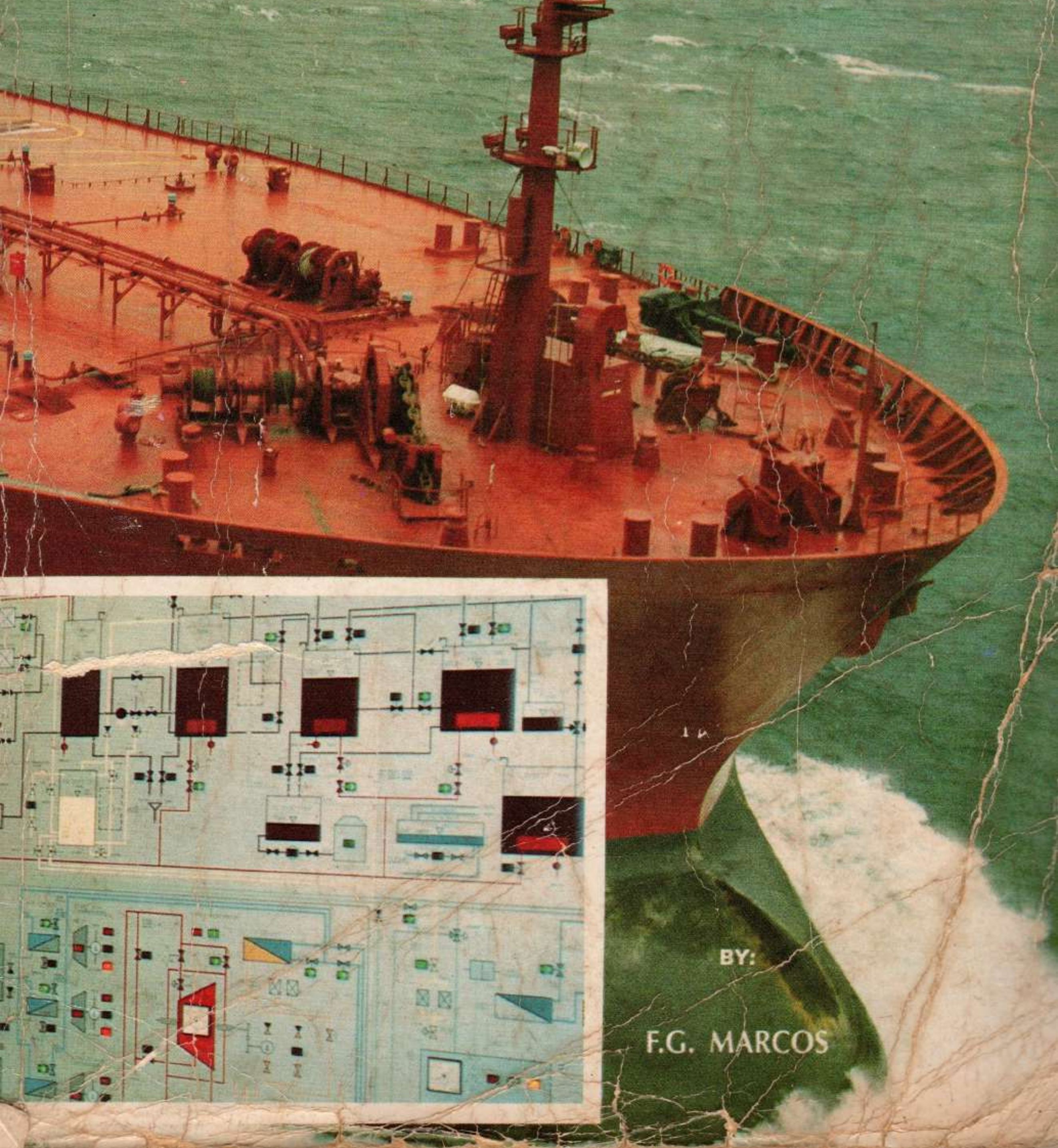
MODERN MARINE ENGINEERS HANDBOOK

and

Review Guide



BY:

F.G. MARCOS

By

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

CONTENTS

PART I

MATHEMATICS

MATHEMATICS

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:

$$2 \times 6 = 12$$
$$432 \times 19 = 8208$$
$$0.32 \times 0.0046 = 0.001472$$
$$3.9472 \times 43.16 = 170.36115$$

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

Examples:

$$6 \div 3 = 2 \quad , \quad 6/3 = 2 \quad \frac{6}{3} = 2$$
$$81 \div 9 = 9$$
$$18653 \div 18 = 1036.28$$
$$1121 \div 3\ 3/4 = 298.93$$

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

Examples:

$$81 + 5 + 12 = 98$$
$$6.5 + 3 + .5 = 10$$

$$\begin{array}{rrrrr} 2a & + & 7b & + & 3c \\ 5a & - & 2b & + & 6c \\ \hline 7a & + & 5b & + & 9c \end{array} \qquad \begin{array}{r} 946.75 \\ 8.42 \\ .00842 \\ \hline 955.17842 \end{array}$$

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

Examples:

$$92 - 12 = 80$$
$$12 - 2.5 = 9.5$$
$$8x - (-5x) = 13x$$
$$8x - 5x = 3x$$

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.

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.

Examples:

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

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)	=	(+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: $212 - 32 = 180 \div 9 = 20 \times 5 = 100$ ˚C

To convert 260 ˚C to ˚F

Divide by 5, multiply by 9 and add 32

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

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

one tenth $= \dfrac{1}{10} = 0.1$

one hundredth $= \dfrac{1}{100} = 0.01$

one thousandth $= \dfrac{1}{1000} = 0.001$

one and three tenths $= 1\dfrac{3}{10} = 1.3$

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

$$\begin{array}{r} 4.3785 \\ \underline{29.46} \\ 33.8385 \end{array}$$

b) Subtract 3.8648 from 48.82

$$\begin{array}{r} 48.8200 \\ \underline{3.8648} \\ 44.9552 \end{array}$$

Conversion of Percent to Decimal

Examples:

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

Conversion of Fraction to Decimal

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:

$2^3 \times 2^4 = 2^7$ (adding indices)
$3^5 \times 3^2 = 3^3$ (a subtracting indices)
$(2^2)^3 = 2^6$ (multiplying indices)

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

Examples:

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

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.

Ratio of times taken :: Ratio of quantities deliver

$55 : x \; :: \; 4400 : 6000$

$X \times 4400 = 55 \times 6000$

$x = \dfrac{55 \times 6000}{4400}$

$x = 75$ minutes.

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?

At a speed of 12 knots, time = 16 days

At a speed of 1 knot, time = 16 x 12 days

At a speed of 15 knots, time = $\dfrac{16 \times 12}{15}$

= 12.8 days

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

Ratio of 4 to 25

$= \dfrac{4}{25}$ in fractional form

$= \dfrac{16}{100}$ 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: $2 \times 3 + 2 \times 4 - 2 \times 5$

$= 2\ (3 + 4 - 5)$

$3x + 2xy - xz$

$= x\ (3 + 2y - z)$

$Y^2 - 16$

$= (y + 4)\ (y - 4)$

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

Examples:

Evaluate $3 \times y + X^2 - 4y$

when $x = 2$ and $y = 3$

$= 3xy + x^2 - 4y$

$= 3 \times 2 \times 3 + 2^2 - 4 \times 3$

$= 18 + 4 - 12$

$= 10$

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.

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 $(4.189)^2$

$$\begin{array}{lcl} \text{log of } 4.189 & = & 0.6221 \\ \text{multiply by the power} & = & \underline{\quad 1} \\ & & 1.2442 \\ \text{antilog of } 1.2442 & = & 17.55 \text{ ans.} \end{array}$$

ROOT – Find the square root of 7365

$$\begin{array}{lcl} \text{log of } 7365 & = & 3.8672 \\ 3.8672 \text{ divide by } 2 & = & 1.9336 \\ \text{antilog of } 1.9336 & = & 85.82 \text{ ans.} \end{array}$$

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

$$\begin{array}{rcl} 4x + 10 & = & 18 \\ 4x & = & 18 - 10 \\ 4x & = & 8 \\ x & = & 2 \end{array} \qquad \begin{array}{rcl} 14x - 2x - 5x & = & 8 - 15 + 28 \\ 7x & = & 21 \\ x & = & 3 \end{array}$$

Simplify the following equations:

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

Ans.

$$\begin{array}{rccccccc} & a & + & b & & \\ \times & a & + & b & & \\ \hline & a^2 & + & ab & & \\ & & + & ab & + & b^2 \\ \hline & a^2 & + & 2ab & + & b^2 \end{array} \qquad \begin{array}{rccccccc} & a & - & b & & \\ \times & a & - & b & & \\ \hline & a^2 & - & ab & & \\ & & - & ab & + & b^2 \\ \hline & a^2 & - & 2ab & + & b^2 \end{array}$$

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

$$\begin{array}{rcrcl} 5x & - & 5y & = & 50 \text{ --- } 1 \\ 7x & + & 5y & = & 130 \text{ --- } 2 \\ \hline 12x & & & = & 180 \\ & & x & = & \frac{180}{12} \\ & & x & = & 15 \end{array}$$

Substitute:

$$5x - 5y = 50$$
$$5(15) - 5y = 50$$
$$75 - 5y = 50$$
$$-5y = 50 - 75$$
$$Y = \frac{-25}{-5}$$

$$Y = 5$$

c) Add the following mixed numbers.

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

$$\frac{43}{8} + \frac{49}{4} + \frac{15}{4}$$

$$\text{LCD} \quad \frac{43 + 98 + 30}{8}$$
$$= \frac{171}{8} \quad \text{or} \quad 21.375$$

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

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

$$8(5) = 40 \text{ bigger number}$$

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.

$\frac{1}{x}$ = work done by Oscar & Bong in one day

$\frac{1}{5}$ = work done by Oscar in one day

$\frac{1}{8}$ = work done by Bong in one day

Equation:

$$\frac{1}{5} + \frac{1}{8} = \frac{1}{x}$$

LCD: $$\frac{5 + 8}{40} = \frac{1}{x}$$

$$\frac{13}{40} = \frac{1}{x}$$

$$13x = 40 \qquad x = \frac{40}{13}$$

$$x = 3.08 \text{ days}$$

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

Solution: Let x = 1st number

$x + 1$ = 2nd number

$x + x + 1 = 26$

$2x + 1 = 26$

$2x = 26 - 1$

$x = \frac{25}{2}$

$x = 12.5$

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

$$\frac{5}{8} + \frac{7}{12} + \frac{11}{24} \quad \text{Find: LCD} = 24$$

$$\frac{15 + 14 + 11}{24} = \frac{40}{24} \text{ or } 1\frac{2}{3}$$

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

$$\frac{5}{6} - \frac{8}{15} \qquad \text{LCD} = 30$$

$$\frac{25 - 16}{30} = \frac{9}{30} \text{ or } \frac{3}{10}$$

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:

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

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

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

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

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

$$-24x = -12$$

$$x = \frac{-12}{-24}$$

$$x = \frac{1}{2}$$

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.

$$°F = \frac{9}{5} C + 32$$
$$= \frac{9}{5} \times 100 + 32$$
$$= \frac{900}{5} + 32$$
$$= 180 + 32$$
$$°F = 212$$

$$°C = \frac{5}{9} (°F - 32)$$
$$= \frac{5}{9} (212 - 32)$$
$$= \frac{5}{9} (180)$$
$$= \frac{900}{9}$$
$$°C = 100$$

2. Convert 300°C – °F
   400°F – °C
   80°C – °F

Answer: 572.°F
204.44 °C
176°F

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) $\frac{60 \text{ mi}}{\text{hr}} \times \frac{1.6 \text{ km}}{1 \text{ mi.}} \times \frac{1000 \text{ m}}{1 \text{ km.}} \times \frac{3.28 \text{ ft.}}{1 \text{ m}} \times \frac{1 \text{ hr.}}{60 \text{ min.}} \times \frac{1 \text{ min.}}{60 \text{ sec.}}$

$$= \frac{314880}{3600} = 87.47 \text{ ft/sec.}$$

$$= \frac{87.46 \text{ ft/sec}}{3.28\text{ft/m}} = 26.67 \text{ m/sec}$$

b) $6.56 \text{ km/hr} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{3.28 \text{ ft.}}{1 \text{ m}} \times \frac{1 \text{ hr}}{3600 \text{ sec.}}$

$$= \frac{21516.8 \text{ ft.}}{3600 \text{ sec}} = 5.98 \text{ ft./sec.}$$

c) $375 \text{ hp} \times \frac{746 \text{ watts}}{1 \text{ hp}}$

$$= 279{,}750 \text{ watts.}$$

d) $700 \text{ mm} \times \frac{1 \text{ cm}}{10 \text{ mm.}} \times \frac{1 \text{ inch}}{2.54 \text{ cm.}} \times \frac{1 \text{ ft.}}{12 \text{ in.}}$

$$= 2.30 \text{ ft.}$$

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 km/hr = 10 m/sec ; 108 km/hr = 30 m/sec.

a) $V = \frac{V_f + V_o}{2}$

$= \frac{30 + 10}{2}$

$= 20$ m/sec.

$V = \frac{36 + 108}{2}$

$= 72$ km./hr.

b) $a = \frac{V_f - V_o}{t}$

$= \frac{30 - 10}{20}$

$= 1 \text{ m/sec.}^2$

c) $S = Vt$

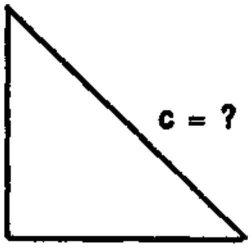
$= 20\,(20)$

$S = 400$ 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?

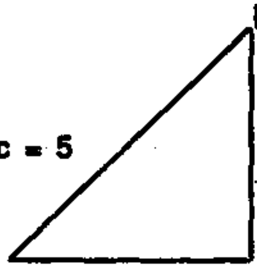
Figure



Formula:

$$C^2 = A^2 + b^2$$
$$= 8^2 + 5^2$$
$$C = \sqrt{64 + 25}$$
$$= \sqrt{89}$$
$$C = 9.43 \text{ ft.}$$

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



By Phythagorean Theorem:

$$C^2 = a^2 + b^2$$
$$b^2 = C^2 - a^2$$
$$b = \sqrt{5^2 - 3^2}$$
$$b = \sqrt{25 - 9}$$
$$b = \sqrt{16}$$
$$b = 4$$

Note: SOH – CAH – TOA

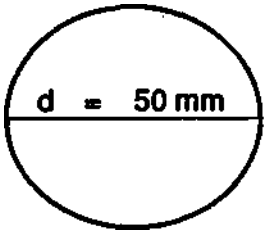
$$\text{Sine} = \frac{\text{opposite}}{\text{hypothenuse}} = a/c = 3/5$$

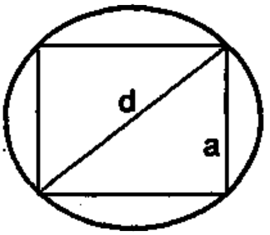
$$\text{Cosine} = \frac{\text{adjacent}}{\text{hypothenuse}} = b/c = 4/5$$

$$\text{Tan} = \frac{\text{opposite}}{\text{adjacent}} = a/b = 3/4$$

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.

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

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

4. What is the circumference of a circle whose radius is $7\,{}^1/_2$ meters?

Formula: Circumference of a circle $= 2\pi r$

where $r = 7\,{}^1/_2 = 7.5$

$$C = 2(3.1416)\,(7.5)$$
$$= (6.2834)\,(7.5)$$
$$= 47.13 \text{ meters}$$

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

Solution:

Area of sphere $= \pi D^2$

$$= 3.1416\,(10)^2$$
$$= 3.1416\,(100)$$
$$= 314.16$$

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

Ans.

$$A = \frac{\pi}{4} d^2$$

$$= \frac{3.1416}{4} (3)^2$$

$$= .7854 (9)$$

$$= 7.068 \text{ sq. ft.}$$

$$A = \frac{\pi}{4} d^2$$

$$= .7854 (914.4 \text{ mm})^2$$

$$= 656694.42 \text{ sq. mm.}$$

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

Volume $= .7854\, D^2 h$

1 gal. = 231 cu. in.

$$\text{height} = \frac{\text{volume}}{.7854\, D^2}$$

$$= \frac{250\,(231)}{.7854\,(24)^2}$$

$= 127.6'$ approx. $10\ ^1/_2$ 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.

$$\text{Diameter} = \frac{\text{Volume}}{.7854\,(H)}$$

$$D^2 = \frac{2{,}600 \times 231}{.7854\,(12 \times 12)}$$

$$D^2 = \frac{600\,600}{113.09}$$

$$D = \sqrt{5310.81 \text{ inches}}$$

$$D = 72.87 \text{ inches}$$

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?

$$\text{Area} = 2\pi R^2$$

$$\text{Circumference} = 2\pi r$$

$$\text{Radius} = \frac{C}{2\pi} = \frac{95}{2\,(3.1416)} = \frac{95}{6.2832} = 15.12\ \text{cm.}$$

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:

$h = 7\ \text{m} = 22.96\ \text{ft.}$ Sp. gr. $= 0.95$

$\text{dia.} = 15\ \text{ft.}$

Solution:

$$\text{Volume} = \text{area of base} \times \text{height}$$

$$= .7854\, d^2 h$$

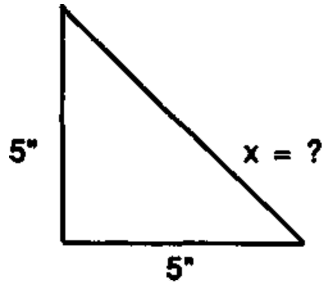
$$= .7854\,(15)^2 \times (22.96)$$

$$= .7854\,(225)\,(22.96)\,(0.95)$$

$$\text{Volume} = 8354.5\ \text{ft.}^3$$

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

By: Phythagorean Theorem.



$$x = \sqrt{(5)^2 + (5)^2}$$

$$= \sqrt{25\ \text{inc.}^2 + 25\ \text{inc.}^2}$$

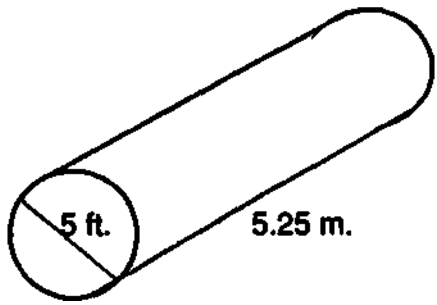
$$= \sqrt{50\ \text{inc.}^2}$$

$$x = 7.07\ \text{inches}$$

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 m where 5 ft. = 1.52 m

Volume = Area of base x height
= .7854 $(1.52)^2$ (5.25)
= .7854 (2.31) (5.25)
= 9.52 m^3 x .96 s.g.
Volume = 9.145 MT



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 gallon = 231 cu. in.

$$GPM = \frac{\text{vol. of cyl.} \times \text{no. of strokes} \times \text{Efficiency}}{231}$$

$$= \frac{.7854 \times 6^2 \times 4 \times 200 \times 0.955}{231}$$

$$= \frac{21601.64}{231}$$

$$GPM = 93.5$$

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?

$$GPM = \frac{\text{vol. of cyl.} \times \text{no. of strokes} \times \text{Efficiency}}{231}$$

$$= \frac{.7854 \times 6^2 \times 10 \times (35 \times 4) \times .90}{231}$$

$$= \frac{35625.74}{231}$$

$$GPM = 154.224$$

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?

$$\text{GPM} = \frac{\text{vol. of cyl.} \times \text{nos. working strokes} \times \text{Efficiency}}{231}$$

$$= \frac{.7854 \times (6)^2 \times 6x(25 \times 4) \times .96}{231}$$

$$= \frac{16286}{231}$$

$$\text{GPM} = 70.502$$

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:

$$\text{Pitch} = \frac{6080 \times \text{observed miles}}{N \times 60 \times 24 \times E}$$

$$= \frac{6080 \times 242.6}{98 \times 60 \times 24 \times 0.87}$$

$$= \frac{1475008}{122774.4}$$

$$= 12 \text{ ft.}$$

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

$$= [(26 \times 24)] + 16 \times 60 + 8$$

$$= 640 \times 60 + 8$$

$$= 38400 + 8$$

$$= 38408 \text{ min.}$$

$$\text{Mile per minute} = \frac{5742 \text{ miles}}{38408 \text{ mins.}} = 0.1495$$

$$\text{Mile per hour} = 60 \times 0.1495$$

$$= 8.97 \text{ or } 9 \text{ knots.}$$

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?

$$\% \text{ slip} = \frac{ES - OS}{ES} \times 100$$

$$= \frac{17.5 - 17}{17.5} \times 100$$

$$= 0.02857 \times 100$$

$$= 2.857\%$$

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

$$\text{Ave. speed} = \frac{\text{distance}}{\text{time}} = \frac{7{,}200 \text{ mi.}}{540.5 \text{ hrs.}}$$

= 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:

$$F = 1500 \text{ lb.} \times \frac{1 \text{ kg}}{2.2 \text{ lb.}} = 681.82 \text{ kg.}$$

d = 44 ft. = 13.415 M

t = 10 sec.

$$\text{Power} = \frac{\text{work done}}{\text{time ellapsed}}$$

$$= \frac{\text{force x distance}}{\text{time}}$$

$$= \frac{681.82 \text{ kg.} \times 9.8 \text{ m/sec.}^2 \times 13.415 \text{ m.}}{10 \text{ sec.}}$$

= 8963.68 joule per sec. or watts

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

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

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

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

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

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

$$\text{Remaining steaming radius} = \frac{10148.2}{.9259}$$

= 10,960 miles

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

$$\text{Propeller Eff.} = \frac{\text{ED} \times 6080 \text{ ft.}}{\text{P} \times \text{RPM} \times \text{Time}}$$

$$= \frac{320 \times 6080}{21 \times 70 \times 1440}$$

$$= \frac{1945600}{2{,}116{,}800}$$

= .9191 x 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?

$$\text{cons./day} = \frac{130 \text{ gr./BHP-HR} \times 12000 \text{ BHP} \times 24}{.92 \times 1000{,}000 \text{ grms.}}$$

$$= \frac{37440000}{920000}$$

$$= 40.7 \text{ m}^3$$

$$\text{cons/day in gal} = 40.7 \times \frac{1000}{1 \text{ m}^3} \times \frac{0.2642 \text{ gal.}}{1 \text{ L}}$$

$$= 10{,}752.94$$

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

$$\text{Consumption Vol.} = \frac{\pi}{4} D^2 h$$

$$= .7854 (84)^2 (15)$$

$$= 83126.736 \text{ in}^3 \text{ per 4 hrs.}$$

$$= 20781.684 \text{ in}^3 \text{ per hr.}$$

$$\text{Cons. in liters} = 20781.684 \times \frac{1 \text{ liter}}{61.0128 \text{ in}^3}$$

$$= 340.611 \text{ Liters per hour}$$

COMPUTATION FOR FUEL CONSUMPTION ON BOARD

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:

$$1.\ 20 \text{ MT} \times \frac{1000 \text{ L}}{1 \text{ Ton}} = 20{,}000 \text{ Liters}$$

$$2.\ \frac{20{,}000 \text{ L}}{.9730 \text{ (sg) } 15^\circ\text{C}} = \frac{20{,}554}{.9542 \text{ (CF) at } 85^\circ\text{C}} = 21.541 \text{ Liters}$$

$$3.\ \frac{21{,}541 \text{ L}}{6 \text{ watch/day}} = 3590 \text{ L/watch}$$

$$= 897 \text{ L/Hr.}$$

$$= 15 \text{ L/min.}$$

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:

$$= 27.10 \text{ MT} \times \frac{1000 \text{ kg}}{1 \text{ ton}} = 27{,}100 \text{ kg/day}$$

$$= \frac{27100 \text{ kg/day}}{24 \text{ hr/day}} = 1{,}129 \text{ kg/hr.}$$

$$= \frac{1{,}129 \text{ kg}}{\text{Hr.}} \times \frac{1000 \text{ grms}}{1 \text{ Kg}} = 1{,}129{,}166 \text{ grms/hr}$$

$$= \frac{\text{fuel cons. in grms}}{\text{actual BHP}} = \frac{1{,}129.166}{7109.52}$$

$$= 158.82 \text{ gms-bhp/hr.}$$

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:

$$\text{Cyl. oil cons.} = \frac{Ne \times Vd \times V^{\circ} \times 1000}{N \times n_e \times 24}$$

$$= \frac{150 \times 189.36 \times .95 \times 1000}{141.30 \times 8200 \times 24}$$

$$= \frac{26{,}983{,}800}{27{,}807{,}840}$$

$$\text{Cyl. oil cons.} = 0.970 \text{ grms-bhp/hr.}$$

where Ne = shop rpm
N = actual rpm
n_e = rated output
Vd = cyl. oil cons.
V° = specific gravity

TANKS CALCULATIONS WHEN BUNKERING

Q. Your fuel tank on board capacity is 1500 M³ (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^3 = $(T_2 - T_1 \times \text{coef. of expansion} \times \text{vol. } m^3)$

First = $1500 \text{ m}^3 \times 95\% = 1425 \text{ M}^3$

Second = $1425 - (45^{\circ} - 15^{\circ} \times .000720 \times 1425)$

= $1425 - 30.78$

= 1394.22 m^3 at 15°C (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/cm²; 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%.

where: Bore = 68 cm ; Stroke = 1.25 ; Area = 3,631.689

Solutions:

1. cylinder constant $= \dfrac{L \times A}{4500} = \dfrac{1.25 \times 3{,}631.68}{4500}$

$= 1.0088$

2. Prop. dist. $= 3.15\text{ M} \times 3.28\text{ Ft.} = \dfrac{10.33\text{ Ft.}}{6080\text{ Ft/Mi.}} = .00169736\text{ Mile}$

3. BHP $= \dfrac{\text{cyl. constant} \times \text{RPM} \times \text{P.} \times \text{ME} \times \text{no. of cyl.}}{100}$

$= \dfrac{1.0088 \times 140 \times 8.5 \times 85 \times 6}{100}$

BHP = 6122

4. F.O. Cons./Hr. = 6122 x 156 gms

= 955,032 ÷ 1,000,000

= 0.95503 MT

Prop. distance/min. = .00169736 x 140 RPM = 0.23762 mi.

