differential pressure, temperature, liquid level, flow rate, viscosity etc. when used in combination with diaphragm control valves at the operating end. It is a pneumatic controller which can automatically regulate various process conditions at the optimum level.

#### **Proportional – Integral Action:**

Assuming that the controller is acting properly and measured value and set value are in equilibrium, (that is, the deviation is "O"), and the same pressure as control pressure is sealed in the proportional bellows and reset bellows. If measured value becomes too high as in the above case, P action immediately takes place and control pressure increases. Thus control pressure flows into the reset bellows through reset throttle valve.

As the pressure inside reset bellows increases, proportional level comes down and flapper approaches to the nozzle and back pressure increases. Consequently pilot relay valve in opens to increase the control pressure and the increasing pressure inside the proportional bellows lifts up the proportional lever and causes the the flapper to detach from the nozzle again. This resetting effect continues until control pressure increases to such extent that the control valve opening enables the reversion of measured value to the set value (that is, until deviation becomes zero).

Pressure of proportional bellows and reset bellows thus balances and the original balance condition is established.



**PROPORTIONAL-INTEGRAL ACTION** 

#### Proportional - Integral - Deviation Action

Rate throttle valve and rate bellows chamber are connected in parallel between the pilot relay and proportional bellows in the aforesaid P. and P.I. action, the inside pressure of proportional bellows is in proportion to the amount of deviation. Therefore, when the measured value changes, control pressure flows in or out with the speed corresponding to such changes, so that the pressure inside the proportional bellows will synchronize with the change of measured value. Since the pressure reduction taking place as it passes through the rate throttle valve is in proportion to the speed of fluctuation of measured value, pilot relay output i.e., control pressure also becomes larger or smaller than the internal pressure of proportional bellows to the extent of the differential pressure at the rate throttle valve.

Rate bellows chamber is provided to transmit control pressure to the proportional bellows utilizing the volume change or rate bellows caused by its elasticity and to give stability the system.

Therefore, when rate action is utilized, control valve opening can be adjusted more quickly and it certainly gives convenience especially to the process where time lag is great.



# **PROPORTIONAL-INTEGRAL-DERIVATIVE ACTION**

# ENGINE ROOM AUTOMATION : THE CENTRAL OPERATION SYSTEM-

It permits a one man operation of the power plant through bridge control of the propeller from full ahead to full astern, a centralized area for observing and operating the major components of the system and a simplified plant operation.

The bridge console contains very few devices, only the essential displays and a single operationg lever to maneuver and communicate with the engine room.

The heart of the COS is the *engine room console*. It centralizes all normal watch duties. Information displayed on the usual three main sections of the console–*propulsion–boiler* and *services* is presented to the engine room watch stander in three forms:

- 1. Continuous or demand display
- 2. Monitor and alarm
- 3. Logged date on a typewriter print-out



The basic block diagram of the engine room and bridge console control.

Besides the engine-room console and the bridge console the COS includes the necessary *sensors* (such as thermometers, pressure gages, level indicators, etc.); *transducers* (devices for transmitting temperatures, pressures, etc., to the COS) and the systems engineering to coordinate with plant *actuators* such as valves and motor controls.

While the small amount of information essential to controlling the propeller is displayed on the bridge console, all information for control of the power plant is displayed on the engine room console. Bringing all this information together in one place (in the COS) increases operator efficiency and permits faster, more accurate decision making.

By continuous automatic surveillance and immediate alarms for off-normal conditions, the COS reduces the possibility of dangerous situations and of inefficiency due to poor plant operation.

Program controls provide automatic sequential operations by a single operating command such as a push-button operation by the engineer. For example, a single

push-button control can provide automatic synchronization and paralleling of a turbine generator. Also start up and shut down boiler feed pumps from a stand-by condition.

As the master control changes (such as main boiler steam pressure) the sub-loop controls will cut out or adjust to compensate for air and oil requirements. The various controls (sub-loop) permit the engineer to set the most efficient plant operating level and then continuously regulate the *controlled variable* to provide stable plant performance under widely varying operating conditions.

The COS automatically records all bells and logs all other important data of the plant. This logging is done by an *automatic printer* thus eliminating errors in recopying rough logs.

In addition to the visual display a complete up-to-the-minute log can be produced on demand by simply pushing a print-out button.



#### **CONSOLE DEVICES**

**Indicating Light and Alarms.** These lights are *red* and will light up if an *alarm* condition exists. They will flash *on* and *off* until the operator acknowledges by throwing the *acknowledge button*. When he does this the light will remain lit until the operator remedies the condition at which time the *red* light will go *off* and the *green* light will go *on*. When the *alarm* conditions exists an *alarm* will sound. This *alarm* stops when the *acknowledge button* is thrown.