Prop. distance.hour = 0.23762 x 60 = 14.25 mi.

Prop. distance/hr. with 5% slip

= 14.25 x .95 = 13.54 mi.

$= \dfrac{7000\text{ miles}}{13.54\text{ mi/hr.}}$

= 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 tons

HP of turbine = 1,500

$6.5\text{ tons} \times \dfrac{2000\text{ lbs.}}{1\text{ ton}} = 13{,}000\text{ lbs.}$

Fuel cons. $= \dfrac{13{,}000\text{ lbs.}}{1500\text{ HP}}$

= 8.666 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.

$= 26 \times 24 + 16 + .133$

$= 640.133$ hrs.

$$\text{Ave. speed} = \frac{\text{distance travelled}}{\text{time ellapsed}}$$

$$= \frac{5700 \text{ miles}}{640.133 \text{ hrs.}}$$

$= 8.90$ 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:

$$\text{Ave. Speed} = \frac{\text{advanced in counter reading}}{\text{minutes in watch}}$$

$$= \frac{87{,}319 - 69{,}985}{3 \text{ hrs. } (60) + 43 \text{ mins.}}$$

$$= \frac{17334}{223}$$

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°C

T_2 = 15°C

corr. coeff. = 0.00063

Solution:

a. $T_1 - T_2 = 24.5 - 15 = 9.5$°C

b. 9.5°C x .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:

$$SG = 0.865$$
$$T_1 = 30°F$$
$$T_2 = 84°F$$
$$\text{corr. coeff.} = 0.00037 \text{ per } 1°F$$

Solution:

a. $T_2 - T_1 = 84 - 30 = 54°F$

b. $54 \times 0.00037 = 0.01998$

c. $0.865 - 0.01998 = 0.8450$ at 84°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 m³. 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 m³ 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 x 511 M³ - [(40 - 15x .000720 x 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 x 511 - (40 - 15x .000720 x 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

c. Using All Suppliers figures:

$$
\begin{aligned}
MT &= .9785 \times 515 - (25 - 15 \times .000720 \times 515) \\
&= .9785 \times 515 - 3.708 \\
&= .9785 \times 511.292 \text{ m}^3 \\
MT &= 500.30
\end{aligned}
$$

$$
\begin{aligned}
\text{Owner Losses} = \;& 500.30 - \text{MT Supplier} \\
& \underline{-\ 485.19} - \text{Ship figure} \\
& 15.11 \text{ MT} \times \$90 = \$1{,}359.90
\end{aligned}
$$

Formula of fuel mixed with specific gravity:

$$
\text{MIXED S.G.} = \frac{(\text{Qty. Before Loading m}^3)(\text{S.G.}) + \text{Qty. Received m}^3 \times \text{S.G.}}{\text{Qty. Bef. Loading} + \text{Qty. Received m}^3}
$$

$$
= \frac{100 \text{ m}^3 (.950) + 200 \text{ m}^3 (.960)}{100 \text{ m}^3 + 200 \text{ m}^3}
$$

$$
= \frac{95 + 192}{300}
$$

$$
\text{S.G.} = 0.956
$$

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/cm³. Determine the pressure worked at the pump intake port.

Solution:

I. $\text{Force} = 6 \times 910 \times 9.81$

$= 53{,}562 \text{ N}$

II. $\text{Pressure} = \dfrac{\text{Force}}{\text{Area}} = \dfrac{53{,}562}{1 \text{ m}^2}$

$= 53{,}562 \text{ Pa}$

$= 53.56 \text{ KPa}$

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:

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

$$= 0.7854\,(0.15)(0.15)(0.13)$$

$$= .0022972 \text{ m}^3$$

II. Area of Small Piston $= \dfrac{1}{100} \times 0.15 \times 0.15 \times 0.7854$

$$= .0001767 \text{ m}^2$$

III. Total Stroke $= \dfrac{\text{Volume}}{\text{Area}} = \dfrac{2.2972 \times 10^{-3} \text{ m}^2}{0.1767 \times 10^{-3} \text{ m}^2}$

$$= 13 \text{ meter}$$

IV. Single Stroke $= \dfrac{13 \text{ m}}{400} = 32.5 \times 10^{-3} \text{ m}$

$$= 32.5 \text{ mm}$$

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 m³.

$V_1 = 0.4 \text{ m}^3$

$P_1 = 900 + 101.3 \text{ KPa}$

$P_2 = 2{,}700 + 101.3 \text{ KPa}$

Formula:

$$\frac{V_1}{V_2} = \frac{P_1}{P_2} \qquad V_2 = \frac{V_1 \quad P_1}{P_2}$$

$$= \frac{1001.3 \text{ KPa} \times 0.4 \text{ m}^3}{2801.3 \text{ KPa}}$$

$$= 0.143 \text{ m}^3$$

CHARLES LAW:

2. A rubber gas reservoir has a volume of 0.1 m³ at -14°C. Its temperature is raised to 90°C. What is it volume increase if the pressure remains the same?

$$V_2 = \frac{V_1 \times T_2}{T_1} = \frac{0.1 \text{ m}^3 \times (90 + 273)}{-14 + 273}$$

$$= \frac{0.1 \text{ m}^3 \ (363)}{259}$$

$$= 0.14 \text{ m}^3$$

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 $\frac{1}{30,000}$ of total oil volume by parts can be discharged at sea.

Solution:

I. Total volume of the tank = Length x Breadth x Depth

$= 43 \times 21 \times 22$

$= 19,866\ m^3$

II. Total volume of oil in the tank $= 43 \times 21 \times 0.005$ m

$= 4.515\ m^3$

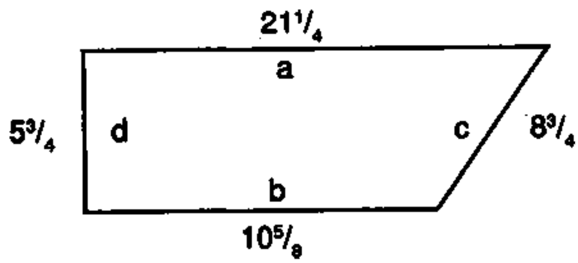
III. By Regulation volume can be discharged $= \dfrac{19,866\ m^3}{30,000}$

$= 0.6622\ m^3$

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:



Perimeter $= 21\ 1/4 + 8\ 3/4 + 10\ 5/8 + 5\ 3/4$

$= \dfrac{85}{4} + \dfrac{35}{4} + \dfrac{85}{8} + \dfrac{23}{4}$

$= \dfrac{170 + 70 + 85 + 46}{8}$

P $= \dfrac{371}{8}$ or 46 3/8

Area $= 1/2\ (a + b)\ (d)$

$= \dfrac{(21\ 1/4 + 10\ 5/8)\ (5\ 3/4)}{2}$

$$= \frac{\frac{85}{4} + \frac{85}{8}}{2} \;\; \frac{23}{4}$$

$$= \frac{85}{8} + \frac{85}{16} \;\; \frac{23}{4}$$

$$= \frac{170 + 85}{16} \;\; \frac{23}{4}$$

$$= \frac{5865}{64}$$

$$A = 91 \frac{41}{64} \text{ m}^2$$

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.

Solution:

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

1,000,000 – 996,430 = 3570

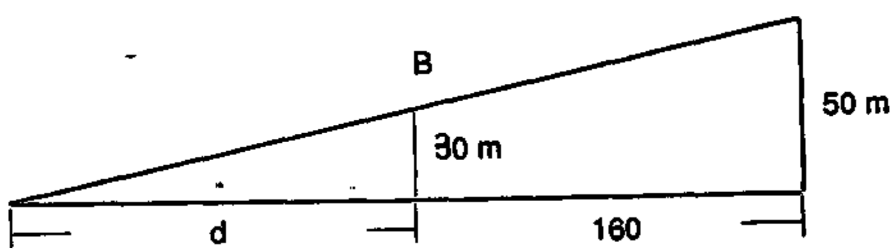
Total revolution after the watch = 026430 + 3570

= 30,000 rev.

$$= \frac{30{,}000 \text{ rev.}}{240 - 20 \text{ mins. advanced}}$$

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?



By Similar Triangle:

$$\frac{50}{160 + d} = \frac{30}{d}$$

$$50\,d = (160 + d)\,30$$

$$50\,d = 4800 + 30\,d$$

$$50\,d - 30\,d = 4800$$

$$20\,d = 4800$$

$$d = \frac{4800}{20}$$

$d = 240$ 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 $= \dfrac{6280 \text{ miles}}{12 \text{ n.m/hr.}} \times \dfrac{1 \text{ day}}{24 \text{ hrs.}}$

$= \dfrac{6280 \text{ miles}}{288 \text{ hrs.}}$

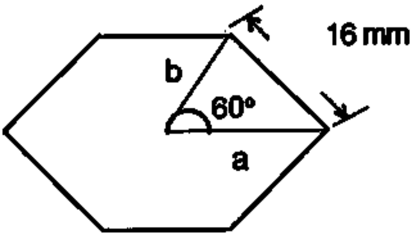
$= 21.8$ days

Total allowance $= 3 + 20 = 23\%$

Fuel consumed for the voyage $= 21.8 \times 125 \times 1.23$

$= 3351.75$ MT

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



$a = b = 16$ mm

$d = 2 \times a$

$= 2 \times 16$

$= 32$ mm

$\sin 30° = \dfrac{8}{a}$

$a = \dfrac{8}{\sin 30°}$

$a = 16$ 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/hr
Distance	=	6,280 nm
Ship speed	=	14 knots
10%	=	allowance

Solution:

Fuel oil cons. $= \dfrac{155 \text{ g–BHP/HR} \times 12000 \text{ bhp} \times 24 \text{ hr/day}}{1{,}000{,}000 \text{ grm/ton}}$

$= \dfrac{44{,}640{,}000}{1{,}000{,}000}$

$= 44.64$ M.T./day

Day the ships travel $= \dfrac{6{,}280 \text{ n.m.}}{14 \text{ knots}} \times \dfrac{1 \text{ day}}{24 \text{ hrs.}}$

$= 18.69$ days

Fuel oil cons. $= 44.64 \times 18.69\ (1 + 10\%)$

$= 44.64 \times 18.69 \times 1.1$

$= 917.98$ 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 counter reset to 0 @ 1,000,000

Rev. before the counter reset to 0 =

1,000,000 – 996,430 = 3570 rev

End of watch eng. rev. = 026430 + 3570

= 30,000

$$\text{RPM} = \frac{30{,}000 \text{ rev.}}{240 + 20 \text{ min. retard}}$$

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	=	1350 mm	=	1.35 m
MEP	=	11 kg/sq. cm.		
Rpm	=	110		

Solution:

$$\text{cyl. constant} = \frac{\frac{\pi}{4} D^2 \times L}{4500}$$

$$= \frac{\pi}{4} \frac{(65)^2 \ (1.35)}{4500}$$

$$= \frac{.7854\,(4225)\,(1.35)}{4500}$$

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 = 3600 mm = 3.6 m

RPM = 118

Slip = -3%

Solution:

$$\text{Eng. Speed} = \frac{\text{Pitch x RPM x 60}}{1852}$$

$$= \frac{3.6 \text{ m} \times 118 \times 60}{1852}$$

$$= 13.76 \text{ knots}$$

$$\text{Slip} = \frac{\text{Eng. Speed} - \text{O. Speed}}{\text{Eng. Speed}}$$

$$-0.03 = \frac{13.76 - OS}{13.76}$$

$$-0.03\,(13.76) = 13.76 - O.S.$$

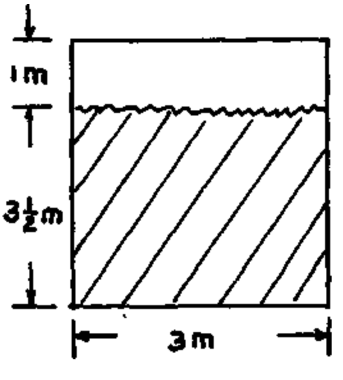
$$OS = 13{:}76 + (0.03)\,(13.76)$$

$$= 13.76 + 0.41$$

$$\text{Observed Speed} = 14.17 \text{ knots.}$$

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:

a) Volume of tank $= \frac{\pi}{4} D^2 \; h$

For an ullage of 1 m; $h = 3 \; 1/2$ m

Vol. of tank @ 3 1/2 m height $= \frac{\pi}{4} (3)^2 \; (3.5 \text{ m})$

$= .7854 \; (9) \; (3.5)$

$= 24.74 \text{ m}^3$

For a F.W. Sp. gr. $= \frac{1000 \text{ kg}}{\text{m}^3} = \frac{1 \text{ ton}}{\text{m}^3}$

F.W. to be pumped $= 24.74 \text{ m}^3 \times 1 \text{ MT/m}^3$

$= 24.74$ MT

b) Sp. gr. of oil $= 0.86$

M.T. of fuel oil $= 24.74 \text{ m}^3 \; \times \; 0.86$ (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:

$$\text{Engine Speed} = \frac{P \times RPM \times 60}{1852}$$

$$\% \text{ Slip} = \frac{ES - SE}{ES} \times 100$$

$$0.12 = \frac{ES - 12 \text{ knots}}{ES}$$

$$E.S. (0.12) = ES - 12$$

$$E.S. (0.12) - E.S. = -12$$

$$-0.88 \; E.S. = -12$$

$$E.S. = \frac{-12}{-0.88}$$

$$E.S. = 13.63 \text{ knots}$$

$$E.S. = \frac{P \times RPM \times 60}{1852 \text{ m}}$$

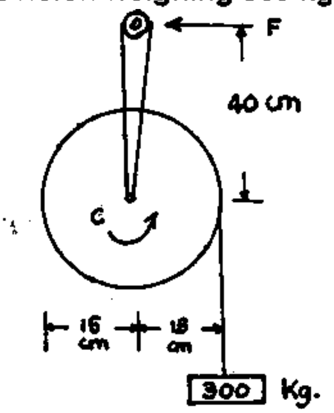
$$13.63 \text{ knots} = \frac{P \times 110 \times 60}{1852 \text{ m}}$$

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

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

$$P = 3.83 \text{ m} = 3{,}830 \text{ mm.}$$

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:

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

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

$$F = 112.5 \text{ kg.}$$

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 Kg/cm^2

RPM = 100 rpm

Formula: IHP = MEP x Cyl. constant x RPM x No. of cylinder

= 11 Kg/cm^2 x .9954 x 100 x 8

= 8759.52 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-hr

BHP = 12,000

Solution:

a) Daily Cons. $= \dfrac{155\text{ gr.}}{\text{Bhp-hr}} \times 12{,}000\text{ BHP} \times 24\text{ hr/day}$

$= \dfrac{44{,}640{,}000\text{ gr/day}}{1{,}000{,}000\text{ gr/ton}}$

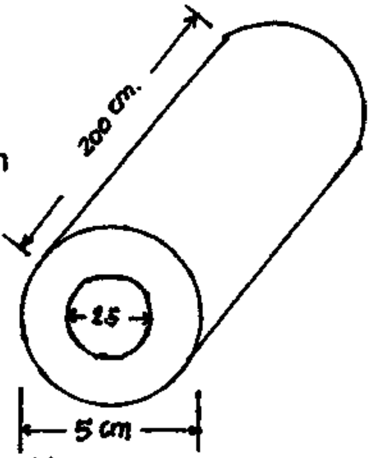
$= 44.64$ MT

b) $\dfrac{\text{grams}}{\text{Kw-hr}} = \dfrac{155\text{ gr/Bhp-hr}}{0.746\text{ Kw/1 HP}}$

$= 207.77$ 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/cm³

Solution:

$$D = \frac{\text{Weight}}{\text{Volume}}$$

$$\text{Volume} = \frac{\pi}{4} D0^2 - \frac{\pi}{4} D1^2 \text{ (Length)}$$

$$= \frac{\pi}{4}(D0^2 - D1^2)\ (L)$$

$$= \frac{\pi}{4}(5^2 - 2.5^2)\ (200)$$

$$= .7854\ (25 - 6.25)\ (200)$$

$$= .7854\ (18.75)\ (200)$$

$$= 2{,}945.24 \text{ cm}^3$$

$$\text{Weight} = \text{Density} \times \text{Volume}$$
$$= 8 \text{ gr/cm}^3 \times 2945.24 \text{ cm}^3$$
$$= 23{,}561.9 \text{ grams}$$
$$= 23{,}562 \text{ kgs.}$$

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 = 47,000 lbs/in^2
Factor of safety = 6

Solution:

$$\text{Working Stress} = \frac{\text{Yield point}}{\text{Factor of safety}}$$
$$= \frac{47000 \text{ psi}}{6}$$
$$= 7{,}833.33 \text{ psi}$$
$$\text{Working Stress} = \frac{\text{Load}}{\text{area of rod}}$$
$$\text{Area} = \frac{\text{Load}}{\text{working stress}}$$
$$= \frac{145{,}200 \text{ lbs.}}{7{,}833.33 \text{ psi}}$$
$$= 18.54 \text{ in}^2$$

$$\text{Area} = \frac{\pi D^2}{4}$$
$$0.7854D^2 = 18.54 \text{ in}^2$$
$$D^2 = \frac{18.54}{0.7854}$$
$$= 23.6 \text{ in}^2$$
$$D = 4.85 \text{ in}$$

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

$$\text{Time of voyage} = \frac{6{,}280 \text{ N. miles}}{12 \text{ N.M./hr.}}$$

$= 523.33$ 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/day

$$\text{Voyage fuel cons} = 25 \frac{\text{MT}}{\text{day}} (218 \text{ days}) (1 + 25\%)$$

$= 25\,(21.8)\,(1.25)$

$= 681.25$ MT

4. Solve the metric indicated horsepower of an 8-cylinder, single acting, 2-stroke cycle diesel propulsion engine with MEP of 11 kg/cm² 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.	=	8; 2 stroke
MEP	=	11 Kg/cm^2
Bore	=	650 mm = 65 cm.
Stroke	=	1350 mm = 1.35 m.
Sp. fuel cons.	=	153 gr/IHP - HR.
RPM	=	145

Solution:

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

$$= \frac{(11\ Kg/cm^2)\ (\frac{\pi}{4}\ (65)^2\ (1.35)\ (145)\ (8)}{4500}$$

$$= \frac{57161292}{4500}$$

$$IHP = 12{,}702.5\ hp.$$

Fuel consumption:

$$= \frac{153\ gr./IHP\text{-}hr. \times 12702.5\ hp \times 24}{1000000}$$

$$= \frac{466,\ 435.80}{1{,}000000}$$

$$= 46.64\ MT/day.$$

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 = 145

Slip = – 3%

Solution:

$$\%\ Slip = \frac{Engine\ speed - Ship\ speed}{Engine\ speed}$$

$$Engine\ speed = \frac{Pitch \times RPM \times 60}{1852}$$

$$= \frac{(3{,}600\ mm \times \frac{1\ m}{1000\ mm})\ (145)\ (60)}{1852}$$

$$= 16.91\ knots$$

$$-0.03 = \frac{16.91 - Ships\ speed}{16.91}$$

$$-0.03(16.91) = 16.91 - Ship\ speed$$

$$-0.5073 = 16.91 - Ship\ speed$$

Ship speed = 16.91 + 0.5073
= 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 Kg/m³. Convert this to grams per cubic centimeter, and to pound mass per cubic foot.

Solution:

$$\frac{2{,}699\ \text{kg}}{1\ \text{m}^3} \times \frac{1000\ \text{grm}}{1\ \text{kg}} \times \frac{1\ \text{m}^3}{1{,}000{,}000\ \text{cm}^3} = 2{,}699\ \text{grm/cm}^3$$

$$\frac{2{,}699\ \text{kg}}{1\ \text{m}^3} \times \frac{2.2\ \text{lbs.}}{1\ \text{kg}} \times \frac{1\ \text{m}^3}{35.29\ \text{ft}^3} = 168.26\ \text{lb/ft.}^3$$

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 $= \dfrac{\text{Pitch x Rpm x 60}}{6080\ \text{ft.}}$

$= \dfrac{16\ \text{ft. x 70 Rpm x 60}}{6080\ \text{ft.}}$

= 11.05 knots

$$\% \text{ slip} = \frac{\text{engine speed} - \text{observed speed} \times 100}{\text{engine speed}}$$

$$\% \text{ slip} = \frac{11.05 \text{ knots} - 10 \text{ knots} \times 100}{11.05}$$

$$= \frac{1.05 \text{ knots}}{11.05 \text{ knots}} \times 100$$

$$\% \text{ slip} = +9.52$$

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 $= \frac{\pi}{4}(d_o^2 - d_i^2)$

$= .7854 [(64)^2 - (49)^2]$

$= .7854 [4096 - 2401]$

$= .7854 (1695)$

$= 1331.25 \text{ mm}^2$

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

Solution: If $y = 5$, $x = ?$

$2x + 5y = 20$

$2x + 5(5) = 20$

$2x + 25 = 20$

$2x = 20 - 25$

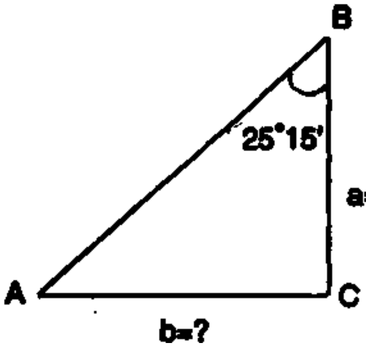
$x = \frac{-5}{2}$

$x = -2.5$

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: $\tan 25°15' = \frac{b}{a}$



$$\tan 25°15' = \frac{b}{4}$$

$$b = (4 \text{ mi})(\tan 25°15')$$

$$b = (4)(0.47163)$$

$$b = 1.886 \text{ miles}$$

$$\text{but time} = 10 \text{ min}$$

$$= \frac{10}{60} = 0.167 \text{ hr}$$

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{1.886 \text{ mi}}{0.167 \text{ hr.}}$$

$$\text{Speed} = 11.29 \text{ knots}$$

2. A wire 120 inches long with a cross section of 0.125 inch² 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 length	=	120 in
	cross-sectional area	=	0.125 in^2
	force applied	=	450 lb.
	change in length	=	0.015 inch.

Find: Young's Modulus of Elasticity (E)

Solution: 1.

$$\varepsilon = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$

$$\varepsilon = \frac{\text{force/area}}{\text{change in length/initial length}}$$

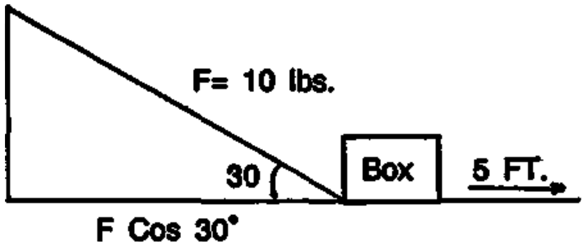
2.

$$\text{stress} = \frac{\text{Force}}{\text{area}} = \frac{450 \text{ lb}}{0.125 \text{ in}^2} = 3600 \text{ psi}$$

$$\text{strain} = \frac{\Delta \ell}{\ell} = \frac{0.015 \text{ in}}{120 \text{ in}} = 0.000125$$

$$\varepsilon = \frac{\text{stress}}{\text{strain}} = \frac{3600 \text{ psi}}{0.000125} = 28{,}800{,}000 \text{ psi}$$

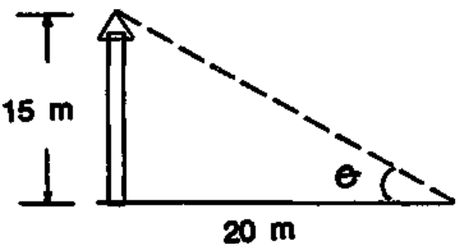
3. **A force of 10 lbs. is used to move a box across a horizontal deck, a distance of 5 ft. If the force makes an angle of 30 degrees with the floor, how much work is done?**



Solution:

$$
\begin{aligned}
\text{Work} &= \text{Force x distance} \\
&= (\text{F Cos } 30^\circ)\ (5 \text{ ft.}) \\
&= (10 \text{ lb.})\ (\text{Cos } 30^\circ)\ (5 \text{ ft.}) \\
&= (10)\ (0.866)\ (5) \\
&= 43.3 \text{ ft.-lb.}
\end{aligned}
$$

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:

$$= \frac{\text{given side}}{\text{given side}} = \text{trigo function of unknown angle}$$

$$= \frac{15 \text{ m}}{20 \text{ m}} = \frac{\text{opposite}}{\text{adjacent}} = \tan\theta$$

$$\tan\theta = \frac{15 \text{ m}}{20 \text{ m}}$$

$$\tan\theta = 0.75$$

$$\theta = 36^\circ 52'$$

1. The gauge pressure of water in the water mains is 35 lbs./inch². How much work is required to pump 500,000 ft.³ of water, at atmospheric pressure, into the mains?

Given: Pressure = 35 lb./in.²

Volume = 500,000 ft.³

Convert 500,000 ft.³ to in³

$$= 500{,}000 \text{ ft.}^3 \times \frac{1728 \text{ in.}^3}{1 \text{ ft.}^3} = 8.64 \times 10^8 \text{ in.}^3$$

Find: Work Req = (35 lb/in.²) (8.64 x 10⁸ in.³)

$$\text{Work Req} = (35 \text{ lb/in.}^2)(8.64 \times 10^8 \text{ in.}^3)$$

$$= 302.4 \times 10^8 \text{ lb-in.}$$

Convert lb-in. to ft-lb.

$$= 302.4 \times 10^8 \text{ lb-in.} \times \frac{1 \text{ ft.}}{12 \text{ in.}} = 25.2 \times 10^8 \text{ ft.-lb.}$$

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.³,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.³

dimension of rectangle = 2 ft. x 3 ft. = 6 ft.²

Solution:

a) Pressure = density x height

= 64 x 100

= 6,400 lb/ft.²

b) Force = pressure x area

= (6,400 lb./ft.²) (6 ft.²)

= 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:

$$\frac{1/2 \text{ ton}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hrs.}} \times \frac{2240 \text{ lb.}}{1 \text{ ton}} = 46.67 \text{ lb./hr.}$$

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.

Given: Total Force Acting = 350 + 150 lbs. = 500 lbs.

Speed = 300 ft./min.

Find: HP delivered

$$\text{Power} = (500 \text{ lbs.})(300 \text{ ft./min})$$

$$= 150{,}000 \frac{\text{ft. lb}}{\text{min}}$$

Convert: $\frac{\text{Ft. lb}}{\text{min.}}$ to HP

$$= 150{,}000 \frac{\text{ft.-lb}}{\text{min.}} \times \frac{1 \text{ HP}}{33000 \text{ ft.-lb}}$$

$$= \frac{150{,}000}{33{,}000}$$

$$= 4.5 \text{ HP}$$

CHIEF MARINE ENGINEER – January, 1990

1. The cross section of the tube at point A 10 inch², and at point B is 2 inch². 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.^{2}

area at pt. B = 2 in.^{2}

velocity at pt. A = 12 ft./sec.

velocity at pt. B = ?

By ratio and proportion

$$\frac{\text{area at A}}{\text{area at B}} = \frac{\text{velocity at A}}{\text{velocity at B}}$$

$$\text{velocity at B} = \frac{(\text{area at B})(\text{vel. at A})}{\text{area at A}}$$

$$= \frac{(2\ \text{in.}^2)\ (12\ \text{ft./sec.})}{10\ \text{in.}^2}$$

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?

Given: cons. A = 74 + 10 tons/day Speed A = 21 knots

cons. B = ? Speed B = 19 knots

distance = 1875 mi.

fuel left = 275 tons

Find: Consumption B.

$$\frac{C_A}{C_B} = \frac{\text{Speed}_A}{\text{Speed}_B}$$

$$1{,}875\ \text{mi.} \times \frac{1\ \text{hr.}}{19\ \text{mi.}} = 98.68\ \text{hr. voyage left}$$

$$\frac{84\ \text{tons}}{C_B} = \frac{(21\ \text{knots})^3}{(19\ \text{knots})^3}$$

$$C_B = \frac{(84\ \text{tons})\ (19\ \text{knots})^3}{(21\ \text{knots})^3}$$

$$C_B = \frac{(84)\ (6859)}{9261}$$

$$C_B = 62.21\ \text{tons/day}$$

$$\frac{98.68}{24\ \text{hr/day}} = 4.11\ \text{days of voyage left}$$

$$62.21\ \frac{\text{tons}}{\text{day}} \times 4.11\ \text{days} = 255\ \text{tons req. to reach port.}$$

Therefore since fuel left is 275 tons, the ship can reach port with still enough fuel.

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)

= $(62.4\ \text{lb./ft}^3)\ (80.16\ \text{ft}^3)$

= 5001.984 lbs.

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

Formula:

$$API = \frac{141.5}{S.G.\ at\ 60°C} - 131.5$$

$$18.5 = \frac{141.5}{S.G.\ at\ 60°C} - 131.5$$

$$131.5 + 18.5 = \frac{141.5}{S.G.}$$

$$S.G. = \frac{141.5}{150}$$

$$S.G. = 0.9433$$

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:

$$Volume = \frac{\pi d^3}{6}$$

$$= \frac{3.1416\ (10)^3}{6}$$

$$= \frac{3.1416\ (1000)}{6}$$

$$= \frac{3140}{6}$$

$$Volume = 523.33\ ft^3$$

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: Pitch of propeller = 16 ft.
Rpm = 70
Engine Speed = 10 knots

Find: a) Engine Speed

$$= \frac{Pitch \times RPM \times 60}{6080\ ft.}$$

$$= \frac{17\ ft. \times 75\ RPM\ \ 60}{6080\ ft.}$$

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

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

$$= 12.58 \text{ knots}$$

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

$$= \frac{12.58 - 11}{12.58} \times 100$$

$$= \frac{1.58}{12.58} \times 100$$

$$= 0.1255 \times 100$$

$$\text{Slip } \% = 12.55 \text{ (positive)}$$

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 Rpm

Formula: $$\text{Mechanical Efficiency} = \frac{BHP}{IHP} \times 100$$

$$= \frac{12}{15.448} \times 100$$

$$= 0.776 (100)$$

$$\% = 77.68$$

Find: $$\text{Area} = \frac{\pi}{4} D^2$$

$$= .7854 (9)^2$$

$$= .7854 (81)$$

$$= 63.62 \text{ in.}^2$$

$$IHP = \frac{PLAN}{33{,}000}$$

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

$$= \frac{33{,}000 (15.448)}{(1 \text{ FT.}) (63.62) (240)}$$

$$P = 33.38 \text{ kg/cm}^2$$

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

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

Formula: volume of cylinder

$$= \frac{\pi D^2 h}{4}$$

$$= .7854\ (43)^2\ (100)$$

$$= .7854\ (1849)\ (100)$$

$$= \frac{145{,}220.46 \text{ cu. in.}}{231 \text{ in}^3\text{/gal.}}$$

$$= 628.66 \text{ gallons}$$

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:

$$\text{Engine Distance} = \frac{\text{Pitch} \times \text{Ave. Rpm} \times \text{Time}}{6080 \text{ ft.}}$$

$$= \frac{16.2 \times 102 \times 1458}{6080 \text{ ft.}}$$

$$= 396.25 \text{ miles}$$

$$\text{Slip \%} = \frac{\text{Engine Distance} - \text{Observe Distance} \times 100}{\text{Engine Distance}}$$

$$= \frac{396.25 - 360}{396.25} \times 100$$

$$= \frac{36.2}{396.25} \times 100$$

$$= 0.0913\ (100)$$

$$= 9.1\%$$

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 = πD

$= 3.1416\ (19)$

$= 59.69$ inches

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

Formula: Area of a circle $= \dfrac{\pi D^2}{4}$

$= \dfrac{3.1416}{4} (13)^2$

$= .7854\ (169)$

$A = 132.7 \text{ in.}^2$

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 $= .7854\ D^2$ height

$= .7854\ (18)\ (18)\ (48)$

$= 12{,}214.54 \text{ in.}^3$

b. Volume in gallons:

$= \dfrac{12{,}214.54}{231}$

$= 52.87$ 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 stroke = 1350 mm = 1.35 m

Cylinder bore = 650 mm = 65 cm

IHP = 13,900

RPM = 154

Solution: a) Find the Area $= \dfrac{\pi D^2}{4}$

$= \dfrac{3.1416\ (65)^2}{4}$

$= .7854\ (4225)$

$A = 3318.32\ cm^2$

b) $IHP = \dfrac{PLAN}{4500}$

$P = \dfrac{4500 \times IHP}{LAN}$

$= \dfrac{4500 \times 13{,}900}{1.35 \times 3318.32 \times 154}$

$= \dfrac{62550000}{689878.72}$

$P = 90.66\ kg/cm^2$

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 $= \dfrac{\pi d^3}{6}$

$$= \frac{3.1416\,(70)^3}{6}$$

$$= \frac{3.1416\,(343{,}000)}{6}$$

$$\text{Volume} = 179{,}594.8 \text{ cu. in.}$$

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

Formula: Area $= \pi D^2$

$$= 3.1416\,(10)^2$$

$$= 3.1416\,(100)$$

$$= 314.16 \text{ in.}^2$$

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:

$$\text{Average RPM} = \frac{\text{Present} - \text{Previous reading}}{\text{Time in watch} - \text{advanced}}$$

$$= \frac{87319 - 69895}{240 - 17}$$

$$= \frac{17424}{223}$$

$$\text{Ave. RPM} = 78.13$$

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 miles = 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 subtract 5/6 from 8/15, what will the sum be the difference?

   A. 1/5 B. 3/10 C. 2/6 D. 2/4

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

   A. 4/7 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:

   A. 1531 B. 15.31 C. 1.531 D. 153.1

6. Multiply .397 by 41 the product is:

A. 16.277 B. 162.77 C. .16277 D. 1627.7

7. From 128 subtract 96.307, the difference is:

A. 31.693 B. 316.93 C. .31693 D. 3169.3

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

A. x = 11 B. x = 12 C. x = 1/2 D. x = 6

9. The quotient of 2.5 divided by .05 is:

A. .50 B. 50 C. .05 D. 5.0

10. -180 degrees farenheit in centigrade is:

A. 117.77 d. C B. -177.77 d. C C. 68 d. C D. -68 d. C

11. Solve for x in the equation 8x - 22 = 12x - 18.

A. x = -1 B. x = 1 C. x = 4 D. x = -4

12. The height of an indicator diagram measured at regular intervals along its height are as follows: 27, 39, 47, 51, 48, 32, 20 , 11, 8, 5, mm. respectively. Find the mean height of the diagram in millimeters.

A. 288 mm. B. 2.88 mm. C. 28.8 mm. D. .0288 mm.

13. A pump can empty a tank in 12 hours, another pump can empty the same tank in 4 hours, and another can empty this tank in 9 hours. If all three pumps are set working together on this tank, how long would it take to empty it?

A. 4/9 hours B. 2 and 1/4 hours C. 2 hours D. 3 hours

14. -243 degrees fahrenheit in absolute is:

A. 217 d. A B. -217 d. A C. 217.29 d. A D. -217.29 d. A

15. -65 degrees centigrade in fahrenheit is:

A. -60 d. F B. 85 d. F C. -85 d. F D. 60 d. F

16. Given 7.5 cm. radius PI is 3.1416. Find the circumference.

A. 47.1238 cm. B. 23.562 cm. C. 47.124 cm. D. 12 cm.

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

A. 25.1328 cm. B. 12.5662 cm. C. -50.2656 cm. D. 50 cm.

18. Negative Forty million eleven minus Six thousand one is:

A. -40,006012 B. -39,994,010 C. 39,993,010 D. 40,006012

19. 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 negative Nine hundred ninety-nine equals:

A. -15,999,002 B. 15,999,002 C. 16,000,901 D. -16,009

21. The distance covered by a ship on four successive days were 320, 300, 310 and 330 nautical miles respectively. Find the average days run.

A. 5040 naut. miles B. 2520 naut. miles C. 1260 naut. miles D. 315 naut. miles

22. An automobile battery supplies a current of 7.5 amps to a headlamp with resistance of 0.84 ohms. Find the voltage delivered 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 piece is shorter than the other by 8 meters. How long are the pieces, if their combined 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 D. 16 m longer piece; 8 m shorter piece

24. A revolution counter reads 69,985 at 8 a.m. at 11a.m. the clock was advanced 17 min. and at noon counter reads 87,316. what was the average on the 8-12 o'clock watch?

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 C. a = 2 1/2 D. a = 4

26. A ship makes an observed speed of 17 knots per hour. The engine speed is 17.5 knots. What is the propeller slip in percent?

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?

A. 1) 13.5 knots
2) 16.2 knots

C. 1) 14.1 knots
2) 15.9 knots

B. 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?

A. 1) 48 hours
2) 840 n.m.

C. 1) 16 hours
2) 12 n.m.

B 1) 24 hours
2) 16. n.m.

D. 1) 12 hours
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	=	length x width
A	=	L x W
Area of circle	=	πR^2
	=	$\frac{\pi D^2}{4}$
Circumference of circle	=	$2\pi r$
	=	πD
Area of square	=	side x side
	=	s x s
Area of triangle	=	$\frac{1}{2} ab$
Area of Ellipse	=	πab
	=	$\frac{\pi Dd}{4}$
Area of Trapezoid A	=	$\frac{1}{2}(b_1 + b_2)h$
Area of Sector A	=	$\frac{1}{2}$ radius x arc
A	=	$\frac{1}{2} r^2 \theta$
Area of Parallelogram	=	base x perpendicular height
Area of Parabola	=	base x $\frac{2}{3}$ height
Area of cylinder	=	circumference x height + area both ends
Area of sphere	=	$d^2 \times \pi$ where $\pi = 3.1416$
Volume of rectangular solid	=	Length x width x height

$$V = L \times W \times H$$

Volume of cylindrical vessel = area of base x height

$$V = .7854\,D^2 h$$

$$V = \pi R^2 h$$

Volume of coal bunker (trapezoidal end)

$$V = \frac{Wr + Wb \times H \times L}{2}$$

Volume of Spherical tank $= \frac{\pi d^3}{6}$

TEMPERATURE SCALES

$$°F = \frac{9}{5}C + 32$$

$$°C = \frac{5}{9}(°F - 32)$$

Deg. absolute = °C + 273

Deg. absolute = °F + 460

Phythagorean Theorem / Right Angles:

$$C^2 = a^2 + b^2$$

Trigonometric Functions:

$$\text{sine}\,\theta = \frac{o}{h} \qquad \text{cosec}\,\theta = \frac{1}{\sin\theta} = \frac{h}{o}$$

$$\cos\theta = \frac{a}{h} \qquad \sec\theta = \frac{1}{\cos\theta} = \frac{h}{a}$$

$$\tan\theta = \frac{o}{a} \qquad \cot\theta = \frac{1}{\tan\theta} \quad \frac{a}{h}$$

where O = opposite h = hypotenus a = adjacent

Physics, Strength of Materials formulas:

Torque = Force x Distance

$$\text{Average Speed} = \frac{\text{Distance travelled}}{\text{Time ellapsed}}$$

$$\text{Velocity} = \frac{\text{Distance}}{\text{time}} \quad \frac{s}{t} = \text{m/sec, Ft./sec, mi/hr.}$$

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

$$\text{Work} = \text{Force} \times \text{Distance}$$

$$\text{Power} = \frac{\text{Worked done}}{\text{time}}$$

$$\text{Acceleration} = \frac{\text{Velocity}}{\text{Time}}$$

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

$$\text{KE energy} = \frac{1}{2} MV^2$$

$$\text{Stress in Tube} = \frac{P_1 \times P_2 \times P}{D^2 \times .7854}$$

$$\text{Volume} = \frac{\text{Weight}}{\text{Volume}}$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Specific gravity} = \frac{mg}{V}$$

Ideal Gas equation:

$$pV = mRT$$

Avogadro's Law:

$$VaMa = V_b M_b$$

Enthalphy

$$h = u + pV$$

Potential Energy:

$$Ep = mgz$$

Internal Energy:

$$du = CvdT$$

Boyle Law $= V_1 \times P_1 = V_2 \times P_2$

Charles Law: $\dfrac{V_1}{V_2} = \dfrac{T_1}{T_2}$

Gay-Lussac Law: $\dfrac{P_1}{P_2} = \dfrac{T_1}{T_2}$

Pressure $= \dfrac{\text{Force (N)}}{\text{Area (m}^2\text{)}}$

Compressive $= \dfrac{\text{Pressure}}{\text{Area}} = \dfrac{P}{A}$

Tensile Stress $= \dfrac{\text{Tensile}}{\text{Area}} = \dfrac{T}{A}$

Strain $= \dfrac{\text{Yield pt.}}{\text{Elastic limit}} = \dfrac{Y}{L}$

ENGINE/LOG-BOOK REPORT FORMULAS:

Indicated horsepower:

$$IHP = \frac{PLAN}{33{,}000}$$

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

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

where: P = mean effective press

L = length of stroke

A = Area $\frac{\pi}{4} D^2$

N = Rpm

$$\text{IHP/cylinder 4 stroke} = \frac{\text{MEP x cylinder constant x RPM}}{2}$$

$$\text{IHP/cylinder 2 stroke} = \text{MEP x cylinder constant x RPM}$$

$$\text{Cylinder constant (Metric)} = \frac{\text{length of stroke x area}}{4500}$$

where: L = Meter

A = Cm^2

$$\text{Cylinder constant (English)} = \frac{\text{length of stroke x area}}{33{,}000}$$

where: L = Ft.

A = $in.^2$

MEP = Average height of the card x Spring constant

Where: Average height = $\frac{\text{(area) in.}^2}{\text{(length) in.}}$

$$\text{Slip} = \frac{\text{Eng. distance} - \text{Observed distance}}{\text{Engine distance}} = \frac{ED-OD}{ED}$$

$$\text{Slip \%} = \frac{\text{Engine distance} - \text{Observed dist.}}{\text{Engine distance}} \times 100$$

Actual Slip = Engine speed – Actual speed

Actual BHP = Total IHP x Mechanical efficiency

$$\text{\% Mech. Efficiency} = \frac{BHP}{IHP} \times 100$$

$$\text{Output Ratio} = \frac{\text{Actual BHP}}{\text{constant}} \quad \text{(BHP max. shop trial)}$$

$$\text{Average RPM} = \frac{\text{Advanced in counter reading}}{\text{Minutes in watch}}$$

$$\text{Average Speed} = \frac{\text{Distance travelled in miles}}{\text{Time in hr.}}$$

$$\text{Engine Distance} = \frac{\text{(Pitch of the propeller) (Ave. RPM) (Time)}}{\text{6080 ft. or 1852 m/miles}}$$

Propeller Constant $= \dfrac{(\text{Pitch})\ (60)}{6080 \text{ ft.}}$

Propeller Speed = Propeller constant x RPM

Propeller Slip % $= \dfrac{\text{Prop. speed} - \text{ship speed}}{\text{prop. speed}} \times 100$

PUMPS FORMULAS:

$$\text{G.P.H.} = \frac{MANS}{231}$$

$$\text{G.P.M.} = \frac{ALNE}{231}$$

$$\text{G.P.H.} = \frac{ALNE \times 60}{231}$$

M = min. in 1 hr.
A = area liquid cylinder
N = no. of stroke
S = length of stroke
E = efficiency

Taper formula for Lathe Work:

Taper per inch $= \dfrac{D - d}{L}$

Taper per foot $= \dfrac{D - d}{L} \times 12$

where:
D = diameter at large end
d = diameter at small end
L = 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 meter	=	39.37 inches or 1.0936 yards
1 kilometer	=	0.6214 mile
1 inch	=	2.54 centimeters
1 foot	=	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
	=	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	=	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 lbs	=	907.2 kilograms
1 barrel oil	=	158.9828 liters
1 cubic meter	=	1000 liters
1 cubic meter	=	6.2899 barrels
1 long ton	=	1.016 MT

COMPUTATIONS In VOLUME:

To get: BARRELS	=	m^3 x	6.2899			
Metric Ton	=	m^3 x	S.G.	x	C.F.	
Long Ton	=	MT	÷	1.016		
Cubic Meter	=	MT	÷	S.G.		

WEIGHTS & MEASURES

METRIC SYSTEM

LENGTH

1 kilometer = 1,000 meters = 3,280 feet, 10 inches
1 hectometer = 100 meters = 328 feet, 1 inch
1 meter = 100 cm. = 39.37 inches
1 centimeter = .01 meter = .3937 inch
1 millimeter = .01 meter = .0394 inch
1 micron = .000001 meter = .00039 inch
1 millimicron = .000000001 meter = .000000039 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

1 cu. ft. at 50°F weighs 62.41 lb.

1 gal. at 50°F weighs 8.34 lb.

1 cu. ft. of ice weights 57.2 lb.

Water is at its greatest density at 39.2°F

1 cu. ft. at 39.2°F

1 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 min. (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

12 inches	=	1 foot (ft.)
3 feet	=	1 yard (yd.)
6 feet	=	1 fathom
5 1/2 yards	=	1 pole
40 poles	=	1 furlong
8 furlongs	=	1 mile
3 miles	=	1 league
69 1/2 miles	=	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	=	1 minute
60 minutes	=	1 hour
24 hours	=	1 day
7 days	=	1 week
30 days	=	1 calendar month
12 months	=	1 year
365 days	=	1 common year
366 days	=	1 leap year
10 years	=	1 decade
20 years	=	1 score
100 years	=	1 century

GENERAL CONVERSION FACTORS

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			
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
Btu 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^2	milliampere per metre^2	10,76	0,0929
gallons (U.S.) per minute	metre^3 per day	5,451	0,1835
pound-force	newton	4,448	0,2248
kilopond (Kp)	newton (N)	9,81	0,102

Part II

ELECTRICITY and ELECTRICALLY DRIVEN PROPULSION

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 valve 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 motor of 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 smalll 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 outer, 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 Xl 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.

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 coils?

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?

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

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 coil?

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

Q. What are the conditions which would cause an AC generator to overheat?

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

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.

Checklist maintenance test and records should be done on board regar safety alarm test, insulation records, overhauling and repairs. Instrumentation 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 effieciency.
2. Allows full power of turbine when astern.
3. Less noise and vibration.
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.

$$\text{P.F.} = \frac{\text{true power}}{\text{apparent power}} = \frac{\text{Kw}}{\text{KVA}} = \frac{\text{Watt}}{\text{Volt-Ampere}}$$

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. Length 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

1. The current in every circuit is the same.
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 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 coils 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 coil 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 volts 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 breakdown.
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.

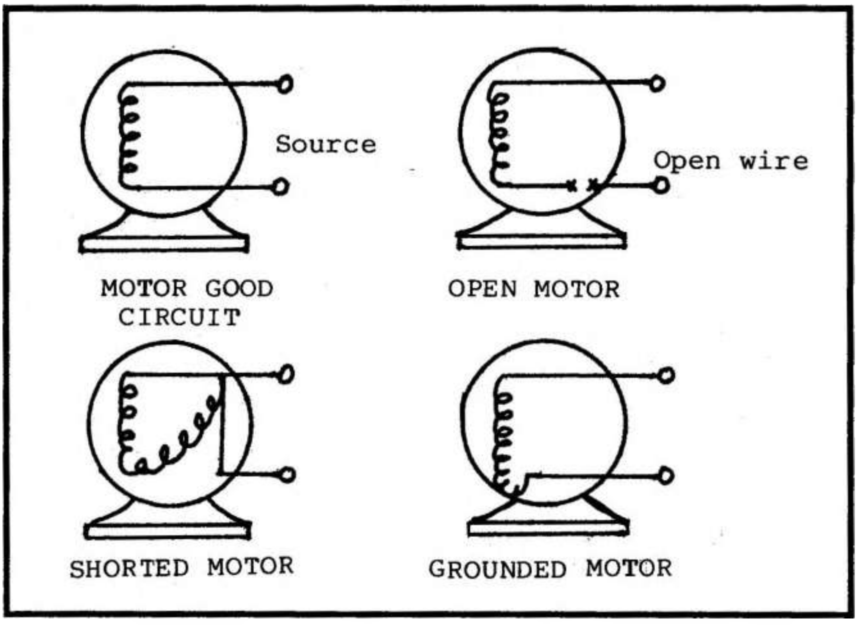
Q. What are the effects of breakdown causes and their characteristics?

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.

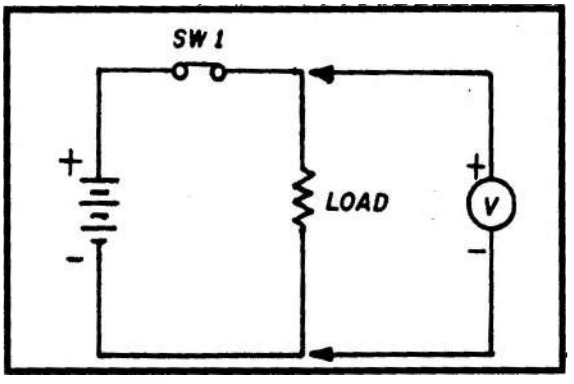
4. **Substitution** – is a technique of replacing a suspected faulty components with a good spare component to save time and effort in locating faults.

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.

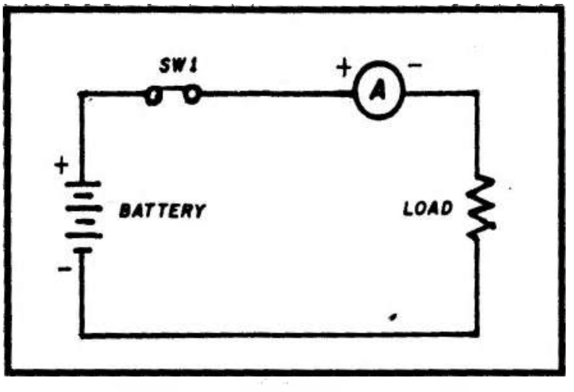
6. **Heat** – by means of applying heat, to a suspected thermal intermittent component will break and mostly using hot blower as device in order not to damage component especially plastic type.

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.

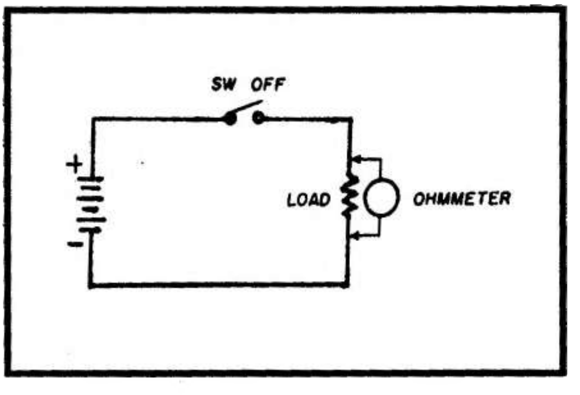


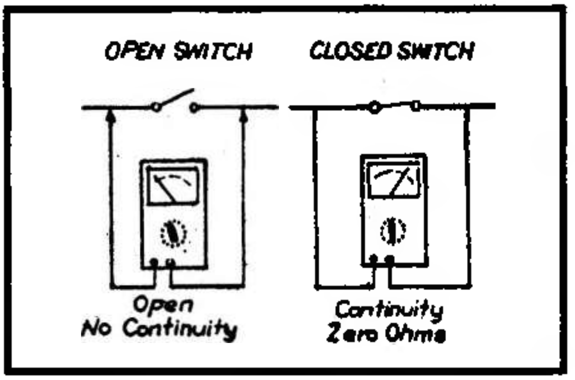
Always connect a voltmeter in parallel with the circuit.