**Acknowledge Button.** Depressing this button will silence the *audio alarm* and stop the *indicating light* from flashing. *Do not depress the acknowledge button until you know what is alarming.* 

**Status Indicating Lights.** These are lights that indicate whether a piece of machinery is *running* or *stopped* or if a valve is *open* or *closed*. They do not flash. No alarm is sounded. Generally the *running* or *open* condition is a *green* light and the *stopped* or *closed* condition is an *amber* light.

**Push-button Stations.** These are *start* and *stop* positions for motors or *open* or *closed* positions for motor operated valves.

**Selector Stations.** These are switches which permit a variety of selections which the operator may require in order to keep the plant functioning. For example—if the main circulator breaks down the operator can switch to a fire pump or general service pump. If the #1 fuel—oil pump stops the operator can switch to the #2 pump, etc.

**Continuous Display Indicators.** These are pressure, temperature, liquid level, liquid flow or position that show the varying conditions at the COS at all times.

**Demand Display Indicators.** By depressing a button or dialing an address the information requested is displayed at the COS.

Figure shows the control locations of *level transmitters* and *controllers, temperature* and *pressure indicators,* etc., as connected to a deaerating feed tank.



# Section IV

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# **ORGANIZATION OF THE ENGINE DEPARTMENT**

This section covers all aspects having to do with the duties and obligations of the

Engine Department, especially with regard to watchkeeping activity. Watchkeeping is a fundamental part of shipboard duties, and it should be noted that it is very different depending on whether the ship is operating with an unmanned or manned engine room.

#### **GUIDELINES ON ORGANIZATION AND RESPONSIBILITIES**

Duties
In charge of Department
Organization of watches
Planning of trip requirements
Organization of Maintenance
Spare parts control
Organization of off-watch work
Control of overtime
Fuel reception
Keeping of watch
1/3 of shifts
Maintenance of electrical plant
Electrical material, storeroom
Maintenance of refrigeration plant
Maintaning cargo in air-conditioned hold
Engine storerooms
Cleanup personnel
Tools control
Tank probes
Watch assistant
Maintenance on off hours

Wiper

- Cleaning in engine rooms
- Painting in engine rooms
- Common labor

#### **USUAL SCHEDULE OF WATCHES IN ENGINE ROOM DEPARTMENT**

From 0000 to 0400 hours	Officer B
From 0400 to 0800 hours	Officer A
From 0800 to 1200 hours	Officer C
From 1200 to 1600 hours	Officer B
From 1600 to 2000 hours	Officer A
From 2000 to 2400 hours	Officer C

Note:

Officer A:	The most experienced
Officer B:	The second most experienced
Officer C:	The least experienced

The Chief Engineer is responsible for establishing all provisions relative to the organization of the watch, both as regards its composition and its implementation. To that end, he shall consult with the Master regarding navigation aspects. In addition, in deciding on the composition of the watch, he shall consider the following:

The type of ship:

- 1. The type and condition of the engines.
- 2. The operating mode imposed by weather conditions, the presence of ice, polluted waters, shallow waters, emergency situations, damage control and contamination prevention.
- 3. The competence and experience of the watch.
- 4. The safety of human life, of the ship, of the cargo, as well as port requirements.
- 5. Compliance with international, national and local regulations.
- 6. Maintenance of normal ship operations.

The Chief Engineer, after consulting with the Master and commenting upon the details of the trip calculates ahead of time the requirements for fuel, lubricants, spares and anything else that may be necessary.

This is a typical obligation of the Chief Engineer, that is not to be delegated to any other crew member.

In addition to the duties and responsibilities vested the Chief Engineer by law, the following are the company's specific policies and recommended duties:

1. Consult and/or coordinate with the Master regarding bunkering schedules, shore engine repairs, job-orders, disposition of fuel oils in the double bottom tanks and all important matters concerning the safety, efficient and economical engine operations.

2. Implement overtime, leave of absence and resignations to be duly approved by the master.

3. Consult the Master before opening up any machinery for inspection or overhaul that will inabilitate the engine operation or propulsion.

4. Prompt submittal to the Master and agents the capacities and bunker diesels, lubricating cylinder oils and fresh water on hand on arrivals and departures.

5. Execute and record in engine log-book all daily consumption and date of noon report at sea for submittal to the bridge.

6. Coordinate with the 1st Engineer all standing order, maintenance work and assignments.

7. Make daily inspection of the engine room, steering room telemeter system, etc., at sea to check the running conditions of all machineries and apparatus outside from the engine room.