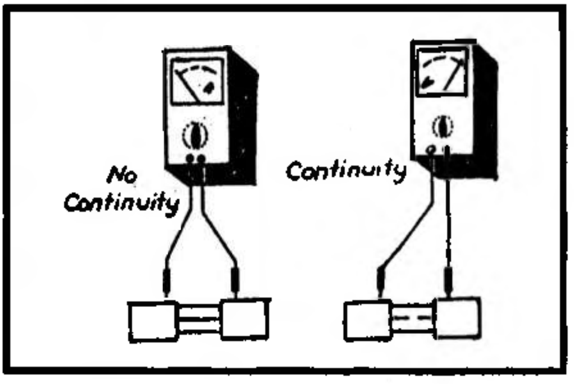
Always connect the ammeter in series circuit.

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



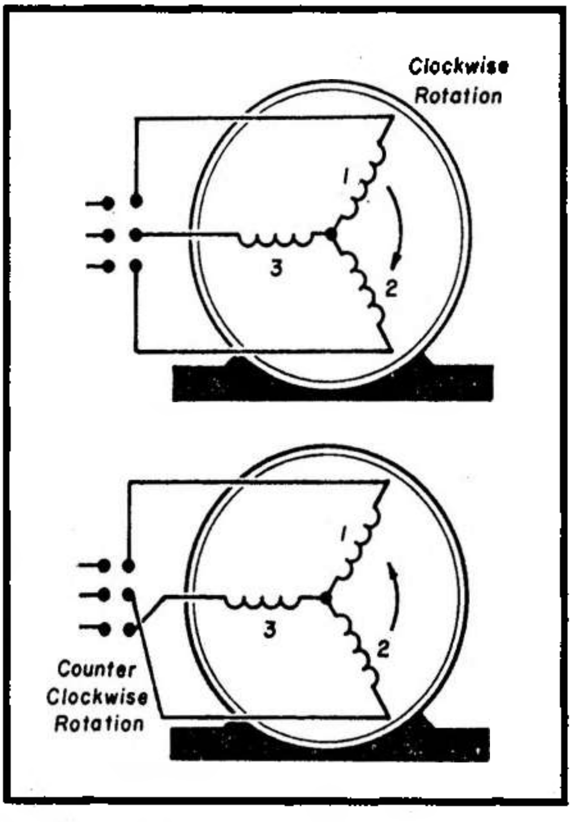


Checking a switch for continuity using an ohmmeter



Checking a fuse 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.



Factors Affecting Insulation

The following factors have an adverse effect on insulation:

1. Moisture condensing on surface of insulation results in lowering of measured value of insulation resistance. Leakage current increases.

2. Dust, oily or saline deposits or other foreign bodies deposited on end windings and connections of machines will result in low reading.

3. Oil vapour are usually present in the E/R. Oil on a surface forms a "fly–paper" which attracts and holds firmly any entrained dust.

4. Insulation material deteriorates with age and this process is speeded along by effect of high temperature, electrical and mechanical stresses, vibration, moisture, dirt, etc.

Testing IR of a motor

Insulation resistance is the resistance of insulation measured.

a) between conductor and earth
b) between conductor and other conductors.

Insulation test is carried out by the use of an insulation tester (a high reading resistance meter) called a **MEGGER**, using high test voltage – usually 500 V dc.

Procedure

a) Short the 2 probes of the **MEGGER** together and turn the handle of the internal hand driven generator in the **MEGGER**. The pointer should show zero. With the probes apart reading should be infinity.
b) Switch off power to the equipment to be tested.
c) Motor windings phases which are in star or delta are disconnected from the terminals before testing.

Procedures for cleaning electrical machines

Open ventilated motor require external and internal cleaning. Motors in areas with high concentration of air bourn dust will naturally require more frequent cleaning.

Internal dust and dirt can be removed either by blowing or extraction. If motors are blown out, the air must be absolutely dry and not more than 2 bar pressure. If pressure is higher, dust will be forced into the winding rather than being removed. Suction cleaning is better than blowing out. Ventilation screens and ducts should also be cleaned.

Any approved cleaning fluid can be used to brush the surface.

Precautions:

a) Excess fluids should be wiped off and deposits of fluid in crevices should be avoided.
b) Care should be taken as not to inhale the vapour. Keep work area well ventilated.

In short: Keeping the motor clean tends to keep it cool, resulting in a longer life, and keeping the machine dry makes it easier to keep the motor clean.

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.

a) DC volt (DCV)

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

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.
   2. To measure current break the circuit and insert the ammeter in the break.

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

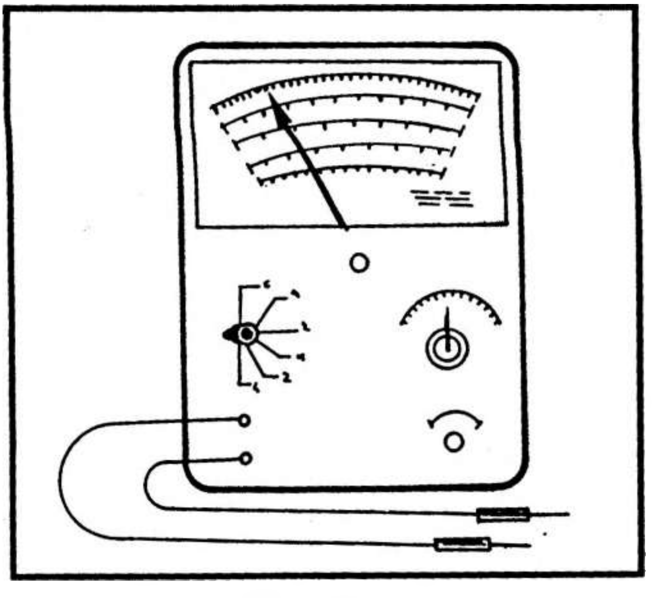
A voltmeter is used to measure emf across 2 points in a circuit. Simply prod the voltmeter across the voltage to be measured.

c) Resistance an O Ω 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 barteries.

   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 Ω is adjusted by turning O Ω ADJ to the right or left in order to place it exactly on O Ω 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.

Burns

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

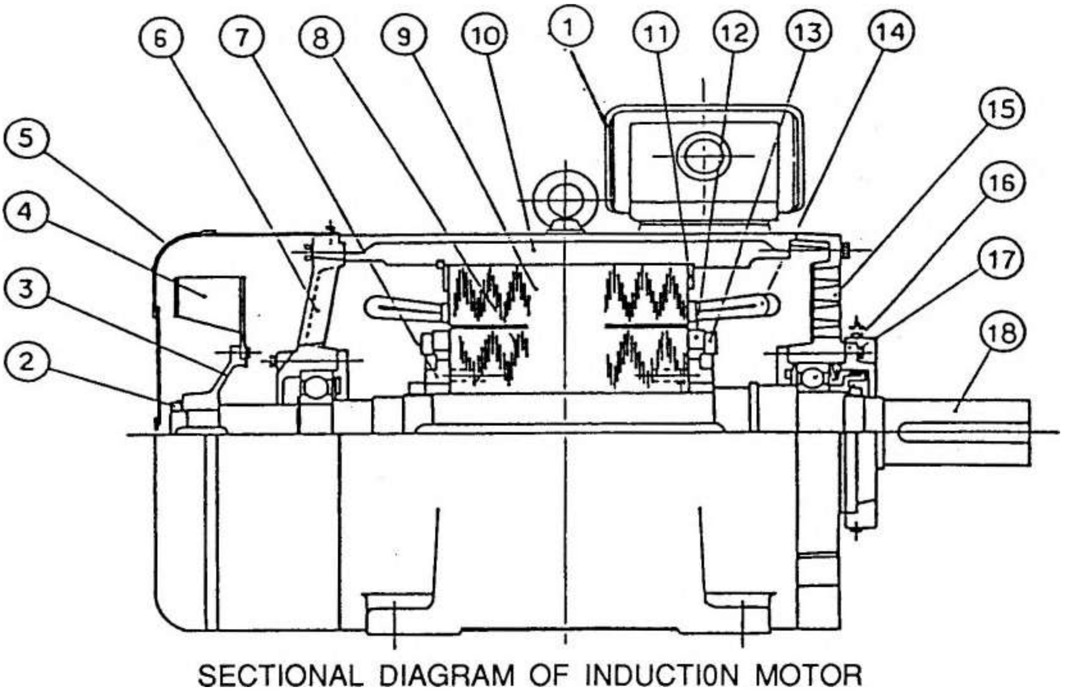
Four rules for safe practice and to avoid burns:

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)

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 used in each section before installing the parts, and after carrying out correct centering of direct coupling, make connection of electric circuits. This ends the reassembly.

Troubleshooting

Trouble	Cause	Countermeasure
Fails to start.	Disconnection or shortcuircuit of winding coil and lead wire	Rewind or repair
	Slackening of connecting terminals, etc.	Carry out additional tightening of the slackened portions.
	Disconnection or misconnection of starter	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 disconnection 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 obstruction preventing the ventilation, and clean

Three-Phase Induction Motor

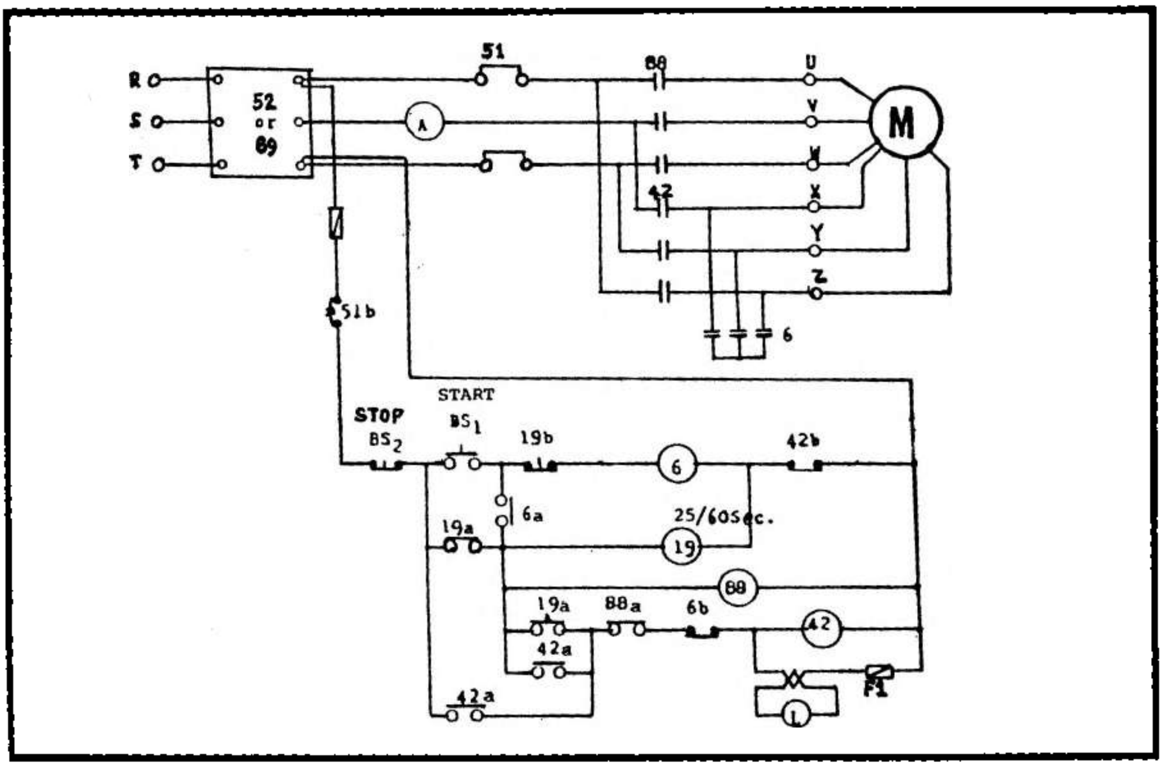
The 3-phase, cage-rotor, induction motor is the most commonly used motor onboard ships. It is popular because it is simple, tough and required very little attention. It is also readily controlled by simple, reliable direct-on-line contactor starters, and AC sources available.

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 starting time.

6. motor windings have to be strengthened to withstand the higher electrical stresses due to the higher current.	large amounts of heat developed in motor during starting tends to reduce the life of the windings.
7. very suitable for motors driving pumps, fans, etc. where the load torque rises very rapidly with increasing speed.	not suitable for such uses.

When star-delta starting, even 70 to 90% rated speed of motor is seldom achieved in the star connection. This means that a new current and torque surge take place on switching over to the delta connection. The switch over current is often almost as great as the current on direct-on-line starting.

So, it is always preferable to use direct on line starting. However, the generators may not be able to take the large starting currents of very large motors about 100 KW say for bow thrusters, etc. So, in such cases star-delta starting is used.

Synchronising Procedure of Generators:

To achieve smooth synchronising, the following operations are necessary:

1. The speed of the incoming machine must be adjusted until its frequency is approximately equal to that of the running generators. Ordinary engine tachometers are not suitable. For this purpose, frequency meter fitted on the main switch board is used.
2. The voltage of the incoming generator must be the same as that of the running generator. The voltage is adjusted (trimmed using exciter field rheostat.
3. Phase rotation should be same i.e. the phase voltage rise to their maximum in the same order. This condition is established when the sets are newly installed, or when reconnecting the feeder wires of alternaor after repair.
4. The circuit breaker of the incoming generator must be closed when the voltages of two generators are in phase with each other i.e. wave form of both busbar and incoming generator are synchronised. This is done by fine tuning the frequency/speed of the incoming generator and watching the synchroscope or synchronising lamps for the moment when two voltages are in phase.

Current surge while closing the circuit breaker

When the condition are right, the circuit breaker is closed immediately. There may be current surge after closing the circuit breaker, the magnitude of which will depend upon difference in:

1. voltage
2. frequency
3. phase difference

It is the moment when the circuit breaker contacts touch that is important. In practice when this is done and the incoming generator ammeter shows very little "kick", the indication is that good synchronisation has been achieved.

In practice it is difficult to adjust the speeds exactly so that synchroscope pointer remains stationary at 12 o' clock. It is good practice to have the pointer rotating not faster than one revolution in 5 seconds in the fast direction, and to initiate closing when the pointer is at about 11 o' clock (considering circuit breaker mechanism also takes some time to close).

In this way, with the incoming machine slightly fast, it will immediately assume load.

If switched when running slow, it would take motoring load which might possibly operate the reverse power relay. That is why reverse power relays are provided with time lag, to give sufficient time to correct the fault.

Consequences of closing the incoming generator's circuit breaker without synchronising

If the incoming generator's circuit breaker is closed without synchronising, the voltage phase difference causes a large circulating current between machines which produces large magnetic force to "pull" the generators into synchronism. This means rapid acceleration of one prime movers, and large circulating current may trip each circuit breaker. Result? Blackout, danger and embarrassment!

Excitation of self excited brushes AC generator

1. The main rotor has residual magnetism i.e. it produces a weak magnetic field.
2. When the rotor turns this weak field flux cuts the main stator winding.
3. A low voltage is generated in the main stator.
4. A part of this generator output goes to the AVR which converts the A.C. power to D.C.
5. This D.C. is fed to exciter stator.
6. A stationary magnetic field is created in the exciter stator by the D.C. fed to it.
7. The exciter rotor when it rotates cuts this stationary field.
8. Since the exciter rotor windings are wound to produce 3 phase A.C. power, 3 phase A.C. is generated in it.
9. All of this 3 phase A.C. is led to a bank of rotating diodes mounted on the same shaft.
10. The diodes convert all this A.C. to D.C.
11. This D.C. is the "excitation" of the main generator.
12. This D.C. in the main rotor adds to the weak magnetic field already there due to residual magnetism of the main rotor.

13. So the total field flux produced by the generator rotor is now increased: field flux due to magnetising current field flux to residual magnetism.
14. Since more flux now cuts the generator stator windings, a higher voltage is generated.
15. This process of voltage build up continues until the generator rated terminal voltage (usually 440 V) is reached. The AVR regulates the voltage to this valve.

Air Circuit Breaker

The circuit breaker of the draw put type found in main switchboard of an ac system. It is used to connect the alternator safety onto the bus bar as well as to disconnect it safely should a serious malfunction occur. It is used because it can break a circuit in abnormal conditions - undervoltage, over-current, short circuit, reverse power in an installation. It thus disconnects automatically a faulty circuit.

Operation Mode of Air Circuit Breaker

1. The main contacts are kept closed and latched against high spring force.

2. Quick acting tripping action is provided by release spring.

3. Cooling and splitting of arc is done by arc chutes. Arcing contacts close earlier and open later than main contacts.

4. Closing coil is provided to close the circuit breaker. This coil operate on DC power from rectifier and is energised by a closing relay operated by a push button.

5. The no-volt coil trips the CB when severe voltage drop (50%) occurs. It also prevents circuit breaker from being closed when generator voltage is very low or absent.

6. This coil operates on DC power. A push button switch for opening the CB by de-energising the no-volt coil is used. A contact is used for de-energising the coil and trip the circuit breaker by electronic over-current and reverse power relays.

PROCEDURE OF SAFETY OPERATIONS

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.

GENERATOR PROTECTION EQUIPMENT

The generator is protected from the abnormal conditions described below by means of the reverse power relay, the short time delay tripper under voltage tripper and instantaneous tripper of the air circuit breaker, over current relay, and so on.

Abnormal Phenomena due to under voltage

If the voltage of generator decrease to less than 50% of the rated value. The under voltage tripping device contained in the air circuit breaker will operate to trip the breaker, thus cutting off the generator from the circuit. Incase of a short-circuit fault, the voltage will lower and may cause the under voltage tripping device (UVC) to operate. With this in mind, a delaying device (for delay of about 0.5 second) has been fitted to the UVC to prevent the ACB from tripping.

Abnormal Phenomena due over current (long time delay)

In case a current above a set value flows, the over current relay will trip the ACB to disconnect the generator from the circuit.

Abnormal Phenomena due to over current.
(preface tripping by over current relay)

Before the over current relay (for a long time delay) for ACB tripping operates to trip the ACB to cut off the generator from the circuit, on over current relay (OCR) for preference tripping will operate for preference disconnection of non essential load thereby providing protection against the over current which would trip the ACB.

In a generating system in which two generators are always operated in parallel, when the ACB for one of two generators is tripped by any cause, the remaining generator will be over loaded, if the ship is of normal design. Also, one of the generators running in parallel may be overloaded. In such a case, the overloaded generator can be protected by preference tripping for automatic disconnection of loads.

When preference tripping is effected the ACB is just before tripping, So, without delay, take such a step as decreasing the loads or partial load shift to the other generator. In the switchboard, the circuit breaker intended for preference tripping has a yellow marked use nameplate.

Abnormal Phenomena due to shorting

In case the bus has been shorted, the ACB will be tripped in a short time (about 210 m/sec) by the short time delay tripping device fitted to the ACB.

Besides,tripping selectivity is ensured with respect to the feeder circuit breaker.

Abnormal Phenomena due to reverse power

If there are abnormalities in the output of an engine during parallel operation, and the generator is functioning as a motor due to the power it receives from the other generator through the common bus bar, the effective reverse power will flow through the connected circuit, causing the reverse power relay (RPR) to function to trip the air circuit breaker, which in turn will cut off the generator functioning as a motor.

FORMULAS FOR ELECTRICAL PROBLEMS

a) Ohms law

Ampere = $\dfrac{\text{volts}}{\text{resistance}}$ $\qquad A = \dfrac{V}{R}$

Volts = amperes x resistance $\qquad V = A \times R$

Resistance = $\dfrac{\text{volts}}{\text{amperes}}$ $\qquad R = \dfrac{V}{A}$

b) Power Rule

Watts = volts x amperes $\qquad W = V \times A$

Volts = $\dfrac{\text{watts}}{\text{amperes}}$ $\qquad V = \dfrac{W}{A}$

Amperes = $\dfrac{\text{watts}}{\text{volts}}$ $\qquad A = \dfrac{W}{V}$

c) Efficiency

Efficiency = $\dfrac{\text{output}}{\text{input}}$

d) Power Factor

Power Factor = $\dfrac{\text{true power}}{\text{apparent power}} = \dfrac{\text{watt}}{\text{volt-ampere}} = \dfrac{\text{kw}}{\text{kva}}$

e) Frequency of AC Generator

Frequency of AC Generator = $\dfrac{\text{no.of poles} \times \text{rpm}}{120} = \dfrac{P \times N}{120}$

f) Direct Current

$$I = \frac{746\ \text{hp}}{E \times \text{eff.}}$$

$$I = \frac{1000\ \text{kw}}{E}$$

$$KW = \frac{I \times E}{1000}$$

$$HP = \frac{I \times E \times \text{eff}}{746}$$

AC - Three Phase

$$I = \frac{746\ \text{Hp}}{1.73 \times E \times \text{Eff} \times \text{pf.}}$$

$$I = \frac{1000\ \text{Kw}}{1.73 \times E \times \text{pf}}$$

$$I = \frac{1000\ \text{Kva}}{1.73 \times E}$$

$$Kva = \frac{I \times E \times 1.73 \times \text{pf}}{1000}$$

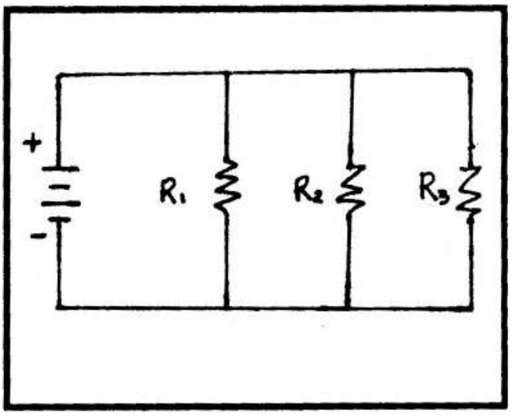
$$Kva = \frac{I \times E \times 1.73}{1000}$$

$$Hp = \frac{I \times E \times \text{eff} \times \text{pf}}{746}$$

where:

I	=	amperes	kw	=	kilowatts
E	=	volts	kva	=	kilovolt – amperes
eff	=	efficiency in decimals	hp	=	horsepower ouput
pf	=	power factor in decimals			

g) Laws on Series circuit:



$$\text{Current}_{\text{Total}} = I_1 + I_2 = I_3$$

$$\text{Resistance}_{\text{Total}} = R_1 + R_2 + R_{3...}$$

$$\text{Voltage}_{\text{Total}} = E_1 + E_2 + E_{3...}$$

h) Laws on Parallel circuit:

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

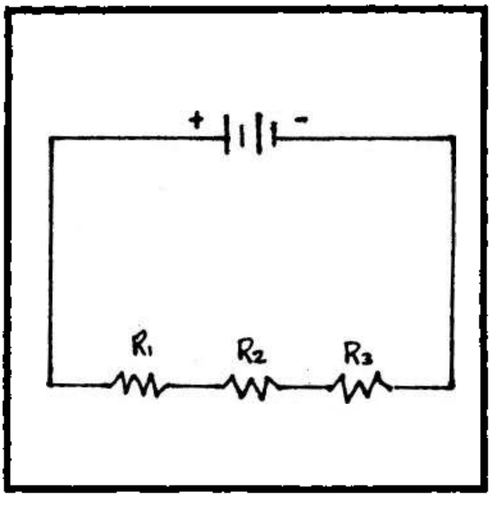
$$V_{\text{Total}} = E1 = E2 = E3$$

$$I_{\text{Total}} = I_1 + I_2 = I_3$$

i) **Frequency** $= \dfrac{\text{no. of poles x rpm}}{120}$

Rpm $= \dfrac{120 \text{ x frequency}}{\text{poles}}$

Poles $= \dfrac{120 \text{ x frequency}}{\text{rpm}}$



BASIC SYMBOLS

SYMBOL	DESCRIPTION
	ONE CONDUCTOR OR A GROUP OF SEVERAL CONDUCTORS
	TWO CONDUCTORS (MULTILINE REPRESENTATION)
	TWO CONDUCTORS (MULTILINE REPRESENTATION
n	n CONDUCTORS (SINGLE-LINE REPRESENTATION)
	CROSSING WITHOUT ELECTRICAL CONNECTION
	JUNCTION OF CONDUCTORS
	TERMINAL CONNECTION OF CONDUCTORS
	JOINT TERMINALS
R	RESISTANCE OR RESISTOR
	INDUCTANCE OR INDUCTOR
	WINDING
	CAPACITANCE, CAPACITOR
	RELAY COIL, GENERAL SYMBOL
	HULL CONNECTION (EARTH)
	MECHANICAL COUPLING GENERAL SYMBOL
	SWITCH, GENERAL SYMBOL
	THREE POLE SWITCH, SINGLE REPRESENTATION
52	CIRCUIT BREAKER
	CHANGE OVER CONTACT BREAKE BEFORE MAKE
	MAKE BEFORE BRAKE CONTACT (OVER LAP CONTACT)
	CONTACTOR NORMALLY OPEN (MAIN)
	CONTACTOR NORMALLY CLOSE (MAIN
	MAKE CONTACT (a CONTACT) GENERAL SYMBOL
	BREAK CONTACT (b CONTACT) GENERAL SYMBOL
	PLUG AND SOCKET (MAKE AND FEMALE)
R	RESISTOR WITH MOVING CONTACT GENERAL SYMBOL
	FUSE
G	GENERATOR
M	MOTOR
	SINGLE PHASE TRANSFORMER WITH TWO SEPARATE WINDINGS
	AUTO TRANSFORMER THREE PHASE
	SEMICONDUCTOR DIODE OR RECTIFIER GENERAL SYMBOL
V	VOLT METER
A	AMMETER
	CURRENT TRANSFORMER
WL	PILOT LAMP (FOR ELECTRIC SOURCE "ON")
GL	INDICATING LAMP (FOR MOTOR RUNNING)
YL	STAND-BY INDICATING LAMP

DESCRIPTION	DESCRIPTION
52	DISCONNECTING SWITCH OR MOLDED CASE CIRCUIT BREAKER
52	MOLDED CASE CIRCUIT BREAKER (WITH SHUNT TRIP COIL)
UVT	UNDER VOLTAGE TRIPPING COIL OF CIRBUIT BREAKER
	SWITCH (GENERAL) SINGLE THROW
	SWITCH (GENERAL) DOUBLE THROW

TERMINALS

	TERMINAL MARK CABLE NO CABLE SIZE
	EQUIPMENT OF OUTSIDE
	EQUIPMENT OF OTHER UNIT

POWER & RELAY CONTACT

a	b	
		CONTACT (GENERAL) OF MANUAL CONTACT
		MANUALLY OPERATED AUTO RESET CONTACT (WITH LOCKING DEVICE)
		MECHANICAL CONTACT0
		HAND RESET CONTACT
		RELAY CONTACTOR OR AUX. SWITCH CONTACT
		CONTACT WITH TIME LIMIT OPERATION (ON DELAY TYPE)
		CONTACT WITH THE LIMIT OPERATION (OFF DELAY TYPE)
		RUCHING RELAY CONTACT
		MAIN CONTACT OF ELECTRO MAGNETIC CONTACTOR
		GANG SWITCH MANUAL OPERATED RESIDUAL CONTACT
		C CONTACT
		CONTROL SWITCH OR CONTROLLER CONTACT

ELECTRICAL SYMBOLS

PROBLEM SOLVING

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:

$$P = \text{Volts x Amperes}$$
$$= (150)\ (220)$$
$$= 33{,}000 \text{ watts } 1000$$
$$= 33 \text{ Kw}$$
$$R = \frac{P}{1^2}$$
$$= \frac{33{,}00}{(150)\ (150)}$$
$$= 1.46 \text{ ohms.}$$

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

SOLUTION:

hp output of gen.	=	input	x	efficiency		
	=	150	x	.9	=	135 hp
watt output of gen.	=	135	x	746	=	100,710 watts

$$\text{current,} = \frac{\text{watt}}{\text{voltage}} = \frac{100{,}710}{220}$$

$$\text{current} = 457{,}772 \text{ amps.}$$

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

SOLUTION:

$$\frac{1}{R_e} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6} = \frac{4 + 3 + 2}{12} = \frac{9}{12}$$

$$R_e = \frac{12}{9} = 1.333$$

$$R_T = Rs + R_e$$
$$= 18 + 1.333$$
$$= 19.333$$

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

SOLUTION:

$$\text{Total watts} = (20 \times 100) + (14 \times 60)$$

$$= 2{,}000 + 840 = 2840 \text{ W}$$

$$\boxed{\text{Ampere} = \frac{W}{V} = \frac{2840}{120} = 23.666 \text{ amp.}}$$

$$\text{Ampere} = \frac{\text{watt}}{\text{voltage}}$$

$$= \frac{2840}{120}$$

$$= 23.666 \text{ amp.}$$

THIRD ENGINEER

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

SOLUTION:

output in watts = output in hp x 746
= 100 x 746
= 74,600 watts

$$\text{input in watts} = \frac{\text{output}}{\text{efficiency}} = \frac{74{,}600}{.75}$$

= 99,466.66

$$\text{current} = \frac{\text{watt}}{\text{volt}} = \frac{99{,}466.66}{220}$$

= 452.1212 amps.

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) $$\text{Current} = \frac{\text{Volt}}{\text{Resistance}}$$
$$= \frac{120}{60}$$
$$= 2 \text{ amperes}$$

b) $$\text{Power} = \text{current} \times \text{volts}$$
$$= 2 \times 120$$
$$= 240 \text{ watts}$$

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

$$= 50 \text{ HP} \times \frac{746 \text{ w}}{1 \text{ HP}} \times \frac{1\text{kw}}{1000 \text{ w}}$$
$$= \frac{50 \times 746}{1000}$$
$$= 37.3 \text{ Kw}$$

b) Horsepower delivered

$$= 50 \times 0.84$$
$$= 42 \text{ HP}$$

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

$$\text{Power Factor} = \frac{\text{Kw}}{\text{KVA}}$$

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

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:

$$\frac{1}{Ra} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{4} + \frac{1}{5} + \frac{1}{6}$$

$$= \frac{15 + 12 + 10}{60}$$

$$1/Ra = \frac{37}{60}$$

$$Ra = \frac{60}{37} = 1.62 \text{ ohms}$$

$$RT = Ra + Rb$$

$$= 1.62 + 12$$

$$= 13.62 \text{ ohms.}$$

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

SOLUTION:

$$\text{Current in gen.} = \frac{50\ (1000)}{220}$$

$$\text{Current}_{total} = 227.27 \text{ amps.}$$

$$= 227.27 + 227.27$$

$$= 454.54 \text{ amps.}$$

$$\text{Resistance}_{total} = \frac{V}{A} = \frac{220}{454.54}$$

$$= 0.484 \text{ ohms.}$$

$$\text{Voltage Total} = I_T \times R_T$$

$$= 454.54 \times 0.484$$

$$= 220 \text{ V}$$

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:

$$E_T = E_2 - E_1$$
$$= 12 - 6$$
$$E_T = 6V$$
$$R_T = R_1 + R_2$$
$$= 12 \text{ ohms}$$

$$\text{Current Total} = \frac{E_T}{R_T}$$
$$= \frac{6}{12}$$
$$\text{Current Total} = 0.5 \text{ amp.}$$

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

GIVEN:

Gen.output = 500 kw 1kw = 1.34 hp

Effeciency = 80%

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$
$$= \frac{80}{100} = \frac{500}{X}$$
$$X = \frac{50000}{80}$$
$$HP = 625 \text{ kw} \times 1.34$$
$$HP = 837.5 \text{ Required}$$

Checked:

$$\text{Eff} = \frac{500 \text{ kw}}{625 \text{ kw}}$$
$$= .8 \times 100$$
$$= 80\%$$

80% of 625 = 500 kw

$$80\% \text{ of } 837.5 = \frac{670 \text{ HP}}{1.34}$$

500 kw

1. Resistance of 4,5 and 6 ohms are in series with another in a 220 V. Circuit. Calculate.

a) Total resistance
b) Line current
c) Voltage drop across each resistance
d) Total power consumed

SOLUTION:

a) $R_T = R1 + R2 = R3$

$= 4 + 5 + 6$

$R_T = 15$ ohms.

b) $A = \frac{V}{RT} = \frac{220}{15}$

$= 14.66$ amps.

c) $V1 = 14.66 \times R1 = 14.66 \times 4 = 58.64$ V

$V2 = 14.66 \times R2 = 14.66 \times 5 = 73.30$ V

$V3 = 14.66 \times R3 = 14.66 \times 6 = \underline{87.96 \text{ V}}$

$V_T = 219.90$

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 $= \frac{V \times A}{1000}$

$= \frac{220 \times 400}{1000}$

$= 88$ KVA

True Power

= app.power x power factor

$= 88 \times .95$

$= 83.6$ kw

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:

$R_a = 100$
$R_b = 120$
$R_c = 150$
$I_c = 1A$

Required:

$It = ?$
$E_B = Ib \cdot Rb$
$= (1)(120)$
$E_B = 120V$
$E_B = Ea = Ec = Et = 120$

$$Rt = \frac{R_A R_B R_C}{(R_A R_B) + (R_B R_C) + (R_C R_A)}$$

$$= \frac{100 (120)(150)}{(100 \times 120) + (120 \times 150) + (150 \times 100)}$$

$$= \frac{1800000}{12000 + 18000 + 15000}$$

$$= \frac{1800000}{45000}$$

$$Rt = 40$$

$$I_T = \frac{E_T}{R_T}$$

$$= \frac{120 \text{ V}}{40}$$

$$I_T = 3 \text{ amps.}$$

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

$$(15)(0.2) + 24 \quad 15R = 117$$
$$3 + 24 + 15R = 117$$
$$27 + 15R = 117$$
$$15R = 117-27$$
$$15R = 90$$
$$R = 90/15$$
$$R = 6 \text{ ohms}$$

BOARD QUESTIONS

FOURTH ENGINEER **MAY-JULY 1992**

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
   B. pole following it
   [redacted] opposite the main pole
   [redacted] none of the above

3. Interpoles are connected in:

   A. series with the armature
   B. series with the shunt field
   C. parallel with the armature
   D. parallel with the series field

4. A DC compound wound generator that has a voltage drop from no load to full load is said to be:

   A. under compounded
   B. over compounded
   C. flat 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
B. flat compounded
C. over compounded
D. cumulative compounded

9. What are commutators made of?

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:

A. yoke
B. commutator
C. armature windings
D. field pole windings

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
B. brushes
C. stationary armature
D. brush holders

16. Which of the following will not cause a generator to vibrate?

A. loose pigtails
B. loose bolts
C. misalignment
D. fruity speed governor

17. Most generators will withstand as overload of:

A. 15 percent
B. 25 percent
C. 30 percent
D. 35 percent

18. [redacted] series-wound generator has the field windings in series with the:

[redacted] armature
[redacted] brushes
[redacted] commutator
[redacted] field poles

19. The pole pieces mounted in a D.C. generator are built up of sheet steel laminations riveted together to:

[redacted] fit the curvature of the frame
[redacted] reduce eddy current losses
[redacted] allow for necessary air gap
[redacted] allow for easy assembly

20. What is the primary reason for commutating poles in a D.C. generator?

[redacted] prevent sparking of the brushes
[redacted] increase field strength
[redacted] neutralize armature reaction
[redacted] aid in a commutation

21. Sparking and grooving of commutator may be caused by:

A. overload
B. strength of field
C. wrong type of brushes
D. any of the above

22. The voltage of a D.C. generator depends on which of the following?

A. speed of armature
B. strength of field
C. number of armature conductors
D. all of the above

23. To correct the polarity of a generator, you should:

A. Rotate armature
B. lift brushes and rotate armature
C. lift brushes and apply D.C.
D. lift brushes and run generator

24. Which of the following groups of motors are D.C. motors?

A. series, shunt and compound
B. series and induction
C. compound and synchronous
D. induction and synchronous

25. A series-wound motor is used to run a pump driven with a belt. If the belt breaks, the motor will:

A. overspeed and run out of control
B. stop
C. slow down
D. keep running at the same speed

26. AC circuits contain resistance, inductance and capacitance. The capacitive reactance of a circuit is expressed in:

A. ohms
B. mhos
C. henrys
D. farads

27. A shunt motor would be best suited for:

A. constant speed results
B. an anchor windlass
C. a cargo winch
D. any of the above

28. If the resistance is increased in the shunt field of a motor, the motor will

A. speed up
B. slow down
C. run at the same speed
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?

A. loose brushes
B. insufficient lubrication
C. overload
D. misalignment

31. In an induction motor, rotor currents are circulated in the rotor by:

A. slip rings and brushes
B. armature and brushes
C. inductive action of the rotating stator flux
D. external variable resistors

32. A device which normally prevents an action occuring until all other required conditions are met is a/an:

A. interlock
B. monitor
C. modulator
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
B. calcium chlorid
C. hydrogen chloride
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
B. ampere hour capacity
C. individual cell voltage
D. total cell voltage

36. Electrical leads and insulation on a motor should be painted with:

A. insulating varnish
B. heat-resisting aluminum
C. heat-resisting enamel
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

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

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
B. terminal polarity
C. stability under charge
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
B. Megohmeter
C. Wattmeter
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 ground in the distribution system
D. ground in a motor accompanied with a short

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
B. the shore power bus
C. the emergency 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
B. excessive charging rate
C. Insufficient circuit in a cell
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 point
B. open circuit
C. polarized ground
D. •short circuit

55. When a megohmeter 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 capacity
B. 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 values
B. 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 fullly charged state over long periods of disuse?

A. Normal charging circuit
B. High ampere charging circuit
C. Quick 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
B. prime mover speed
C. number of series conductors
D. magnetic field strength

63. The total number of watts in one horsepower is

A. 746 watts
B. 663 watts
C. 500 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 — *MAY-JULY 1992*

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
B. Wood
C. glass
D. any of the above

3. In cold weather the specific gravity of a battery:

A. rises
B. lowers
C. remains the same
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?

A. 1.280 to 1.300
B. 1.180 to 1.182
C. 1.100 to 1.150
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:

A. 1.280 to 1.300
B. 1.025 to 1.075
C. 1.050 to 1.350
D. 1.200 to 1.500

7. A dead cell of a lead-acid battery is checked by:

A. megger
B. hygrometer
C. test light
D. hydrometer

8. How many 1.5 volt batteries are required to supply a load of 12 volts if the batteries are connected in series?

A. 8
B. 6
C. 12
D. 10

9. How many 1.5 volt batteries are required to supply a load of 12 volts if the batteries are connected in parallel?

A. 12
B. 6
C. 3
D. none of the above

10. The rating of a storage battery that delivers 15 amps for 12 hours is:

A. 180 ampere hours
B. 150 ampere hours
C. 27 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 circuit
B. quick charge circuit
C. 20-amp charging rate circuit
D. test discharge circuit

13. H_2So_4 is:

A. sulphuric acid
B. hydrochloric acid
C. hydraulic acid
D. muriatic acid

14. The total voltage and amperage of two 50-amp 6-volt batteries connected in series is:

A. 12 volts, 50 amps
B. 12 volts, 100 amps
C. 6 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:

A. 6 volts, 100 amps
B. 6 volts, 50 amps
C. 12 volts, 100 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 by:

A. blow out coils
B. governor relay
C. undervoltage trips
D. reverse current trips

22. How is the rotation of a D. C. generator reversed?

A. reverse field connections
B. switch armature leads
C. switch armature leads
D. both B and C

23. On la D.C. generator where is the pigtail located?

A. feather spring
B. conductors
C. brush holder
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
B. flat compounded
C. shunt
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
B. over compounded
C. flat compounded
D. under flat 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
B. decrease
C. increase
D. reduce to half

29. D.C. generators are rated in

A. KVA
B. KwA
C. Kw
D. HP

30. The voltage output of a compound D.C. generator is adjusted by rheostat placed:

A. in series with the shunt field
B. in series with the series field
C. across the series field
D. across the shunt field

31. The electrolyte used in a nickel-cadmium battery is hydroxide.

A. potassium
B. cadmium
C. sodium
D. calcium

32. The device which most commonly utilizes the principle of electromagnetic induction is the:

A. transformer
B. diode
C. transistor
D. rheostat

33. A tubular fuse should always be removed from a fuse panel with:

A. a screwdriver
B. a pair of insulated pliers
C. any insulate object
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
B. Pump
C. Fan
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
B. capacitance
C. inductance
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
B. end rings
C. a centrifugal switch
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:

A. 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 relay

45. Protection against sustained overloads in molded-case circuit breakers is provided by an/an:

A. overvoltage release
B. thermal acting trip
C. thermal overload relay
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
B. cycles per second
C. revolutions 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
B. square millimeter
C. cubic inch
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

A. equalizing reactor
B. prime mover governor control
C. main alternator field rheostat
D. exciter field rheostat

56. The inductance of a conductor is measured in

A. henries
B. volts ohms
C. ohms
D. amperes

57. The voltage of an operating AC turbogenerator is raised or lowered by adjusting the

A. generator field exciter
B. phase sequence switch
C. generator governor controls
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
B. reverse charging
C. equalizing 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
B. cleaning solvent
C. compressed air
D. vacuum suction

62. Sparking at the brushes of a running motor could be an indication of

A. normal operation
B. increased brush capacity
C. a dirty commutator
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?

A. dynamic excitation
B. armature reaction
C. commutation
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

A. shorted B. dirty C. good D. grounded

68. What should be used to measure the temperature of an electrolyte?

A. alcohol thermometer
B. thermocouple pyrometer
C. mercury thermometer
D. potentiometer

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 battery
B. remove the battery caps
C. fully charge the battery
D. 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
B. yoke
C. field pole windings
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 — *MAY-JULY 1992*

1. What happens in a series circuit when the voltage remains constant and the resistance increases?

A. current decreases
B. current increases
C. current remains the same
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:

A. voltage
B. amperage
C. coulombs
D. resistance

4. One megohm is equal to:

A. 1,000,000 ohms
B. 10,000 ohms
C. 100,000 ohms
D. 1,000 ohms

5. A multiconductor cable:

A. has a number of separate circuits
B. is a single circuit cable composed of a number of strands
C. is a flexible cable to carry motor current
D. is a special heating conductor

6. In D.C. circuits, power is expressed as the product of:

A. volts and amperes
B. ohms and amperes
C. volts and coulombs
D. amperes and coulombs

7. A mil is:

A. 1/10 inches
B. 1/100 inches
C. 1/1,000 inches
D. 1/1,000,000 inches

8. One kilowatt is equal to:

A. 1.34 horsepower
B. 1.25 horsepower
C. 1.50 horsepower
D. 2.00 horsepower

9. Defects in wiring which permit current ot jump from one wire to another before the intended path has been completed are called:

A. grounds
B. shorts
C. opens
D. breaks

10. Which of the following is not a good conductor of electricity?

A. mica
B. copper
C. silver
D. aluminum

11. One horsepower equals:

A. 1,000 watts
B. 746 watts
C. 100 watts
D. 940 watts

12. An instrument often used to check the degree of motor shaft misalignment is the

A. Voltmeter
B. Clamp-on ammeter
C. Growler
D. Megohmmeter
E. Dial indicator

13. The electrical power is kilowatts used by a 220 volt motor drawing 15 amps is:

A. 3.3 B. 3.6 C. 3.8 D. 4.0

14. A horseshoe magnet has:

A. two poles
B. three poles
C. four 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 circuit
B. voltage of the circuit
C. resistance of the circuit
D. 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. $P = I^2R$
B. $P = R^2E$
C. $P = E^2R$
D. $P = E+R$

19. High voltage and low current gain are characteristics of the:

A. common base circuit
B. common emitter circuit
C. common collector circuit
D. both A and C

20. Which of the following statements is true?

A. like poles repel each other
B. like poles attract each other
C. unlike pole repel each other
D. none of the above

21. How is a lead-acid cell tested?

A. hydrometer
B. hygrometer
C. hogometer
D. megometer

22. A 24-volt lead-acid storage battery consists of:

A. 12 cells
B. 6 cells
C. 8 cells
D. none of the above

23. If the charging rate to a battery was too high, it would:

A. increase the terminal voltage
B. increase the specific gravity
C. increase the rate of hydrogen liberation
D. decrease the terminal voltage

24. In a 12-volt battery there are how many cells?

A. 6
B. 4
C. 2
D. 8

25. If the specific gravity of a 12-volt battery at 80° is 1.225, the battery is:

A. dead
B. fully charged
C. shorted
D. partially charged

26. The state of charge of a nickel-cadmium battery is determined by the use of a/an

A. voltmeter
B. hydrometer
C. ammeter
D. potentiometer

27. The physical size of a resistor that determines the ability of the resistor to absorb heat is rated in :

A. Ohms
B. Volts
C. Watts
D. Farads

28. A circuit that has infinite resistance is called ____________ circuit.

A. A short
B. A ground
C. An Open
D. All of the above

29. What determines the voltage of a lead-acid cell?

A. the type of electrolyte
B. the strength of the electrolyte
C. the size of the plates
D. none of the above

30. Salt water in contact with storage batteries will develop:

A. chlorine gas
B. nitrogen gas
C. carbon monoxide
D. 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 silver 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
B. electromagnet
C. piezoelectric device
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:

A. electromagnet
B. arc quencher
C. shading coil
D. holding coil

41. The method used to produce electron emission in most vacuum tubes is:

A. photoelectric
B. secondary
C. cold cathods
D. thermionic

42. A microprocessor is:

A. Another name for a computer
B. A CPU integrated circuit
C. A name for a calculator
D. A small scale integrated circuit

43. What device measures pressure and converts it into an electrical signal?

A. transducer
B. reducer
C. transformer
D. rectifier

44. Grounds found in electrical machinery due to insulation failure are usually caused by:

A. deterioration due to age
B. excessive heat
C. vibration
D. all of the above

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
B. regenerative braking
C. squirrel-cage induction
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:

A. degrees centigrade
B. circular mils
C. amperes
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 mover
B. resistance of the armature
C. centertap of the balance coil
D. 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 gassing

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 brushes
B. lubricating brush holders
C. cleaning the collector rings
D. increasing length of pigtail

55. When an alternator governor control switch is moved to "raise", this willl

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 megohmeter 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
B. an electromotive
C. resistance
D. inductive

59. The resistance in electrical wiring decrease as increase in

A. temperature
B. cross sectional area
C. metal impurities
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

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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
B. ohms
C. amps
D. coulombs

3. With other factor remaining constant, when the applied voltage is doubled, current flow in a given circuit will:

A. double
B. remain the same
C. be divided by two
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
B. R times E
C. E divided by R
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?

A. impendance
B. current
C. voltage
D. resistance

8. When using Ohm's Law, E divided by R would solve for:

A. amperage
B. voltage
C. resistance
D. watts

9. When using Ohm's Law, E divided by I would solve for:

A. amperage
B. voltage
C. resistance
D. watts

10. A wire gauge is used to measure:

A. size of wire
B. insulation value
C. current carrying capacity
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:

A. ohm B. watt 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:

A. an open circuit
B. a closed circuit
C. as series 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
B. pressure
C. magnetism
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:

A. doubled
B. quadrupled
C. the same
D. cut in half

22. If the length of a wire is doubled and the cross-sectional area is reduced to one-half, the change in resistance will be:

A. quadrupled
B. halved
C. doubled
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
B. voltage drop across them
C. resistance to the flow of current
D. current passing through them

26. An increase in current:

A. increases temperature
B. decreases temperature
C. has no effect on 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:

A. temporary magnet
B. permanent magnet
C. natural magnet
D. solid magnet

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
B. cambric
C. rubber
D. porcelain
E. impossible to insulate

31. A semi-conductor that decreases in a resistance with an increase in temperature is known as a:

A. resistor
B. thermistor
C. diode
D. thermopile

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
B. slip rings
C. commutators
D. all of the above

34. An operating characteristics which appears on the name plates of shipboard AC motors is:

A. temperature rise
B. input kilowatts
C. the type of winding
D. locked rotor torque

35. Low horsepower polyphase induction motors can be started with full line voltage by means of :

A. compensator
B. autotransformer
C. across-the-line
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 circuit
B. quick charging circuit
C. trickle charging circuit
D. high ampere charging circuit

38. A ground can be defined as an electrical connection between the wiring of a motor and its:

A. metal framework
B. circuit breaker
C. shunt field
D. interpole

39. External shunt are sometimes used with ammeters to:

A. increase meter sensitivity
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
B. prive mover speed
C. load on the alternator
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
B. infinite
C. 100 kilohms.
D. 1 megohm

47. An accidental path of low resistance which passes an abnormal amount of current is known as a/an:

A. open circuit
B. short circuit
C. polarized ground
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

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
B. autotransformer
C. compensator
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
B. exciter field rheostat
C. main alternator files 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
B. angle of coil displacement
C. inertia of the movable coil
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
B. asbestos
C. rubber
D. silicon

56. Which could you use to locate a grounded field coil in a synchronous motor?

A. voltmeter
B. multimeter
C. frequency meter
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:

A. off B. on **C.** trip D. reset

58. A milliameter with a full scale deflection reading of 100 milliamperes has an accuracy of + or -2%. A meter reading of 10 milliamperes would indicate a line current between:

A. 9.8 and 10.2 milliamperes
B. 8.0 and 10.0 milliamperes
C. 9.8 10.0 milliamperes
D. 8.0 and 12.0 milliamperes

59. When the current through a copper wire increases, its

A. temperature will increase
B. conductivity will increase
C. insulation will burn
D. resistance will decrease

60. Which type of flux should be used when soldering wire connection?

A. Rosin flux
B. Solid flux
C. Acid flux
D. Silver flux

61. When placed in a magnetic field, what material will have the highest permeability?

A. glass
B. bakelite
C. aluminum
D. soft iron

62. A shore power circuit breaker should be closed only

A. in a shipyard
B. when the ship's generators have been removes from the bus
C. when the ship's generators have been paralleled to those on shore
D. if a quick disconnect coupling is used

63. Which meter uses a shunt connected in series with the load and parallel with the meter movement?

A. power factor meter
B. ammeter
C. voltmeter
D. wattmeter

64. When using an ohmmeter to test a diode, you find a low resistance in both the forward and reverse bias directions.

A. open diode
B. good resistance quality
C. high power overspeeding
D. good capacity quality

65. The purpose of the reversed power relay in ship's service alternator panel is to trip circuit in the event of

A. alternator motorization
B. main circuit overload
C. high power overspeeding
D. generator overspeeding

66. An internal resistance would be placed in series with the meter movement of which instrument?

A. AC ammeter
B. main circuit overload
C. DC voltmeter
D. generator overspeeding

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 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 Boiler – 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 Boiler – 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 Boiler – 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 Boiler – 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 Boiler:

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 feed-water 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 top- air 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?

Boiler 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.

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:

	Blr. 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^2 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 valves: 1 – 4% of set pressure.

To prevent leaking or "weeping" of safety valves, the boiler operating pressure should be lower than the design pressure.