8. Check daily the engine room log-book for incidents entered and recorded by watch Engineers.

9. Make a weekly inspection of all engine personnel's living quarters, toilet room, reefer chambers and store rooms.

10. Prompt and accurate submittal of engine reports at the end of each voyage, the following reports are:

- a. Port and sea abstract. All columns to be filled properly and adjustments of the quantity of fuels as per Charterer's Surveyors must be recorded for the Office record.
- b. Diagram cards and date.
- c. Important maintenance and work accomplishment.
- d. Tank soundings and capacities.
- e. Detailed incidents and breakdown report.
- f. Lubricating oil, greases and compunds report. These figures are to be recorded in the "Miscellaneous Oils" columns of the Port And Sea Abstract.
- g. Submittal to the office of personnel service rating record.
- h. Requisitions for the engine department, consummable and stores.
- i. Requisitions for the engine department spare parts.
- j. Job Orders and repairs.

11. Prompt and accurate submittal of the engine department inventory semi-annually

12. Periodical machinery continuous surveys must be maintained whenever possible in ports to avoid delays in drydock, to be completed during the five-year period from the last special survey and keep up to date all surveys and inspections of machineries in a record chart sheet. 13. A graphing system will be kept to record all fuels and lubricants consumptions, ship and engine data and main engine cylinder liner wears.

14. Instruct all ranking Engineers including the Electrician and Oilers No 1 and No. 2 to familiarize themselves in the manipulation of the fire extinguisher system to all ship's compartments. For this purpose, issue to all concerned "Operational Instructions" of the fire extinguisher system.

15. After around every 1,000 hours of main engine operation, submit to the lube oil suppliers sample of the circulating lube oil for analysis including one generator lube oil sample and submit to the office one copy of the lube oil service report.

16. If port time permits, calibrate all main engine cylinder liner wears in one port and submit to the office all data for graphing.

17. Instruct all engine personnel to report to the Master for his approval before purchasing any high priced article.

18. Ban strictly all forms of smuggling narcotics and gambling on board.

19. To keep better understanding and harmony in the engine department, instruct the First Engineer and Oiler No. 1 to report any differences among the engine personnel to the Chief Engineer for arbitration and justice.

20. To personally supervise the taking of bunkers at all times and must be most particular in getting the fuel weight, fuel analysis report, computations and samples of the fuel received.

21. Enjoin all ranking Engineers to assist the Chief Engineer during engine breakdowns at sea to be acquainted on its repairs.

22. Implement strictly all memoranda and circulars from the operations department of the Main Office issued from time to time.

23. Observe strictly the "STANDARD PROCEDURES OF MAINTENANCE, ROU-TINE OPERATIONS AND STANDING ORDERS" and the taking over of duties of Chief Engineer, memorandum supplied.

24. The Chief Engineer will be solely responsible to the Office for all tools, stores, equipment and spare parts in the engine department by any engine personnel disembarking.

25. The Chief Engineer is in charge of training all his subordinates for future promotions. Recommendations for promotions will be based on efficiency, moral character, engineering knowledge, behavior and discipline. Report to be submitted to the Office every six months on the back page of the service rating report.

The Watch Officer continues to be responsible for operations in the engine room areas even though the Chief Engineer is present in those same areas, unless the Chief Engineer

specifically advises him that he has assumed responsibility and that is clearly understood by both of them.

The Watch Officer shall give instructions to all other members of the watch to advise him of any potentially dangerous situation. At the same time, members of the watch have the obligation of informing the Officer of anything that may be dangerous or raises questions as to its potential danger.

On ships with manned Engine rooms, the Watch Officer shall be available at all times be prepared to operate the propulsion equipment in response to any requirements made from the bridge as to changes of direction and speed.

On ships with an unmanned Engine room, the Watch Officer shall be available at all times for any emergency.

The Watch Officer shall supervise the shutting down of all engines that are his responsibility and those on which any work is to be done.

No one may take an engine out of service without his consent, because otherwise the Watch Officer would lose control of the plant.

All spares, tools and stores must be carefully stowed and tied down, regardless of the navigation situation. If this is not done, they may shift and create danger both to the ship and the crew.

The Watch Officer shall not turn over the watch to the relief officer if he has reason to believe the latter is not in a position to carry out his watch duties efficiency, in which case he shall advise the Chief Engineer.

Before taking over the watch, the Officer coming on shall check the following points, as a minimum:

- 1. The standing orders and special instructions of the Chief Engineer relative to the operation of the ship's systems and engines.
- 2. Work that is being performed on the engine, the personnel involved, and any risks that may be involved.
- 3. The level and condition of water in the bilges, as this is a sign of losses and flooding.
- 4. The level of the ballasts, fresh water and dirty water tanks, as well as existing regulations on contamination for dumping.
- 5. Condition and level of fuel tanks.
- 6. Regulations relative to the dumping of sewage.
- 7. Condition and operating mode of the main and auxiliary engines.