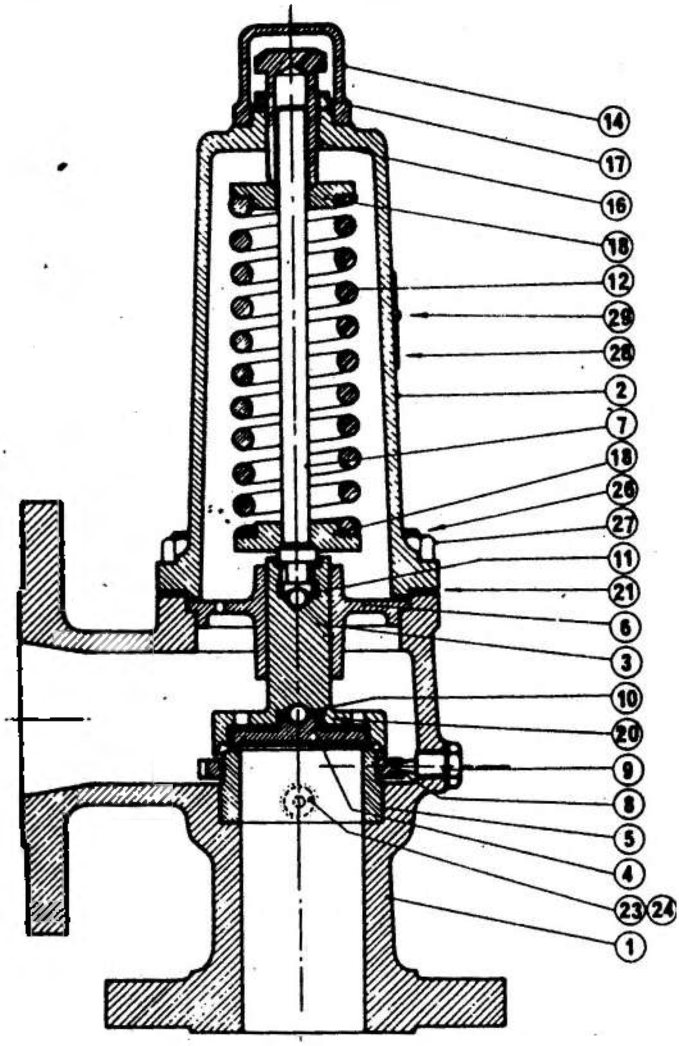
The ideal lift for a safety valve is 1/4 of the valve (throat) diameter.

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.



1	Body	17	Locknut
2	Cover	18	Spring Plate
3	Valve Disc Holder	20	Disc Retaining Clip
4	Valve Disc	21	Body Gasket
5	Seat Ring	23	Seat Securing Pin
6	Guide	24	Securing Pin Plug
7	Spindle	26	Body Stud
8	Blow Down Ring	27	Body Stud Nut
9	Setting Screw	28	Nameplate
10	Valve Disc Ball	29	Nameplate Screw
11	Spindle Ball		
12	Spring		
14	Dome		
15	Adjusting Screw		

Safety Valve

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

Chatter: 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.

WATER LEVEL GAUGES

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.

ROTARY CUP BURNER

The burner asssembly 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 **atomising air** *(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 **secondary air** 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 tool)*

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 press 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. Re-adjust 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^+ ions to receive electrons at cathode.

The metal ion combines with the OH^- 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 semi-permeable 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

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 $CaSO_4$ 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.

$$MgCL_2 + H_2O = Mg(OH)_2 + HCl$$

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:

Contaminants from Sources External to the Ship	Contaminants from Sources Inside the Ship
1. Calcium salts	1. Oil
2. Magnesium salts	2. Iron
3. Chlorides	3. Copper
4. Silica	4. Carbon dioxide
5. Carbon dioxide	5. Oxygen
6. 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_2 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 maintained.

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.

$$3N_2H_4 \dashrightarrow 4NH_3 + N_2$$

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 20ºC x 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_2CO_3) 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_2CO_3) 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

Boilers up to 32 bars	in ppm	Means of Adjustment
Total hardness	< 1.0	
P–alkalinity ($CaCO_3$)	100 - 150	GC
Total Alkalinity ($CaCO_3$)	200 - 300	GC
Phosphate	20 - 40	Adjunct B
Hydrazine	0.1 - 0.2	Amerzine
Chlorides	300	Blowdown
T.D.S.	500 - 550	
pH–value	10.8 - 11.3	
Conductivity	700 mmho/cm	

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^+ ion conc.) makes the pH-value which is the logarithm of the reciprocal of the hydrogen ion concentration in water.

H^+	OH^-	
10^{-5} x	10^{-9} solution acidic.	ph = 5
10^{-7} x	10^{-7} solution Neutral.	ph = 7
10^{-9} x	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,w hile 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/cm² (450 psig, 3200 kN/m³)

	MEANS OF ADJUSTMENT	TEST RESULTS (control Limits in Blue)		DOSAGE 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=		
HYDRAZINE TEST	AMERIZINE Corrosion Inhibitor	LESS THAN 0.10 ppm		INCREASED BY 25%
		0.10 – 0.20 ppm		SATISFACTORY – NO CHANGE
		OVER 0.20 ppm		DECREASED BY 25%
		INITIAL DOSAGE 0.15 LTR (0.3 PT) X TONS=		
PHOSPHATE TEST	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 =
		20 – 40 ppm		SATISFACTORY
		40+ ppm		HIGH BLOWNDOWN REDUCE DOSAGE
		INITIAL DOSAGE 30 GRAM (1 OZ) X TONS=		
"P" ALKALINITY TEST	GC Concentrated Alkaline Liquid	ML SULFURIC ACID N/10	PPM	
		0-0.3	0-30	0.15 ltr. (0.3 PT) X TONS =
		0.4 - 0.7	40 – 70	0.10 ltr. (0.2 PT) X TONS =
		0.8 – 0.9	80 – 90	0.05 ltr (0.1) X TONS =
		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, DOSE 1 LTR (2 PTS) OF GC REGARDLESS OF THE "P" ALKALINITY. TEST AGAIN IN 2 HOURS

		SATISFACTORY NO 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
BLOWDOWN	Conductivity in µmhos	UP TO 700 µmhos													700 µmhos AND OVER
	Blowdown should be carried out as per boiler manufacturer's instructions. Blowdown is necessary to reduce dissolved and suspended solids. If sspended solids are noticed in boiler water samples, blowdown regardless of chlorides test results. weekly flash blow is advisable to remove normal sludges and to ensure clear operational lines.														

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 60ºC 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.

SCOPE OF SURVEYS

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.

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 inthe 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 bê 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 cradles, 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

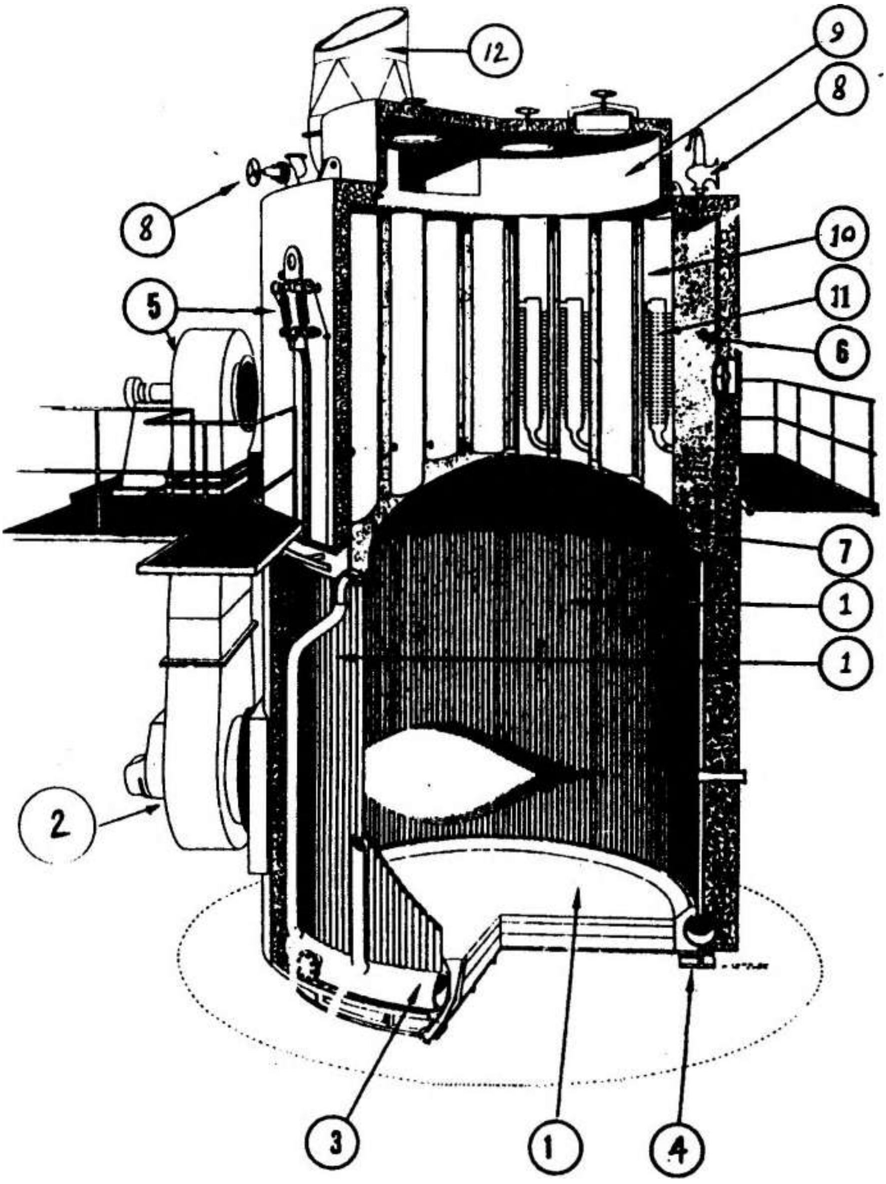
Major mounting are removed, dismantled and inspected. Gauge glasses, safety valves, feedcheck valves, steam stop valves, are all checked for corrosion, erosion, strength and correct operations. Internal feed and chemical injection pipes are inspected for oxygen pitting and corrosion. Waste steam pipes 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.



SUNROD OIL FIRED BOILER

Parts:

1. Furnace
2. Burner
3. Bottom Header
4. Boiler bottom
5. Gange Glass/ F.d. Fan
6. Steam space
7. Furnace Crown
8. Upper mountains
9. Gas Space
10. Vertical tube
11. Sunrod tube
12. Gas uptake

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 ($Na_3 PO_4$) 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_2, O_2 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/cm²	5,000 kg/cm²
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 m³	5.7 m³
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.

Causes of Boiler Explosion:

1) Excessive pressure
2) Localized weakness
3) Flareback
4) Low water level

Q. If the water become dangerously low in a scotch boiler, what would you do?

If the water becomes dangerously low in a scotch boiler, the fusible plug would melt out. When this happen observe the following procedure:

1. Secure the fire and feed water at once.
2. Secure the main and auxiliary steam stop and open the safety valve with the hand lifting gear.
3. Secure the air supply to the furnace and allow the boiler to cool gradually then call the chief Engineer.
4. When the boiler has cooled, carefully examine crown sheet and upper tubes for sag or any other sign of overheating. If no damage is found, renew fusible plug and get up steam again. If damage is found, the inspector must first approve any necessary repairs.

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 pump 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.
l. *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.

$$\%\ \text{Speed Reg.} = \frac{\text{no load speed - full load speed}}{\text{full load speed}} \times 100$$

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 air-cell 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 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;
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:

$$\text{Wear rate} = \frac{\text{increase in dia. (total)}}{\text{Running hrs. (total)}} \times 1000$$

$$= \_\_\_\_ \text{ mm/1000 hrs.}$$

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.

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:

$$\text{Wear rate} = \frac{\text{increase in dia. (total)} \times 1000}{\text{Running hrs. (total)}}$$

$$= \_\_\_\_ \text{ mm/1000 hrs.}$$

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

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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 parts. 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 parts 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 the 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.

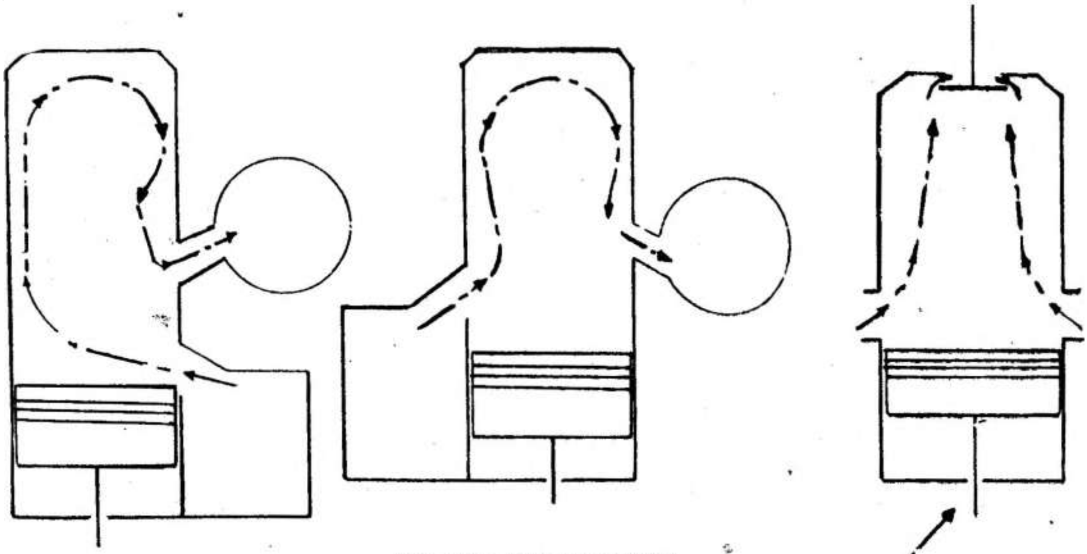
So, the first phase of scavenging process is Perfect Scavenging which then changes into complete mixing process.

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	*Short Circuit	*Sulzer
*Less Maintenance	*Lower Efficiency	*RD, RND
*Low Cost	*Less BMEP	
Loop Scavenge		
*Higher Efficiency	*Piston/Liner Distortion due to Temp. gradient from exhaust to scavenge ports.	*M.A.N
*Simple	*Crankcase/under piston space more dirty.	*RND-M Sulzer
*Less Maintenance	*Exhaust port carbonisation excessive.	
*Reliable	*Uneven piston ring wear.	
*Simple Cylinder – can sustain higher thermal stresses.	*Less efficiency due to overmixing	
Uniflow Scavenge		
*No short circuiting	*More complex	*B & W
*No overmixing	*Higher cost	*SULZER-RTA
*Very high efficiency	*More maintenance	

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

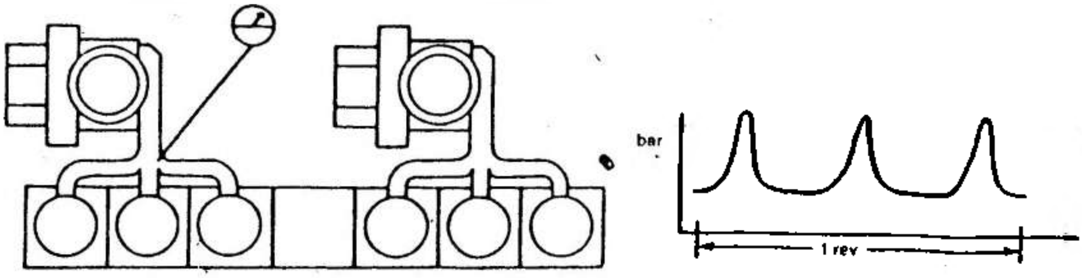
Scavenge ports open at approximately 35 degrees b.d.c. and close 35 degrees after b.d.c. The exhaust valve will open ahead of the scavenge ports to give a blow down period and close at some time to leave the correct amount of air in the cylinder for the combustion of fuel. The open period for the exhaust 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.



PULSE SYSTEM

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 scavenging 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

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

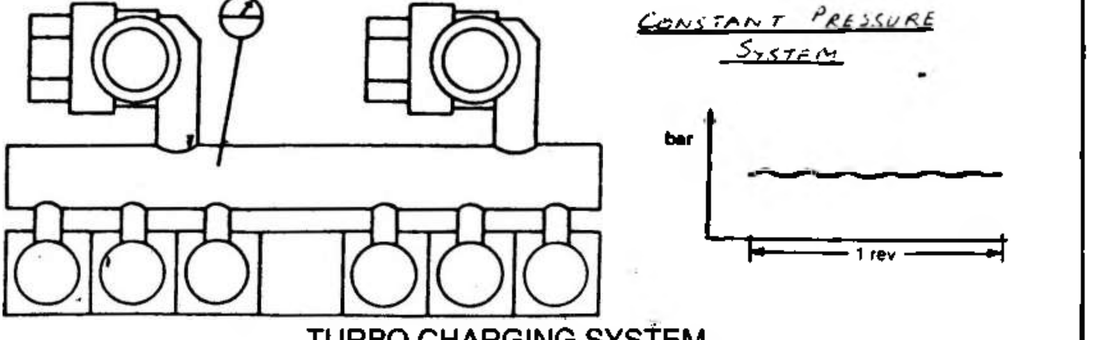
1. Howling Noise
2. Rapid surges in scavenge air pressure
3. "Gulping" of air by blower
4. Repeated irregular violent thud from air intake to blower.
5. Alternate "suck-in" and "push-out" at blower air intake.

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



TURBO CHARGING SYSTEM

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
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 enging 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, losss 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
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 2^0 to 5^0. 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-120^0	120^0
-4 cylinders-90^0	180^0
6 cylinders-60^0	120^0

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 valve 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 value 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/cm².
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.
l) 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:

a) Check the engine speed, pressures and temperatures at regular intervals.
b) After each start, check that the starting air pressure is above the lower limit, i.e. 15kp/cm². If the pressure is lower, the starting air bottles have to be charged.
c) At intervals drain the starting air bottle for condensation.
d) The lube oil pressure in the main system after filter should normally be 2.5 - 3.0 kp/cm². For the valve gear lub. oil system 0.5 kp/cm² minimum.
e) The lube oil temperature at outlet from engine should normally be 60°C.
f) The cooling water pressure should normally be 1.0 - 2.5 kp/cm².
g) The cooling water temperature at outlet from engine must not exceed 80°C. Normal outlet temperature is 70°C. depend on engine instruction.
h) The charge air temperature must not exceed 60°C after cooler. When the charge air temperature increases, the exhaust gas temperature will also increase. Check the charge air temperature at full load.
i) Instruction for turbocharger and intercooler, separate service manual.
j) Instruction for Woodward Governor see separate service manual.
k) 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.

b) Longer interruption of operation.

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.

1. STARTING DIFFICULTIES AND TROUBLE SHOOTING:

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.
3. The starting valve leaking in cylinder
4. Clogged fuel nozzles.
5. Pilot valve shut.
6. Starting distributor valve shut

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:

a. Worn or broken piston rings.
b. Leaking valves in cylinder cover.
c. Leaking gaskets between the cylinder covers and the cylinder liners.
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.
4. Clogged pipe lines or fuel oil filter.
5. A piston has seized.

3. ENGINE RPM DROPS

1. Engine is overloaded.
2. Injection pumps are working irregularly. Air in fuel system.
3. A piston or a bearing has a breakdown due to insufficient lubrication or dirt in lube oil.

Possible causes

1. One cylinder "falls out".
2. Leakage between the cylinder liner and the piston.
3. Leakage in top gasket.
4. Clogged fuel oil filter.
5. The inlet and/or the exhaust valves are leaking.
6. The valve clearances are too small.
7. Filter for turbo-charger is clogged.

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 valve in the filter or the safety valve 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

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 anf 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:

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 incrrease efficient operation.

e. Impulse blade are generally attached directly to the wheels, made in longer lenght 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.

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.

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. Réstricted 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 valve 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
   B. corrosion
   C. foaming
   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
   B. diaphragm
   C. wheel casing
   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 150^0F
   C. 150^0F
   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
   B. pop test
   C. steam stop test
   D. safety adjustment 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
   B. air ejector
   C. steam condenser
   D. boilers

8. The lap of a steam valve of reciprocating steam engine is measured when the valve is in the

A. central position
B. air ejector
C. steam condenser
D. boilers

9. Kinetic energy is the energy of the body has due to its

A. position
B. temperature
C. motion
D. horsepower

10. Work is conveniently expressed in:

A. pounds per minute
B. kilograms per minute
C. kilogram meter
D. foot-pounds per minute

11. Power is the work done as

A. 33,000 ft. pounds
B. 2450 kilograms.
C. per unit of time
D. work times distance

12. Which of the significant combustible elements of fuel oil is a major source of boiler corrosion?

A. oxygen
B. sulphur
C. hydrogen
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 sediment
B. 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. sulfates
B. excess oxygen
C. phosphates
D. 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?

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
B. pressure
C. timing
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. Superheated steam is used in the main propulsion turbine instead of saturated steam, because superheated steam has

A. greater heat energy per pound of steam
B. less specific gravity per pound of steam
C. higher pressure than saturated
D. less specific volume than saturated

26. When heated, brickwork in a boiler is kept from buckling by installing

A. anchor bolts
B. sliding saddles
C. expansion joints
D. insulating blocks

27. What refractory material can be used in an area directly expose to the highest heat in the furnace?

A. firebrick
B. insulating brick
C. baffle mix
D. insulating block

28. How can the proper speed of the propeller be reduced against the speed of the turbine?

A. by reduction gear
B. by modified turbine blades
C. by installation of interm
D. by reducing steam inlet opening

29. What do you call the instrument that measure the radial position of the crankshaft or rotor shaft?

A. shafting gauge
B. bridge gauge
C. spirit level gauge
D. dial gauge

30. Steam produced by a boiler should be separated from moisture

A. before leaving boiler
B. by way of the superheater
C. through the dry pipe
D. in the turbine steam trap

31. Vacuum refers to pressures

A. 34 inches of mercury
B. 31 inches of mercury
C. below atmospheric
D. zero gauge

32. Specific heat of a substance is defined as the heat required to raise the temperature of

A. 1 lb. of it to 1°C
B. 1 kg. of it to 1°F
C. 1 lb of it to 1°F
D. 10 lbs of it to 1°F

33. Too high alkalinity of boiler water may cause

A. scale
B. corrosion
C. caustic embrittlement
D. acidity

34. The number of cubic feet of fresh water that will weigh one ton is

A. 62 cu. ft.
B. 35.84 cu. ft.
C. 24.5 cu. ft.
D. 30.4 cu. ft.

35. The pressure due to a column of H_20 one foot high is

A. .491 lbs/sq. in
B. .434 lbs/sq. in
C. .5 lbs/sq. in
D. .625 lbs/sq. in

36. Specific heat of water is:

A. 1
B. 10^0F
C. 100^0C
D. 212^0F

37. Latent heat of evaporization of water is

A. 100 BTU per lb
B. 212 BTU per lb
C. 100 calories per
D. 970 BTU per lb.

38. 23°C reads in absolute degrees Centigrade as

A. 123° AC
B. 146° AC
C. 276 AC
D. 296° AC

39. Air starting valve-overlap in a 4-cylinder 2 cycle air starting diesel engine

A. 25^0
B. 40^0
C. no overlap
D. 10^0

40. Flash point of oil is the temperature at which

A. fuel will ignite in the cylinder
B. fuel must be heated to allow flammable vapors to form on its surface
C. fuel temperature above 150^0F
D. 150^0F temperature

41. In a 4 cycle engine the intake valve begins to open while the piston is on its

A. exhaust stroke
B. power stroke
C. compression stroke
D. suction stroke

42. In a 4 cycle engine the exhaust valve opens while the piston is on its

A. suction stroke
B. exhaust stroke
C. power stroke
D. compression stroke

44. In a natural aspirated 4 cycle diesel engine the exhaust valve is open in the cycle for a period of

A. 180^0
B. 200^0
C. 250^0
D. 190^0

45. In a modern turbine installation lube-oil system strainers are usually located in the line:

A. pump suction
B. 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

48. The most likely effect of water slugs in the steam supply of a ship service turbo-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?

A. centrifugal
B. propeller
C. reciprocating
D. rotary

50. In a turbine installation, the condensate pump discharges to:

A. air ejector condenser
B. the hot well
C. overboard
D. the feed water heater

51. What constituent of the fuel oil determines the specific heat

A. hydrocarbons
B. oxygen
C. nitrogen
D. sulphur

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 psia
B. 30.0 inches of water
C. 30.0 inches of vacuum
D. 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 mercury
B. 32 inches of mercury
C. zero gauge
D. 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

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
B. steam regulator valve
C. steam valve
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.

A. explosion proof gear
B. non-vented plunger
C. two-stage centrifugal
D. positive displacement rotary

68. The volume swept through by the piston in moving between the TDC and BDC is called:

A. stroke
B. piston displacement
C. piston
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
B. stability
C. surging
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?

A. feeder valve
B. hydrokineter valve
C. bottom blow valve
D. circulating valve

71. A unit of measure used to express the chloride content of boiler water is the

A. pH
B. Micro ohm
C. PPM
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

74. 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

73. What type of strainer is used in a turbine lube-oil system to remove metallic particles?

A. Simplex filter
B. Magnetic basket strainer
C. Metal edge strainer
D. Fullers earth filter

75. The third stroke of four-stroke cycle diesel engine is called:

A. compression stroke
B. power stroke
C. air stroke
D. expansion stroke

76. A sample of boiler water can be chemically tested by adding a few drops of a 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
B. air stroke
C. ignition 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 pressure
B. firing pressure
C. mean effective pressure
D. mean height of diagram

81. In an engine cylinder there exist a certain average pressure throughout a stroke 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?