- 8. Condition of control console equipment, with emphasis on knowing which equipment is being manually operated.
- 9. Special sailing situations, such as heavy weather, ice and polluted or shallow water.
- 10. Special operating procedures due to equipment failures and to conditions unfavorable to the ship.
- 11. Tasks assigned to the engine room hands.
- 12. Availability of firefighting devices.

The Watch Officer is responsible for the periodic inspection of the engines. He shall check that the following are in proper condition:

- 1. The main and auxiliary engines, the control systems, the indicator panels and the communications systems.
- 2. The steering apparatus.
- 3. The level and condition of the bilges.
- 4. All pipes, especially the pressurized oil pipes and the control system pipes.

The Watch Officer shall indicate in the Engine room Log all maintenance work that is done.

The Officer coming on watch shall not take over without examining the Engine room Log and making sure that it agrees with his own observations.

The Watch Officer shall immediately notify the bridge:

- 1. In case of fire: Of the measures that are about to be taken in the engine areas and that can lead to a slow down in the speed of the ship.
- 2. Any failure in the steering apparatus, a shutdown of the ship's propulsion system or problem in electric power generation that are imminent.
- 3. Safety threats. Whenever possible, suitable notice shall be given before making any changes so that the bridge can have the maximum amount of time available to take all possible measures to prevent the possibility of a maritime accident or loss.

The Watch Officer shall immediately inform the Chief Engineer of:

- 1. Any damage or operating defects that decrease the safety factor in the ship's operations.
- 2. Operating defects in the propulsion and auxiliary engines, and in the control and steering systems.

3. Any situations where he is in doubt as to the decision or steps to be taken.

Notwithstanding the foregoing obligation, the Watch Officer shall not hesitate to immediately perform those corrective measures that will ensure the safety of the ship and the crew.

# **ENGINE ROOM INSTRUCTION**

Based on IMCO's "International Convention on Standards of Training, Certification and Watchkeeping for Seafarers". 1978 (STCW–Convention).

# A. BASIC PRINCIPLES TO CONSIDER

#### i. General:

On every ship the Chief Engineer is responsible to ensure that the watchkeeping arrangements are adequate to maintain a safe engineering watch taking into consideration the following:

1. Type and condition of the machinery.

2. Special modes of operation dictated by weather conditions, ice, polluted waters, shallow waters, adverse ship operations, loss prevention or pollution abatement.

3. Qualification and experience of the crew forming the watch.

4. Considerations concerning international, national and local regulations.

5. Under the direction of the Chief Engineer, the engineer officers of the watch or on duty are responsible for the required inspections, operation and testing of all machinery and all equipment within their area of liability.

6. In consultation with the Master, the Chief Engineer should plan in advance the requirements needed for the intended voyage, such as fuel, water, lubes, chemicals, expendable and other spare parts, tools, supplies and other pertinent requirements.

#### II. Operation:

1. The engineer officer on watch or duty is to ensure that the watchkeeping arrangements are adequate and are complied with.

2. At the commencement of a watch, the required operational parameters and condition of all machinery should be confirmed. Any machinery not functioning
properly or expected to malfunction or requires special service should be noted as should any action already taken.

3. The engineer officer in charge should ensure that periodic checks are made of the propulsion machinery and the auxiliary equipment and that immediate remedial steps are taken in the event of any malfunction.

4. All bridge orders should be promptly executed. Changes in propulsion machinery speed and direction of rotation should be noted, unless recording is logged by special equipment.

Appropriate attention should be paid to the maintenance work of the entire machinery equipment.

5. The Chief Engineer should ensure that the engineer officer in charge is informed about all preventive maintenance, inspection or repair work which is to be carried out during his duty. All work performed is to be recorded.

6. Before going off duty, the engineer officer should ensure that all events relating to the main and auxiliary machinery which has occured during the watch or duty have been recorded.

7. The engineer officer on watch should immediately notify the bridge in the event of fire of impending actions that may cause reduction in ship's speed imminent steerage failure, stoppage of the ship's propulsion system and similar hazardous casualties.

8. Whenever "standby" mode is requested, the engineer officer on watch should ensure that all machinery equipement involved with the manoeuvring of the ship can be placed in manual modes of operations when notified and ensure that an adequate reserve of power is available for steering and other manoeuvring requirements.

#### Watchkeeping:

1. All watchkeepers should appreciate that the efficient performance of their duties is necessary in the interest of safety of life and property at sea and the avoidance of pollution of the marine environment. Each member should have:

- a. Knowledge of how to use appropriate internal communication systems.
- b. Knowledge about the engine room escapes.
- c. Knowledge about the location of and how to use the fire fighting equipment.