A. Auxiliary fuel oil system
B. all of these
C. Auxiliary Feed
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
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
B. pumps
C. deaerator
D. condensed

87. What type of fuel pump is usually used with a unit type auxiliary boiler

A. Reciprocation
B. Centrifugal
C. Propeller
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
B. pressure regulator
C. fuel rack
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
B. indicator diagram
C. temperature 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:

A. expansion
B. compression
C. scavenging
D. cycle

93. What is the "driving force" behind heat transier by conduction

A. The size of the heat sink for absorbing heat
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
B. two-stroke engine
C. four-stroke engine
D. all of these

95. It is the actual horsepower delivered by the engine to the drive shaft.

A. power stroke
B. 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
B. screen tubes
C. water headers
D. water walls

97. Peculiar property of Babbit metal which makes it the best lining metal for crankpin and main bearings is

A. Its soft and can be cast easily
C. it does not expand when heated
B. 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
B. none of these
C. valve timing
D. tappet clearance

101. In a modern turbine installation, lube oil system strainers are usually located in the line.

A. bearing supply
B. pump suction
C. gravity tank discharge
D. gravity tank overflow

102. A test being used for boilers to detect leaks and to check water tightness after certain repairs:

A. efficiency test
B. hydrostatic test
C. temperature test
D. conductivity test

103. The water in a steaming auxiliary boiler should be tested daily for

A. dissolved oxygen
B. dissolved nitrogen
C. chloride
D. sludge

104. The astern guardian valve must be open when a vessel is

A. loading cargo
B. at full speed
C. maneuvering into port
D. 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?

A. Sentinel valve
B. Main steam stop
C. Guarding valve
D. Nozzle valve

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 line
   B. simplex fuel oil strainer
   C. settling tanks
   D. 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 temperature
   B. decreased refractory maintenance
   C. increased furnace size
   D. proper combustion

5. To maintain design discharge pressure from a centrifugal pump, the design clearance 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 pressure
   B. air volume regulators
   C. fuel-air ratio knob
   D. forced draft fan dampers

7. The purpose of the air chamber on the discharge of an emergency boiler feedsteam reciprocating pump is to

   A. reduce pulsation in the feed line
   B. facilitate draining of the cylinder
   C. adjust the speed of the pump
   D. provide for easy suction

8. Which of the following safety devices should be installed on turbines?

A. lubrication low pressure stop mechanism
B. atmosphere relief valve
C. rupture disk
D. vacuum breaker

9. Which of the following is the correct answer concerning the lubrication system for a high power turbine flexible coupling

A. 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

A. radiation
B. friction
C. leakage past rings
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 as

A. exposure stress
B. caustic embrittlement
C. alkaline stress
D. corrosion

17. Unequal distribution of combustion in the furnace is known as

A. flame impingement
B. furnace overload
C. temperature failure
D. 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

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
B. overspeed trip
C. atmospheric relief valve
D. vacuum breaker

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?

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
B. reversing latch
C. sliding camshaft
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
B. burner cone
C. orifice plate
D. air 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 atomizing
B. for centrifuging
C. in a storage-tank
D. in the recirculating line

29. In a segmentall pivoted shoe thrust bearing, the load among the shoes is equalized by the

A. leveling plates
B. oil wedge
C. base ring
D. thrust collar

30. Carbon ring packing is secured in a turbo-generator gland by means of

A. garter springs
B. centering rings
C. steam pressure
D. labyrinth rings

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
B. bomb calorimeter
C. throttling 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 inhibitors
B. antifoaming agents
C. extreme pressure additives
D. 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. collar
B. lower leveling plate
C. upper leveling plate
D. 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 generator
B. a line from the gravity tank
C. hand operated pump
D. 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
B. main condenser
C. boiler drum
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. shoes
B. lower leveling plates
C. dowel disk
D. 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
B. double-flow reaction turbine
C. multi-stage impulse 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

A. I and II
B. I and III
C. II 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
B. non-stability
C. sensitivity
D. hunting

47. The ability of the engine governor to correct speed disturbance with a minimum of false motions is known as

A. stability
B. sensitivity
C. speed droop
D. compensation

48. The steam turbine auxilliary for emergency purposes in case the turbine overspeed is the

A. vacuum breaker
B. rupture disk
C. overspeed trip
D. atmospheric relief valve

49. The weakening of boiler steel as the result of inner crystalline cracks is known as

A. exposure stress
B caustic embrittlement
C. alkaline stress
D. corrosion.

50. Unequal distribution of combustion in the furnace is known as

A. flame impingement
B. furnace overload
C. temperature failure
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
B. compensation
C. dead band
D. sensitivity

52. In a diesel engine which uses a continuous pressure pump, the fuel is introduced into the combustion chamber of the cylinder

A. hydraulically
B. mechanically
C. pneumatically
D. unit injector

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 rack
B. sensitive band
C. compensating spring
D. 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
B. sensitive band
C. dead band
D. isochronous

56. The part of the hydraulic governor which actuates the fuel racks controlling the flow of fuel to the engine is the

A. speed sensitive section
B. power section
C. compensating section
D. dashpot

57. In solving for the I.H.P. developed in the cylinder the indicator card is used to determine the

A. compression pressure
B. firing pressure
C. mean effective pressure
D. 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. 200^0 **B.** 280^0 C. 220^0 D. 230^0

59. For maximum efficiency the speed of impulse blades of steam turbine varies

A. directly as the steam speed
B. one-fourth the steam speed
C. one half of 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 trap
B. inverted bucket type trap
C. live steam separator
D. 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
B. I, II and III
C. I, II and IV
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
B. I, II, III
C. II, III
D. I, III

64. What is the purpose of a converging-diverging nozzle

A. all of these
B. to lessen the critical pressure
C. to control turbulence
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 point
B. condensation point
C. vaporation point
D. 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

A. drooping
B. surging
C. turbulence
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
B. adiabatic
C. entropy
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
B. evaporating
C. heating
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
B. isometric
C. isentropic
D. isothermal

75. 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

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
B. ear mufflers
C. silencers
D. head mufflers

78. What do you call the instrument that measure the radial position of the crankshaft or rotor shaft?

A. bridge gauge
B. spirit level gauge
C. shafting 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 incfease 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

A. enthalpy value
B. thermal value
C. calorific 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
B. pure steam
C. wet 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
B. I, III and IV
C. I, II 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
B. water jacket
C. pump
D. radiator

86. The fusible plugs used in fire-tube auxiliary boilers are installed in the

A. end bell
B. furnace
C. stay tube
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

A. II, III and IV
B. I, II and IV
C. I, III and IV
D. I, 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

90. Labyrinth seals, used to reduce leakage around a turbine shaft, are constructed 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
B. I and II
C. II and III
D. I, II and III

92. In which lube oil line should you expect to find an illuminated sight glass (bull's eye)?

A. Lube oil pump discharge
B. Gravity tank overflow
C. Lube oil pump suction
D. 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

A. septic tank
B. service tank
C. settling 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
B. work
C. rotation
D. stress

96. Boiler horsepower is equivalent to

A. 33,000 ft. lb.
B. 33,475 BTUper hour
C. 30,000 BTU per 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
B. throttling calorimeter
C. pneumercator
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

A. dew point
B. moisture point
C. vaporation point
D. melting point

100. Absolute pressure is accurately indicated by

A. Bourdon gauge
B. mechanical gauge
C. manometer
D. barometer

101. The overspeed trip device installed on a auxilliary turbine is actuated by:

A. spring force
B. back pressure
C. centrifugal force
D. hydraulic force

102. Which of the following fuel injection pump are used for constant speed machines such as electrical generators?

A. common rail
B. constant stroke pump
C. variable stroke pump
D. mechanical system

103. The logical firing sequence for a 6-cylinder 4-cycle right hand rotation

A. 1-4-2-5-3-6
B. 1-5-3-6-2-4
C. 1-6-2-5-3-4
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

105. An instrument used to measure the contents of a tank in which it is not convenient to use a glass gauge or sounding rod is

A. balance chamber
B. tank gauge
C. depth gauge
D. pneumercator

Part IV

REFRIGERATION
and
AIRCONDITIONING MACHINERY

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

		CHEMICAL SYMBOL	BP at Atmospheric	Freezing Point
1.	Ammonia	NH_3	-28.0 °F	-107.9 °F
2.	Carbon Dioxide	CO_2	-109.3 °F	-69.9 °F
3.	ETHYL CHLORIDE	C_2H_5CL	+54.5 °F	-218.0 °F
4.	FREON 12	CCL_2F_2	-21.6 °F	-252.0 °F
5.	FREON 22	$CHCLF_2$	-41.4 °F	-256. °F
6.	ISOBUTANE	$(CH_3)_3$ CH	+10.3 °F	-229.0 °F
7.	METHYL CHLORIDE	CH_3CL	-10.8 °F	-144.0 °F
8.	SULFUR DIOXIDE	S02	+14.0 °F	-104.0 °F

A. Characteristic of Freon 12 (CCL_2F_2)

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_3)

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_2)

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.

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

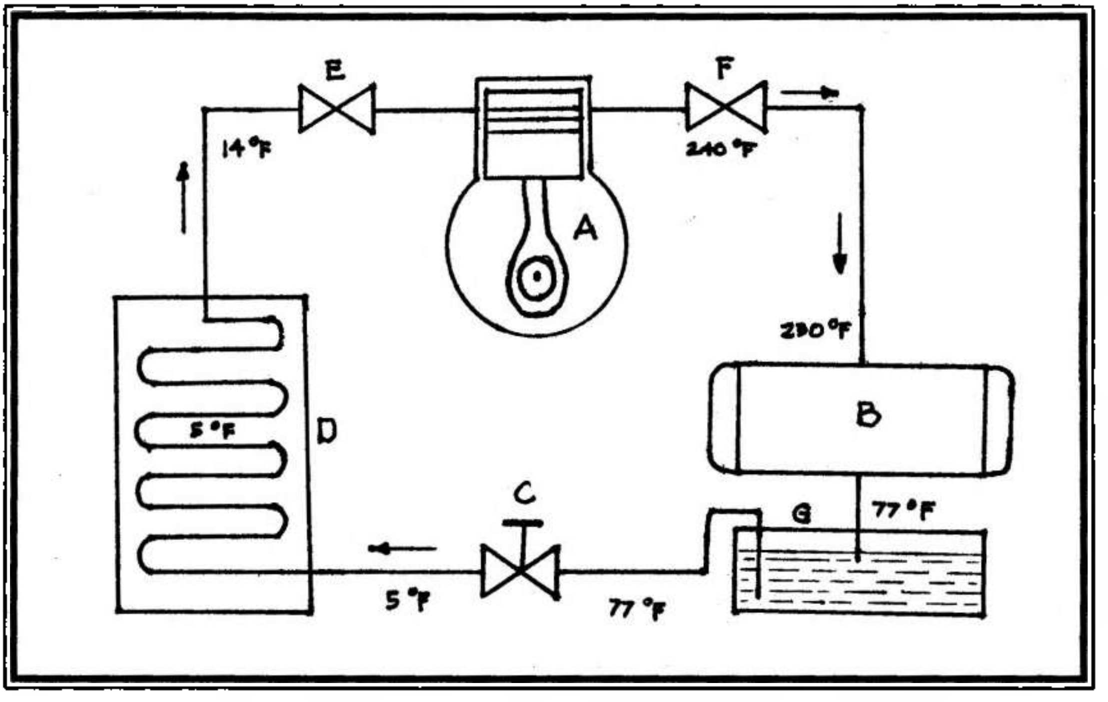
2. **Compression System of Refrigeration** – usually used three refrigerants on merchant ship like Freon, ammonia and carbon dioxide, and the method of expansion system can be divided in two category either direct or indirect.

   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.

Difference between Direct and Indirect System of Refrigeration

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.

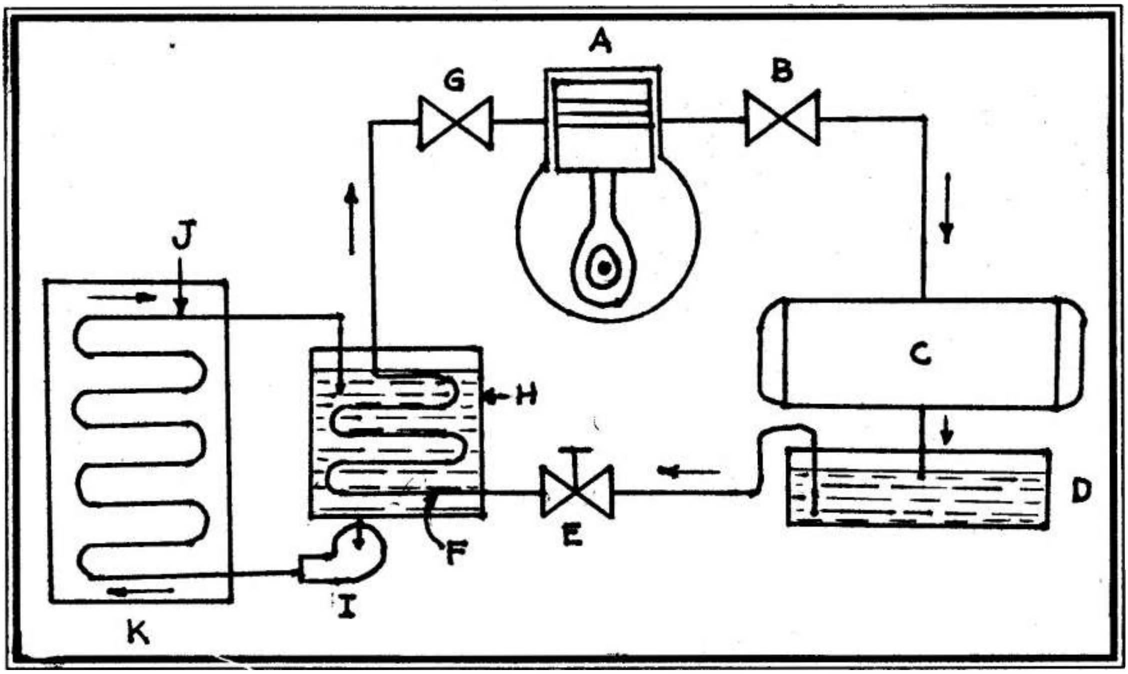
Indirect expansion system - the refrigerant is evaporated into the coils of the evaporator, which are in a brine tank, thus the brine secondary refrigerant is circulated to the coil of the cold storage chamber to do the cooling instead the coil with the refrigerant inside.



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



INDIRECT SYSTEM OF REFRIGERATION

A. Compressor	F. Evaporator coils
B. Discharge valve	G. Suction valve
C. Condenser	H. Brine cooler
D. Liquid Receiver	I Brine Pump
E. Expansion valve	J. Cooling coils
K. Cold storage room	

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 witha 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 VALUES - 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, bellow** 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.

What are the Refrigeration System accessories?

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 moisture 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 chemical 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.

   LOCATION: At the liquid line between receiver and the expansion valve, made of glass tube or glass window in the refrigerating mechanism

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.

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.

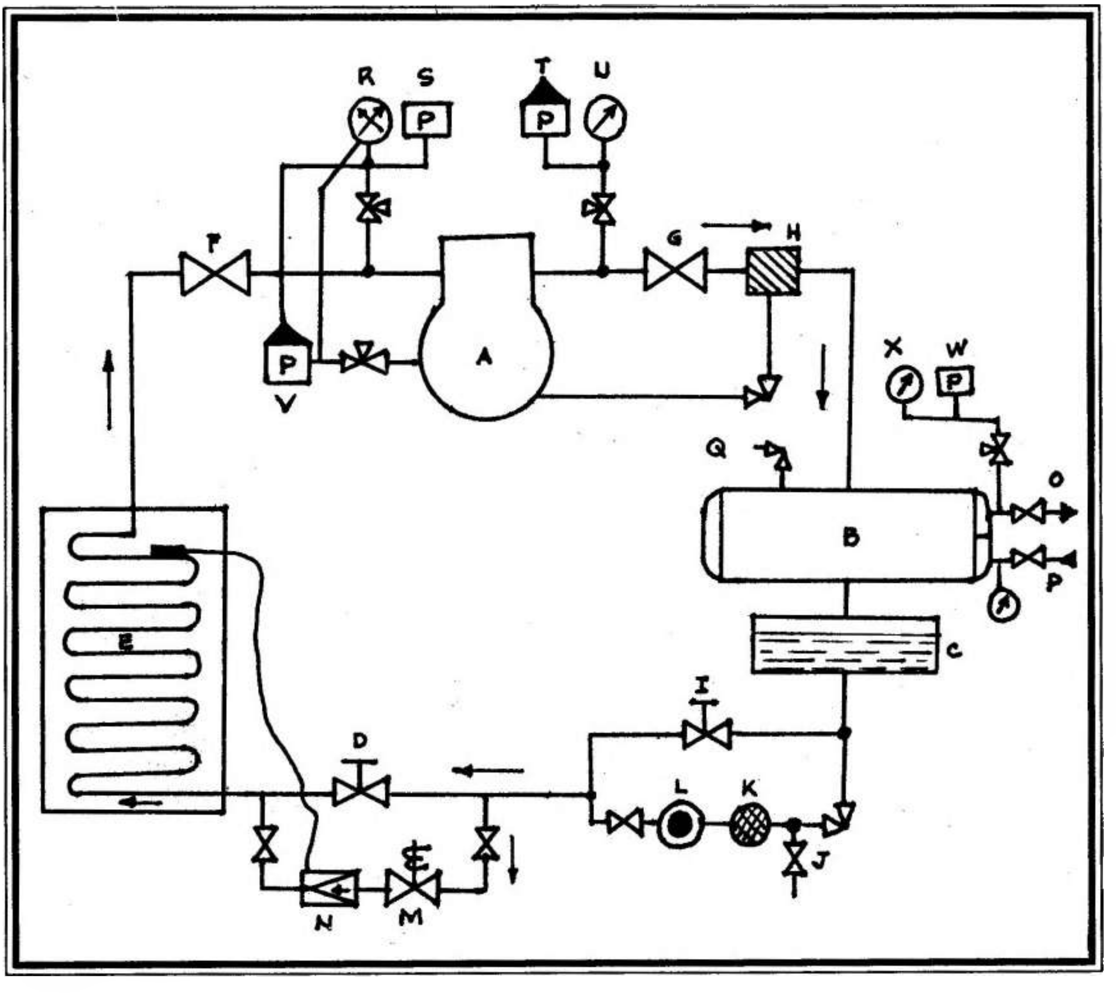
b. LOW-PRESSURE CUTOUT SWITCH - fitted on suction side of compressor, opened the contact when the pressure fall below a set point also prevent the suction prevent from falling to a point where damage occur due to low temperature such as freezing. It also a device to stop the compressor when pressure & 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 vapo absorbing the heat that was remove from the refrigerated area by the cooli which is water.

COMPRESSION RATIO - ratio of the volume of the clearance space to the of the cylinder. In refrigeration used as the ratio of the absolute low-s 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.

OPERATION AND MAINTENANCE

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 valve of the compressor slightly until evaporator pressure is pumped down to about 20 PSI, then open it full.
5. Open the liquid valve and adjust the expansion valve to give the desired suction pressure.

STOPPING

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 valve or king valve 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 ше 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 valve to the refrigerating machine discharge valve.

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

Trouble shooting chart for reciprocating compressors

Fault due to:

1. No current – main switch not coupled in
2. Fuses burnt out – loose electrical connection
3. Electrical voltage too low
4. No pilot current
5. Over current relay open – reset
6. Pilot current circuit open
7. Pumps/fans not started
8. Welded contacts in the motor protection
9. High-pressure pressure switch cut-out – reset
10. Low-pressure pressure switch cut-out – reset
11. Low-pressure pressure switch differential too small
12. Oil pressure pressure switch cut-out – reset
13. Capacity regulator incorrectly set
14. Defrost timer causes power cut-out
15. Insufficient oil charge
16. Excessive compressor capacity during start-up
17. Insufficient oil pressure – adjust oil pressure regulating valve
18. Oil in the crankcase foaming

Observed fault					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Compressor	1	1.2.1	Compressor will not start	1	*	*	*	*	*	*	*		*	*		*		*				
		1.2.2	Compressor starts and stops frequently	2										*	*		*					
		1.2.3	Compressor starts, but stops immediately afterwards	3			*		*	*			*	*	*	*	*	*	*		*	*
		1.2.4	Compressor runs continuously	4								*										
		1.2.5	Abnormally noisy compressor	5																	*	*
		1.2.6	Insufficient compressor capacity	6													*		*		*	*
		1.3.1	Liquid hammer (slug) in the compressor during start-up	7																*		*
		1.3.2	Liquid hammer (slug) in the compressor during operation	8																		
Pressure	2	2.2.1	Excessive discharge pressure	9									*									
		2.3.1	Insufficient discharge pressure	10																		
		2.4.1	Excessive suction pressure	11													*				*	
		2.5.1	Insufficient suction pressure	12											*		*					
Temperature	3	3.2.1	Excessive discharge pipe temperature	13											*							
		3.2.2	Discharge pipe temperature too low	14																		
		3.3.0	Oil temperature too high	15																		
Oil	4	4.2.1	Oil level in the crankcase falls	16																*		*
		4.2.2	Oil in the crankcase foaming intensely	17																*		
		4.2.3	Insufficient oil pressure	18												*			*		*	*
		4.2.4	Sweating or frozen crankcase	19																*		*
Misc.			Bubbles in the liquid sight glass	20																*		
			Low refrigerant level in the receiver	21																		
			Impossible to evacuate the plant	22										*								
			Capacity regulator hunting	23													*		*	*	*	*
Check-points when starting-up					Electrical supply			Electrical connections					Automatic controls						Oil (4)			

																				*					19	Excessive oil charge
									*				*												20	Poor oil return – oil in the evaporators
Refrigerant	5				*							*	*				*		*		*		*		21	Limited supply of refrigerant
				*	*							*	*		*				*		*		*		22	Insufficient refrigerant charge
					*							*	*				*		*				*		23	Refrigerant vapour in the liquid line
				*															*		*		*		24	Leaky refrigeration plant
																*									25	Excessive refrigerant charge
						*	*	*	*		*			*			*	*		*					26	Liquid in the suction line
				*																					27	The degree of filling in the evaporator rises at low operating temperature
Condenser	6											*				*									28	Insufficient cooling water/air to the condenser
												*				*									29	Temperature of the cooling water/air too high
												*				*									30	Non–condensable gases in the condenser
												*				*									31	Condenser should be cleaned
											*		*		*				*				*		32	Too much cooling water/air in the condenser
										*		*				*									33	Water valve out of operation
Expansion valve	7									*		*		*					*				*		34	Expansion valve external equalizing closed
										*		*	*						*				*		35	Expansion valve is partially blocked by ice, dirt or wax
										*		*	*						*				*		36	Expansion valve has lost its charge
						*				*		*	*				*	*	*				*		37	Expansion valve sensor incorrectly placed
																		*							38	Leaky expansion valve
						*		*			*			*			*	*							39	Expansion valve gives insufficient superheat
										*		*	*						*				*		40	Expansion valve gives excessive superheat
Miscellaneous					*							*	*						*		*	*	*		41	Filters in liquid/suction line clogged
													*									*			42	Solenoid valve in liquid/suction line closed
			*		*																		*		43	Leaky solenoid valve
													*					*	*				*		44	Evaporator frozen or clogged
													*						*						45	Cooling air recirculates (shorted)
					*							*							*		*				46	Plant load too high
				*																					47	Refrigerant collects in cold condenser (close by–pass)
																				*					48	Coupling misaligned or loose
Compressor		*					*												*	*		*			49	Defective oil pumps
							*			*									*	*		*			50	Bearings worn or defective
			*						*						*				*	*			*		51	Defective piston rings or worn cylinder
			*							*		*		*	*				*	*	*		*		52	Discharge valves defective or leaky
			*											*					*	*	*				53	Suction valves defective or leaky
			*									*		*	*					*			*		54	Compressor by–pass open – leaky safety valve
		*					*															*			55	Compressor oil filter clogged
		*											*	*				*	*	*	*		*		56	Defective capacity regulator
		*			*	*		*	*									*							57	Excessive compressor capacity during start–up
									*											*					58	Solenoid valve in oil return clogged/faulty
									*																59	Filter in oil return clogged
					*								*										*		60	Compressor capacity too large
			*											*	*				*		*				61	Compressor capacity too small
								*										*				*			62	Heating element in crankcase defective

TROUBLESHOOTER'S GUIDE TO REFRIGERATION PROBLEMS

Symptoms	Probable Cause	Recommended Action
Trouble: Compressor "Short-Cycles"		
1. Normal operation except too frequent stopping and starting	1. Intermittent contact in electrical control circuit	1. Repair or replace faulty electrical control
2. Normal operation except too frequent stopping and starting	2. Low-pressure controller differential set too close	2. Reset differential in accordance with proper job conditions
3. Valve may hiss when closed. Also temperature change in refrigerant line through valve	3. Leaky liquid line solenoid valve	3. Repair or replace
4. Reduced airflow a. Dirty air filters b. Broken fan belt c. Fan belt tension improperly adjusted	4. Dirty or iced evaporator	4. Clean or defrost evaporator. Check filters and fan drive
5. Excessively high discharge pressure	5. Faulty condensing	5. Check for water failure or evaporative condenser trouble
6. High discharge pressure	6. Overcharge of refrigerant or noncondensable gas	6. Remove excess refrigerant or purge noncondensable gas
7. Normal operation except too frequent stopping and starting on low-pressure control switch	7. Lack of refrigerant	7. Repair refrigerant leak and recharge
8. High discharge pressure	8. Water-regulating valve inoperative or restricted by dirt, or water temperature too high	8. Clean or repair water valve
9. High discharge pressure	9. Water piping restricted or supply water pressure 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 rapidly	11. Faulty motor	11. Repair or replace motor
12. Compressor cuts off on high pressure cutout	12. Fouled shell-and-tube condenser	12. Clean condenser tubes
13. Compressor cuts off on high pressure cutout a. No water b. Spray nozzles	13. Faulty operation of evaporative condenser	13. Determine cause and correct 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		nozzles c. Repair faulty pump d. Clean coil e. Remove obstruction f. Repair

Trouble: Compressor Runs Continuously

1. High temperature in conditioned area	1. Excessive load	1. Check for excessive fresh air or infiltration. Check for inadequate insulation of space
2. Low temperature in conditioned area	2. Thermostat controlling at too low a temperature	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. Bubbles in sightglass	4. Lack of refrigerant	4. Repair leak and charge
5. High discharge pressure	5. Overcharge of refrigerant	5. Purge or remove excess
6. Compressor noisy or operating at abnormally low discharge pressure or abnormally high suction pressure	6. Leaky valves in compressor	6. Overhaul compressor
7. Air-conditioned space too cold	7. Solenoid stop valve stuck open or held open by manual lift stem	7. Repair valve or restore to automatic operation

Trouble: Compressor Loses Oil

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 suction. Noisy compressor operation	4. Liquid flooding back to compressor	4. Readjust superheat setting or check remote bulb contact
5. Too frequent starting and stopping of compressor	5. Short cycling	5. Defrost; check pressure cutout
6. Oil around compressor base and low crankcase 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 compressor broken	4. Overhaul compressor
5. Abnormally cold suction 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 evaporator 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 chamber ahead of valve
7. Abnormally cold suction 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 compressor hold-down bolts
Trouble: System Short of Capacity		
1. Expansion valve hisses	1. Flash gas in liquid line	1. Add refrigerant
2. Temperature change in refrigerant line through strainer or solenoid stop valve	2. Clogged strainer or solenoid stop valve	2. Clean or replace
3. Reduced airflow	3. Ice or dirt on evaporator	3. Clean coil or defrost
4. Short-cycling or continuous 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 superheat and reset thermostatic expansion valve
7. Short-cycling or continuous running	7. Expansion valve improperly 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 excessive discharge pressure	4. Air or non-condensable gas in system	4. Purge
5. Exceptionally hot condenser and excessive discharge pressure	5. Overcharge of refrigerant	5. Remove excess or purge

Trouble: Discharge Pressure Too Low

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 compressor discharge valves	3. Remove head, examine valves, replace faulty ones
4. Low discharge pressure and high suction pressure	4. Leaky relief bypass valve	4. Inspect valve to determine 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 suction line. Liquid flooding to compressor	2. Overfeeding of expansion valve	2. Regulate superheat setting expansion valve, see remote bulb OK on suction line
3. Abnormally cold suction line. Liquid flooding to compressor	3. Expansion valve stuck open	3. Repair or replace valve
4. Abnormally cold suction line. Liquid flooding 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

		charge system
2. Compressor short-cycles	2. Light load on evaporator	2. Not enough refrigerant
3. Temp. change in refrigerant 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 evaporator	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 valve 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.