2. The complement of the watch should at all times, be adequate to ensure the safe operation of all machinery equipment involved with the operation of the ship and be appropriate to the prevailing circumstances and conditions. The following points are among those to be considered:

a. The condition, reliability and control location of any remote operated propulsion and steering equipment, and the complexities involved in placing them in a supervised manual mode of operation in the event of an emergency.

b. The location and methods of employment of fire detecting and extinguishing apparatus and fire containment devices.

c. The steps and procedures necessary to maintain the conditions of all machinery installations during all modes of ship operation.

#### IV. Fitness for Duty:

The watch systems should be such that the efficiency of the engineer officer is not impared by fatigue.

#### V. Protection of the Marine Environment:

All the engineer officers and engine room ratings should be aware of the serious effects of pollution to the marine environment and should take all reasonable precautions to prevent such pollution within the framework of existing international and local regulations.

#### **B.** CHECK POINTS FOR SAFER OPERATION

#### **Diesel engines**

Run time – Periods of overhaul Valve play – Abnormal sound Turbo charger – Oil – Air filter Speed governor – Oil Lubricating oil – Quality

#### Alternators

Terminals Carbon brushes Voltage regulation rectifiers ' Cooling Cleaning/cleanliness Distribution of load Bearing lubrication Overload

#### **Electrical system**

Fuses Motor protection settings Insulation reading earth fault Breakers, function Priority release groups

#### Separators

Density, gravity disc

Temperature Counter pressure Oil flow Vibration (bowl) Oil level Coupling

#### instrumentation

Pipe connections Vibrations Control instruments, set values Function, linkage, lubricating Periodical testing Intervals, maintenance

#### **Boilers**

Burner equipment – Size of nozzle Water level gauges – Testing Air supply Soot blowing Photocell – Flame guard Oil leak Function safety valves Fuel oil filters Control equipment auto manual Feed water control

## Pipe systems, Valves

Flange connection packings Insulation Leak detection Corrosion attacks, anodes Vibrations of pipe suspensions Gland boxes, grease spindles

## **Compressors, Air systems**

Intervals of start/stop, leakage Oil level Cooling Bearings, lubrication, couplings Vibrations High and low pressure valves Drainage

## Heat exchangers

Temperature inlet/outlet Cooled media Temperature inlet/outlet Coolant Pressure drop Tightness

# Pumps, Motors

Shaft seals Counter pressure Couplings, bearings, greasing Cavitation Overheating, motor, bearing Vibrations

Note: Always follow the manufacturer's instructions

# C. SAFETY MANUAL FOR THE ENGINE ROOM

## Examples of table of contents:

- 1. Instructions for the engineer officer of the watch or on duty.
- 2. Instructions for calling the Chief Engineer.
- 3. Start-up of machinery equipment at arrival/departure.
- 4. Instructions for special equipment.
- 5. Manoeuvring in narrow or congested waters.
- 6. Measures at arrivals/departures with alternator(s) out of operation.
- 7. Measures in the case of tripping.
- 8. Measures in the case of black-out.
- 9. Measures in the case of grounding.
- 10. Measures in the case of fire.
- 11. Test routines of emergency equipment.
- 12. Testing of manoeuvre, alarm and stop functions.
- 13. Information concerning relieving an engineering watch.
- 14. Information to new engine room personnel.
- 15. Recording in the engine log and oil record book.

Note: A clean engine room is a safer engine room.

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Outside the Mediterranean Sea, Baltic Sea. Black Sea, Red Sea, and Gulf Area				Inside the Mediterranean Sea, Baitic Sea. Black Sea, Red Sea, and Guil Area				Offshore Platforms and Asspciated Ships		
Distance from Shore	ance Type of Dunnage Permitted Shore to be Durnped at Sea			Distance from Shore	Type ( to	of Garbage Permitted be Dumped at Sea		Distance from Shore	Type c to	of Garbage Permitted be Dumped at Sea
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12 nautical miles or more All Gro		od Waste-Not Ground or Comminuted Il Other Garbage-Not round or Comminuted				Comminuted		Type of Carba	10	At Sea Dumping Restrictions Apply
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		miles from shore				(Dumping Prohibited)		Ground or Comminuted		(Dumping Prohibited)
Food Waste		Less than 3 nautical		Not Ground or Con	nminuted	Alkways (Dumping Prohibited)		Not Ground or Comminuted		Alkways (Dumping Prohibited)
No Ground or Comminuted		Less than 12 nautical miles from shore		Mixed Garbage Ty	pes	Most Stringent Requirements Apply		Mixed Garbage Ty	pes	Most Stringent Requirements Apply
All Other Garbage Ground or Comminuted		Less than 3 nautical miles from shore		Plastics - including, but not limited to, synthetic ropes, synthetic fishing net, and plastic garbage bags				Offshore platforms and associated ships refer to fixed or floating platforms engaged in exploration, exploitation and associated offshore processing of seabed mineral resources and all other ships when alongside or within 500 meters of such platforms.		
Not Ground or Comminuted		Less than 12 nautical from shore		Ground or comminuted garbage must be able to pass through a screen with openings no greater than 25 millimiters						
Mixed Garbage Types		Most Stringent Requirements Apply		All Other Garbage - including paper products, rage, glass, metal, bottls, crockery, and similar refuse						

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# **BUNKERING PROCEDURE**

Whenever your vessel is scheduled to refuel at any port, especially in the United States, the following has to be observed:

## I. BEFORE REFUELING OR OIL TRANSFER COMMENCES:

1. All drain pipes and all deck scuppers has to be plugged and cemented by the carpenter or bosum.

- 2. The Chief Engineer should prepare a bunkering plan indicating or identifying.
  - a. Fuel oil tanks to be filled.
  - b. Quantity of fuel to be loaded in each tank.
  - c. Sequence of loading.
  - d. Name, rank and duties of the engine crew involved inthe refueling operations, which should preferably include;

- The Chief Engineer as the officer incharge of refueling operations. (He should be ready to discuss with the coastguard or maritime authorities, and also with the head of the terminal or delivery barge supplying the fuel, the bunkering operations to be undertaken.)

- The 1st Asst. Engineer incharge of taking sounding of barges when refueling from fuel barges of taking meter readings when refueling from shore installations.

- The 2nd Asst. Engineer to be stationed at the filling manifold valve at the engine room during refueling operations.

- The 3rd Asst. Engineer/oilers at sounding pipes to take soundings the ships fuel tanks to be loaded and also to check and open all air vents of such tanks.

- Pumping pressure should not exceed three (3) kilogram/square centimeter also depend on the construction design of every ship.

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3. The Chief Mate should see to it that the "NO SMOKING" signs are placed in the areas where filling hoses are to be connected and in the vicinity of the sounding pipes of the tanks where fuel is to be loaded.

4. Electrician should hook up and test the telephone and/or communication system both at the filling pipes station and the filling manifold value at engine room and should see to it in good working order.

5. If refueling at night, Electrician should hook up the necessary lights in the vicinity of the filling pipe, sounding pipes of the tanks to be loaded and in the vicinity of the jacobs ladder in case of refueling from barges.

6. The bosun should make fast appropriate jacobs ladder in the side where fuel barges are moored including a life line of at least one (1) inch circumference, Manila rope.

7. Oiler No. 1 inspect and open all fuel oil air vents on deck which may have been missed by the oilers.

8. The Chief Officer orders the bosun to place portable fire extinguisher in the vicinity of sounding pipes of the tanks being refueled.

9. The 1st Asst. Engineer will see to it that drip pans are placed under the filling pipe and air vents. The drip pans should be least the size of a half drum.

10. The 1st, Asst. Engineer should see to it that sawdust and dispenser are placed in the vicinity of filling pipe and near the air vents of the tanks to be loaded.

11. All fire hoses should be connected to the respective fire hydrants by the 3rd mate.

## **II. LOADING OPERATIONS**

1. The Chief Engineer should hold a conference with the person incharge of the vessel delivering fuel or incharge of the shore facility, to ensure that the loading plan is understood before refueling is commenced.

2. The Chief Engineer or 1st Asst. Engineer should sign the declaration of inspection whenever required.

3. The Mate on watch hoists International Flag "B" during day time and red light at night, specifying vessel loading fuel and or dangerous cargo.

4. While loading, the officer on watch should make a continuous round of the ship and inspect vessel's mooring lines to be sure that they are tight.

5. The 3rd Asst. Engineer is incharged of the telephone and/or communication system and be ready at all times to relay instruction to the engineer at the filling manifold valve.

6. 1st Asst. Engineer should inspect and see to it that the overhead discharged and W.B.T. suction valves connected to F.O. double bottom tanks are locked or closed position.

7. 1st Asst. Engineer should supervise the connecting or disconnecting of the filling hose. While loading he should see or it that the oil transfer hose is properly supported at all times with appropriate means to avoid unnecessary lag or kinds in the hoses.

8. 1st Asst. Engineer should see to it that the other sides filling connections are properly closed blinds and complete with bolts and nuts.

9. In all ships where the filling pipes are adjacent to the cabin, saloon, or galley, the Chief officer should see to it that all ports holes of such cabins facing the filling pipes or sounding pipes and/or air vents are closed and dogged.

10. "NO SMOKING" on deck and other open or exposed areas is to be observed until refueling is completed.

# PRC-ENGINE DEPT-APPLICATION FOR ADMISSION

**Requirements for:** 

## FOURTH ENGINEER:

- 1. PRC Application Form
- 2. PRC Examination Record
- 3. Medical Certificate
- 4. Certificate of Service of 2 yrs. experience
- 5. Seaman's book orig. w/ xerox copy
- 6. Three pcs. 2 x 2 pictures in uniform w/ bars
- 7. AME Diploma/TRanscript of Records/S.O.
- 8. Certification from the Company

## THIRD ENGINEER:

- 1. PRC Application Form
- 2. PRC Examination Record
- 3. Medical Certificate
- 4. Certificate of Service of one yr. experience as 4/E
- 5. Seaman's book orig. w/ xerox copy
- 6. Three pcs. 2 x 2 pictures in uniform w/ one bar
- 7. Residence Certificate
- 8. Certification from the Company
- 9. License as 4/E w/ xerox copy

# **SECOND ENGINEER:**

- 1. PRC Application Form
- 2. PRC Examination Record

- 3. Medical Certificate
- 4. Certificate of Service of one yr. experience as 3/E
- 5. Seaman's book orig. w/ xerox copy
- 6. Three pcs. 2 x 2 pictures in uniform w/ 2 bars
- 7. Residence Certificate
- 8. Certification from the Company
- 9. License as 3/E w/ xerox copy

## CHIEF ENGINEER:

- 1. PRC Application Form
- 2. PRC Examination Record
- 3. Medical Certificate
- 4. Certificate of Service of 2 yrs. experience as 2/E w/ xerox copy
- 5. Seaman's book orig. w/ xerox copy
- 6. Three pcs. 2 x 2 pictures in uniform w/ 3 bars
- 7. Residence Certificate
- 8. Certification from the Company
- 9. AME Diploma / Transcript of Records / S.O. (Special Order)
- 10. License as 2/E w/ xerox copy

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## PROGRAM OF THE MARINE ENGINEERING LICENSURE EXAMINATION TO BE GIVEN BY THE BOARD FOR ENGINE OFFICERS OF PROFESSIONAL REGULATION COMMISSION.

## FOR CHIEF, SECOND, THIRD, FOURTH MARINE OFFICERS

DATE AND TIME First Day of Examination	SUBJECTS	WEIGHT	
8:00 A.M. – 9:30 A.M.–	MATHEMATICS (Physics, Geometry and Strength of Materials – For Chief and Second Marine Engineer) (Arithmetic, Algebra, Physics and Geometry – For Third and Fourth Engineer)	10%	
10:30 A.M. – 12:30 P.M.–	ELECTRICITY AND ELECTRICALLY DRIVES PROPULSION	10%	
1:30 P.M. – 5:30 P.M.–	STEAM BOILERS, ENGINES, TURBINES INTERNAL COMBUSTION AND MACHINE SHOP (Includes Fire Fighting/Fire Prevention)	30%	

## Second Day of Examination

8:00 A.M 9:30 A.M	DRAWING	10%
10:30 Å.M. – 12:30 P.M.–	REFRIGERATION AND AIRCONDITIONING MACHINERY	10%
1:30 P.M. – 5:30 P.M.–	PRACTICAL QUESTIONS (Includes Survival Craft (basic), Personal Survival Technique, Eirst-aid at sea)	30%
	TOTAL	100 %

Note: 1. Books, notes, review materials and other examination aids not stated on this program to be used during the examination shall not be brought inside the examination building.

- 2. Bring the following:
  - a) Two or more pencils (No.1) to be used in blackening or shading your Examinee Identification/Answer Sheet Set.
  - b) One ballpen of one color of ink either blue, black or blue-black to be used in accomplishing other examination forms.
  - c) One piece of brown envelope
- 3. Secure your instruction sheet on how to accomplish and handle the Examinee Identification/Answer Sheet Set (EIASS) and sample sheets for practice. You may get these from the Application Division when you come back for your room assignment.
- 4. Your room assignment will be posted at the school premises one or two days before the examination.

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5. Read carefully the instruction in your NOTICE OF ADMISSION.

#### PLACE OF EXAMINATION:

- MANILA January and Other Dates
- ILOILO May
- CEBU September

## **Section V**

# CODE OF ETHICS

For the marine profession to progress and remain as an orderly and dignified profession, and to further maintain its fruitful standard of practice for the interest of the nation and general public, these rules of professional conduct are hereby formulated and adopted as guidance for all its practitioner.

#### CODE OF ETHICS FOR FILIPINO MARINE OFFICERS

#### ARTICLE I General Definition

1. A marine officer shall mean any person who holds a certificate as a deck officer and/or as a marine engineer of any grade.

2. A marine officer shall be covered by this Code even if he is under suspension, but this status as a marine officer shall cease if his license has been revoked for any cause.

3. A marine officer is said to have performed as act unethical to the profession if such action or actions are contrary to the established conduct hereforth mentioned.

#### ARTICLE II Duty to the Profession

1. A marine officer shall strive to elevate, maintain and contribute to the honor and dignity of the profession.

2. He shall conduct himself with the traditional decorum of an officer and gentleman, restraining himself from all acts contrary to the established rules of morality and personal discipline.

3. He shall continually improve his professional competency by keeping up-to-date with the latest technological and scientific knowledge being applied in the marine fields.

4. He shall all, continually consider the preservation of life, health and property, even at the risk of his own life, to enhance the sense of public interest that is an integral obligation of the profession.

## ARTICLE III Duty to the State

1. A marine officer, in his capacity as a person of high technical potentialities and delegated with leadership for the discipline of his men shall recognize and respect the supreme authority of the state.

2. A marine officer shall strive to become an exemplary citizen by a devoted or fruitful fulfillment of his civic duties.

3. He shall endeavor to assist and cooperate with the proper authorities in the enforcement of maritime and custom laws and regulations.

4. He shall perform his professional duties in conformity with existing laws.

5. He shall offer to the state his full knowledge, experience and material possesion in time of national emergency.

## ARTICLE IV Duty to the Public

1. Every marine officer shall compose himself as an officer and a gentleman, and to act honorably when dealing with the general public.

2. He should be concerned foremost with the safety of everyman, woman and child who boards his vessel as a passenger by following all safety measures prescribed for shipboard use.

3. He shall contribute his professional knowledge for the general welfare and comfort of the reading public to gain their respect and confidence.

4. It shall be his obligation to keep himself in readiness for the next higher license by constant reading, diligent studies and keep observation of the shipboard activities.

5. He shall make financial gain secondary only to the service that the entire profession can render to the economic growth of the country.

6. A marine officer shall not hesitate to consult his fellow marine officers in matters that will affect the honor and integrity of the marine profession.

7. He shall expose, without fear or favor, to the proper authorities of the profession, corrupt or dishonest conduct of member of the profession whose existing practices can degrade the reputation of other practitioners.

8. Many marine officer should aid in safeguarding the profession against the admission to its rank persons who are unfit or unqualified in moral character of profession training.

## ARTICLE V Duty to the Superior

1. Marine officers in a subordinate capacity shall always render traditional respect to a superior officer.

2. Subordinates shall render the necessary assistance if possible above and beyond the call of duty, so that their superiors, or the entire organization, can be assured of a successful operation or undertaking duly assigned to them.

3. A subordinate shall strive to gain the confidence and respect of his superior through prompt and efficient performance of his assigned duties.

4. A marine officer shall promptly and efficiently follow and obey all lawful orders of his superior without questioning his integrity.

5. A subordinate should always remember that he can only give recommendation to his superior and that final decision must be left to his superior's discretion.

6. A subordinate should never openly criticize the actuation of his superior and must give the proper assistance within or beyond his specific duties.

7. A subordinate should never openly criticize the actuation of his superior with other subordinate officers more particularly with unlicensed personnel.

8. In the event of inquiries he should only state actual facts but never his opinion as to whether his superior is right or wrong.

#### ARTICLE VI Duty to a Subordinate

1. A superior officer shall always conduct himself with the proper decorum in his act or deeds and thoughts to set an example for his subordinate be fitting his rank or designation.

2. He should give the necessary training, guidance and opportunities for the improvement of his subordinate's competency and especially to overcome his shortcoming demanded by his license as a marine officer.

3. He should continually mold the character of his subordinate to impress the importance of command responsibility.

4. He should give merits unselfishly when due, to inspire his subordinates to

achieve greater result.

5. He should not hesitate to listen to advice of his subordinates but to exercise discretion before implementation.

6. He should not hesitate to admit errors in his decision when it is obvious, but it must be done within the circle of his staff.

## ARTICLE VII Duty to his fellow-Practitioner

1. Every marine officer should work together in mutual cooperative and harmonious relationship by sharing individual knowledge for professional advancement.

2. He should associate with his colleagues in any reputable and recognize marine society to further broaden his knowledge.

3. He should never attempt to issue statements to the general public concerning the short-comings of his fellow officer.

4. The following specified acts of a marine officer shall be deemed to be unethical as a breach of a professional ethics, subject to immediate disciplinary action;

- a. Open criticism of a fellow officer without the knowledge of the other.
- b. Spreading false information on the professional competency and ability of the other practitioner.
- c. Degrading a colleague in order to acquire his position.
- d. False recommendation on the competency of another officer.
- e. Maliciously withholding information or knowledge to place other in a controversial situation.
- f. Tending to accept a position lower than his highest license to displace another applying for the same.
- g. Exerting political influence to displace a marine officer.
- h. Certifying that he can worked better or could render service more satisfactorily than another.
- i. Openly expressing that he holds exclusive methods or practice or style of service.

#### ARTICLE VIII Violation and Effectivity

1. Non-compliance with any of the provision of this Code shall be deemed sufficient grounds for proceeding against a marine officer which may lead to suspension or revocation of his license.