TROUBLESHOOTER'S GUIDE TO CENTRIFUGAL PUMP PROBLEMS

Symptom	Probable Cause
B. Pump does not deliver rated capacity	1. Wrong direction of rotation. 2. Suction line not filled with liquid. 3. Air or vapor in suction line. 4. Air leaks in suction line or through stuffing boxes. 5. Suction-line intake not submerged enough. 6. Available NPSH not sufficient. 7. Height from liquid level to centerline of pump too great. 8. Distance from suction-well liquid level to centerline of pump too small. 9. Difference between suction pressure and vapor pressure too small. 10. Pump not up to rated r/min. 11. Total head greater than head for which pump was designed.

	12. Foot valve too small. 13. Foot valve clogged with trash. 14. Viscosity of liquid greater than that for which pump was designed. 15. Mechanical defects such as wearing rings worn, impeller damaged, or internal leaks caused by defective gaskets.
C. Pump's discharge pressure low	1. Gas or vapor in liquid. 2. Pump not up to rated r/min. 3. Greater discharge pressure needed than that for which pump was designed. 4. Liquid thicker than that for which pump was designed. 5. Wrong rotation. 6. Mechanical defects such as wearing rings worn, impeller damaged, or internal leaks caused by defective gaskets.
D. Stuffing boxes overheat	1. Packing too tight. 2. Packing not lubricated. 3. Wrong grade of packing. 4. Not enough cooling water to jackets. 5. Stuffing box improperly packed.
E. Pump loses prime after starting	1. Suction line not filled with liquid. 2. Air leaks in suction line or through stuffing boxes. 3. Gas or vapor in liquid. 4. Air or vapor pockets in suction line. 5. Available NPSH not high enough. 6. Inlet to suction line not submerged far enough. 7. Height from liquid level to centerline of pump too great. 8. Distance from suction-well liquid level to centerline of pump too small. 9. Difference between suction and vapor pressure too small. 10. Liquid seal piping to lantern ring plugged. 11. Lantern ring not properly placed in stuffing box.
F. Pump overloads drive	1. R/min too great. 2. Total head lower than rated head. 3. Either the specific gravity or viscosity of liquid or both different from that for which pump is rated. 4. Mechanical defects such as misalignment, shaft bent, rotating element dragging, or packing too tight.
G. Vibration	1. 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. 2. Misalignment.

	3. Worn or loose bearings. 4. Rotor out of balance, because of the impeller being plugged or damaged. 5. Shaft bent. 6. Control valve in discharge line improperly placed. 7. Foundation not rigid.
H. Bearings overheat	1. Oil level too low. 2. Improper or poor grade of oil. 3. Dirt in bearings. 4. Dirt in oil. 5. Moisture in oil. 6. Oil cooler clogged or scaled. 7. Various failures of oiling system. 8. Not enough cooling water. 9. Bearings too tight. 10. Oil seals fitted too closely on shaft. 11. Misalignment.
I. Bearings wear rapidly	1. Misalignment. 2. Shaft bent. 3. Vibration. 4. Excessive thrust resulting from mechanical failure inside the pump. 5. Lack of lubrication. 6. Bearings improperly installed. 7. Dirt in bearings. 8. Moisture in oil. 9. Excessive cooling of bearings.

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 = 2544 Btu per hour

$$1 \text{ brake horsepower} = \frac{2544}{100,000} = 0.02544 \text{ therm-hour}$$

$$1 \text{ therm-hour} = \frac{100,000}{2544} = 39.3082 \text{ brake horsepower}$$

(40 hp is close enough)

$$1 \text{ therm-hour} = \frac{100,000}{33,475} = 2.9873 \text{ boiler horsepower}$$

(3 hp is close enough)

Example: How many therm-hours in a 100-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:

$$H = WS\,(t_2 - t_1)$$
$$= 200 \times 0.64 \times (82 - 40)$$
$$= 200 \times 0.64 \times 42$$
$$= 5376 \text{ BTU of heat required.}$$

Q. What horsepower is needed to raise 3000 gallon of water to a height of 100 ft?

SOLUTION:

$$3000 \text{ gal.} \times 8.33 \frac{\text{lb.}}{1 \text{ gal.}} = 24{,}990 \text{ lbs.}$$

Pumping for 1 hour $24{,}990 \div 60 = 416.5$ lb/min.

416.5×100 ft. $= 41{,}650$ ft. lb./min.

Therefore: $\dfrac{41{,}650}{33{,}000} = 1.26$ 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:

$$hp = \frac{\text{gal./min.} \times \text{S.G.} \times \text{head}}{3960 \times \text{Eff.}}$$
$$= \frac{250 \times 1 \times 70}{3960 \times 0.65}$$
$$= \frac{17{,}500}{2574}$$
$$= 6.8 \text{ HP}$$

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:

$$Kw = \frac{\text{gal./min.} \times \text{Sp. gr.} \times \text{head}}{5308 \times Ep \times Em}$$
$$= \frac{250 \times 1 \times 100}{5308 \times 0.50 \times 0.80}$$
$$= \frac{25000}{2123.2}$$
$$= 11.775 \text{ Kw.}$$

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
= $\frac{1{,}386{,}000 \text{ BTU/day}}{288{,}000 \text{ BTU/day/tons}}$
= 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 x 100 x 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 cm = 1.97 inch   1728 cu. in. = 1 cu. ft.
stroke 5 cm = 1.97 inch

$$Vd = \frac{\text{Area} \times L \times N \times Xn}{1728}$$

$$= \frac{0.7854 \times (1.97)^2 \times 1.97 \times 1500 \times 2}{1728}$$

= 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:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

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?

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

Output = input x Efficiency
= 8.376 x 0.76
= 6.366 Kw.

BOARD QUESTIONS

Fourth Engineer May July 1992

Refrigeration and Airconditioning Machinery

1. The process of changing a solid to a liquid is called the latent heat of

   A. Vaporization
   B. Evaporation
   C. Fusion
   D. Condensation

2. The purpose of the evaporator is to:

   A. Transmit latent heat of fusion
   B. Transmit latent heat of evaporation
   C. Absorb latent heat of fusion
   D. Absorb latent heat of evaporation

3. Which of the following would give the most trouble when operating with hot condenser:

   A. Freon - 12
   B. Ammonia
   C. CO_2
   D. Methyl Chloride

4. A liquid receiver is used to:

   A. Separate the oil from the refrigerant
   B. Cool the hot gases
   C. Store the refrigerant
   D. Receive the refrigerant on charging

5. The heat used to change a liquid to a gas is called latent heat of:

   A. Fusion B. Vaporization C. Absorption D. Liquid

6. A refrigerant gives up heat when it

   A. Evaporates B. Condenses C. Vaporizes D. Boils

7. When securing a system, the first step would be to:

   A. Close king valve
   B. Open Solenoid Valve
   C. Close compressor high pressure valve
   D. Open by pass valve

8. The lowest temperature of the system refrigerant is at the

   A. Evaporator
   B. Condenser
   C. Receiver
   D. Expansion valve outlet

9. Moisture in a vapor compression system will cause:

   A. High suction temperature
   B. High suction pressure
   C. Faulty Expansion valve
   D. Low discharge temperature

10. A thermostat expansion valve can be tested by:

    A. Holding its bulb in ones hand
    B. Immersing its tube in hot water
    C. Immersing its bulb in ice water
    D. Shorting out the cut-out switch

11. Primary reason for use of compressor in a vapor compression system:

A. To compress refrigerant gas
B. To save the expanded liquid so that it can be reused many times
C. Raise the temperature of the gas
D. As principal part of the system

12. Ambient temperature means

A. Temperature of the body
B. Temperature of air in a space
C. Temperature of machinery
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 compressor
B. 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:

A. Wet and dry
B. Dry and flooded
C. Finned and tube
D. Short and extended

18. The most practical material used as evaporator of ammonia system is:

A. Copper
B. Copper alloy
C. Steel
D. Brass

19. Test for leak for system containing methyl chloride:

A. Ammonia swab test
B. Soap and water test
C. Halide torch
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

A. Bottom to top C. Bottom to bottom
B. Top to bottom 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
B. Temperature of air in a space
C. Temperature of compressed gas
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
C. high suction temperature
D. faulty expansion valve

35. Zinc rods are found in the:

A. salt water side of the condenser
B. evaporator area
C. compressor crankcase
D. gas side of the condenser

THIRD ENGINEER *May-July 1992*

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
B. 2-ton compressor
C. 4-ton compressor
D. 6 ton compressor

5. The actual refrigeraing 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

6. To handle 144,000 BTU load of cooling, if the cooling is to be done in 12 hours, you will need:

A. 2-ton compressor
B. 1-ton compressor
C. 3-ton compressor
D. 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
B. Leak tracing eye
C. Ammonia swab test
D. Sulphur candle 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
B. Dry and flooded
C. Prime surface and extended
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
B. pressure and bellows control
C. Bellows control
D. temperature & spring control

13. Excess refrigerant is removed from the:

A. discharge side of compressor
B. suction side of the system
C. condenser vent
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

16. Excess frost on the evaporator coils

A. Keep ice box cooler
B. does not affect the system
C. Lessen load on compressor
D. reduce efficiency of the plant

17. The suction pressure switch is operated by

A. Electric current
B. Pressure on a bellow
C. Cut-out relay
D. Thermocouple

18. If frost forms on the cylinders, the cause would be:

A. leaky compressor discharge valve
B. leaky compressor suction valve
C. expansion valve open too wide
D. dehydrator-drier clogged

19. How is the CO2 system purged?

A. The same as the ammonia system
B. The same as the freon system
C. with a vacuum pump
D. temperature of compressed gas

20. Ambient temperature means

A. temperature of the body
B. temperature of air in space
C. temperature of machinery
D. 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

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
B. Automatic expansion valve
C. Thermostatic Expansion valve
D. Simple valve

24. The most widely used refrigerant, it is completely safe non-toxic, non-flammable and non-explosive.

A. Sulfur dioxide B. Carbon dioxide C. Ammonia D. Freon 12

25. Name of the two methods of exercising the proper control of temperature in the refrigeration and which are well known.

A. thermostat control
B. low pressure control
C. electronic control
D. both A and B

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

A. sodium chloride
B. potassium chloride
C. calcium 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
B. Diaphragm type
C. Bourdon 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
C. gas side of the condenser
D. evaporator area

37. It expands the high pressure liquid to a mixture of low pressure liquid and gas particles.

A. condenser
B. evaporator
C. expansion valve
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

A. compressor
B. high pressure area
C. low pressure area
D. 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

1. What takes the place of the suction stroke of the compressor in an absorption system of refrigeration?

   A. Absorber
   B. Generator
   C. Liquefier
   D. Refrigerant pump

2. What is the absorber in the aqua-ammonia absorption system of refrigeration?

   A. Water
   B. Bromide
   C. Ammonia
   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:

   A. wet and dry
   B. finned and tube
   C. short and extended
   D. dry and flooded

5. Temperature ranges used in the preservation and storage of perishable foods for consumption:

   A +28°F to +40°F
   B. -10°F to -15°F
   C. -20°F to 30°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
   B. Lack of refrigeration
   C. Lack of condenser
   D. Dirty expansion valve

8. Trouble of system: Suction pressure too low
Symptom: Too high superheat
Cause:

A. Clogged liquid line strainer
B. Expansion valve too small
C. Too much pressure drop through evaporator
D. Light load on evaporator

9. What is the maximum theoretical suction lift of a pump when the mercury barometer reads 28 inches?

A. 33 feet B. 32.5 feet C. 28 feet D. 31.6 feet

10. Test for leak for system containing sulphur dioxide:

A. Halide torch
B. Leak tracing dye
C. ammonia swab test
D. sulphur candle test

11. Cylinder water jacket cooling is used on

A. Ammonia compressors
B. Methyl chloride compressors
C. Propane compressors
D. Butane compressors

12. General types of solenoid valves:

A. Vertical and horizontal
B. Liquid and vapor
C. Direct-acting and pilot operated
D. Electric and pressure

13. What takes the place of the compression stroke of the compressor in an absorption system?

A. evaporator pump
B. absorber
C. generator
D. condenser pump

14. When removing reusable refrigerant from a system, the line to the storage drum must:

A. be made of copper
B. have no bends in it
C. contain a strainer-dryer
D. be above the level of the compressor

15. Does ammonia have any effect on lubricants?

A. will not have any effect
B. will cause sludging
C. will lower efficiently of the oil
D. 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
B. 4-ton compressor
C. 2-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
B. compressor and condenser
C. condenser and receiver
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
B. it will crystallize
C. nothing will happen
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. -60°F
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. lubricant
D. secondary coolant
C. primary coolant

25. A refrigerating unit of one ton capacity can remove

A. 500 BTU per minute
B. 288 BTU per minute
C. 200 BTU can remove
D. 100 BTU per minute

26. Frost in the high pressure side of a thermostatic expansion valve would probabely be caused by:

A. refrigerator box too cold
B. dirty expansion valve
C. condenser too cold
D. High head pressure

27. High temperature of cylinder heads and crankcase is caused by:

A. noncondensable gases
B. high head pressure
C. insufficient refrigerant
D. too much refrigerant

28. In every refrigeration installation, the cooling effect is produce in the

A. compressor
B. evaporator
C. condenser
D. liquid reservoir

29. If the thermal bulb becomes loose on the evaporator coils, it will cause:

A. an electrical short
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
B. head pressure too high
C. refrigerating compartment too cold
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:

A. less circulating water needed
B. effect of refrigerant increased
C. liquid less likely to vaporize
D. B and C

33. Absolute zero on Fahrenheit scale is:

A. 460° below zero
B. -273.15°C
C. any of these
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
B. electronic control
C. thermostatic control
D. both A and B

35. What is the compression system of refrigeration?

A. It is the system which uses heat energy to make a change in the cond. req. in the 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:

A. open bypass valve
B. open solenoid valve
C. cut compressor on high pressure
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
B. Leaky relief - bypass valve
C. Lack of refrigerant
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-12 compressor will stop when the:

A. Expansion valve closes
B. Expansion valve opens
C. Solenoid valve closes
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 Freon 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 load
B. any of these
C. air in the system
D. 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. Why is high latent heat desirable in a refrigerant?

A. smaller compressors can be used
B. small amount of refrigerant will absorb a large amount of heat
C. will boil at low temperature
D. will allow smaller evaporators

54. What part of the ammonia vapor compression system must the charging connection be hooked up?

A. between compressor and condenser
B. between condenser and condenser
C. between king valve and evaporator
D. between solenoid vlave and drier

55. In a refrigeration system, a fluid that serves only as a heat carrier is called a:

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. When ordering an expansion valve which of the following information is necessary?

A. size and pressure
B. size, tonnage, temperature and pressure
C. pressure and temperature
D. size and tonnage

PART V

SECTION I

PRACTICAL ENGINEER GUIDES

FRESH WATER DISTILLER
AIR COMPRESSOR
PURIFIER
OPERATION AND MAINTENANCE

SECTION II

BOARD QUESTIONS

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

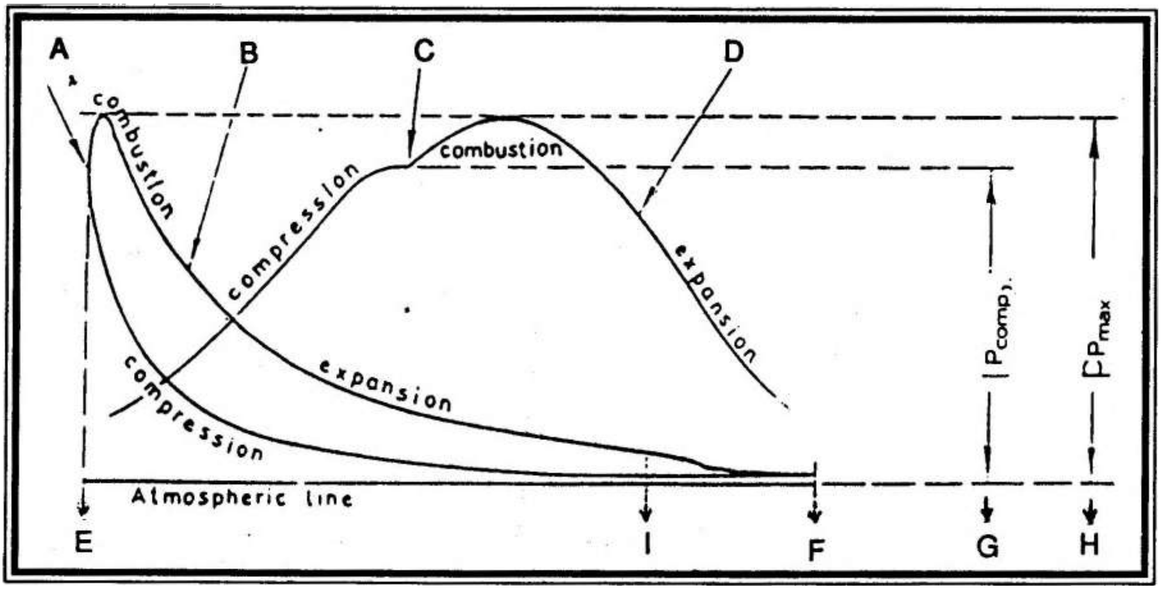
Procedures:

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

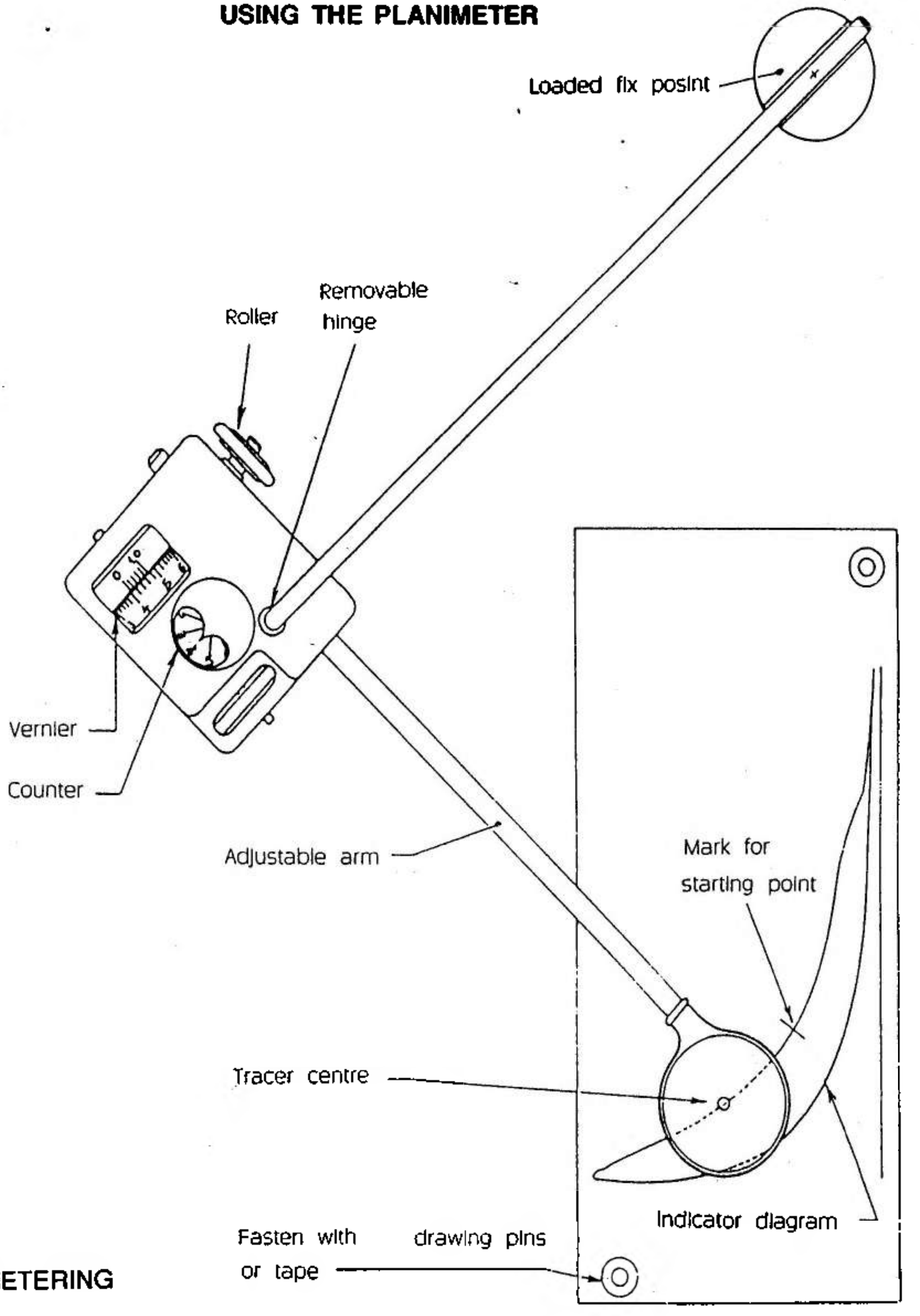
Procedures in taking the diagrams:

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.

USING THE PLANIMETER



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: 6S70MC
BHP : 20,940 at 88 Rpm
TYPE : 2 CYCLE, SUPERLONG STROKE, CROSSHEAD
FIRING ORDER: 1534265 Built: 1991

CYL No.	P-Comp. Kg/cm²	P.Max Kg/cm²	Fuel P. Index	Exhaust Temp.	MEP Kg/cm²	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	335..5	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 cm²
Length of atmospheric line = 7.7 cm
Spring constant = 0.3

FORMULA: $MEP = \frac{Area}{Length} \times \frac{10}{0.3}$

$$= \frac{3.7}{7.7} \times \frac{10}{0.3}$$

$$= 16.02 \text{ kg/cm}^2$$

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

Formula:

$$\text{Cylinder constant} = \frac{.7854\ (\text{cyl. dia})\ (\text{length of stroke})\ (1.02)}{60\ (7500)}$$

$$= \frac{.7854\ (70)\ (70)\ (267.4)\ (1.02)}{60\ (7500)}$$

$$= \frac{1{,}049{,}659.7}{450{,}000}$$

$$\text{Cyl. constant} = 2.332$$

Average Rpm during test at least 1 hour.

$$\text{Ave. Rpm} = \frac{\text{present reading} - \text{previous readings}}{60\ \text{mins.}}$$

$$= \frac{41304210 - 41299110}{60}$$

$$\text{Rpm} = 85$$

Indicated Horsepower each cylinder (No.1)

Formula:

$$\text{IHP} = \text{MEP} \times \text{Cyl. constant} \times \text{Rpm}$$
$$= 16.02 \times 2.332 \times 85$$
$$= 3175.4$$

Actual Brake horsepower

$$\text{BHP} = \text{Total IHP} \times \text{Mech. Efficiency}$$
$$= 19{,}070 \times 94.5\ \%$$
$$= 18{,}021$$

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^3
58.32 x 0.9429 = 54.98 MT

d. Fuel consumption in Grams/BHR-HR.

54.98 MT x 1000 kgs. = 54980 kg/day

$= \dfrac{54980}{24 \text{ hr}} = 2{,}290$ kg/hr.

= 2,290 x 1000 gms/kg. = 2,290,000 gms/HR.

$= \dfrac{2{,}290{,}000}{18{,}021 \text{ BHP}}$

= 127.1 grms./BHP–HR

G. To find cylinder oil consumption: grms/bhp – hr

DATAS:	BHP = 18021	CYL No. = 6
	S.G. = 0.92	1 LTR = 1000 grms.

Time measured in cylinder lubricator pump No. 1

$\dfrac{24.30}{60}$ mins/liter = 24.5 mins.

Therefore: $\dfrac{1 \text{ L } (1000) \times (0.92)}{\left(\dfrac{18021}{6}\right) \times \left(\dfrac{24.5}{60}\right)}$

$= \dfrac{1000 \times 0.92}{3003 \times 0.4083}$

$= \dfrac{920}{1226}$

= 0.750 grms./ bhp-hr

= 2.449 gms/HR x 6 x 24

$= \dfrac{352.656 \text{ gms/day}}{1000 \text{ gm/ltr.}}$

= 352 L/day

H. To find BHP/day base on Consumption:

54.98 MT x 1,000,000 grms/ton

$= \dfrac{54.980.000 \text{ grms.}}{127.1 \times 24}$

$= \dfrac{54.980.000}{3050.4}$

BHP = 18023 approx.

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.

   (-) 5.50 m Frwd.

   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 m³ 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	Vol. 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.						160.29

Computation:

A. HFO Service tank:

Ullage sounding = 310cm = 86.35 m3
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
= <u>.9392</u>

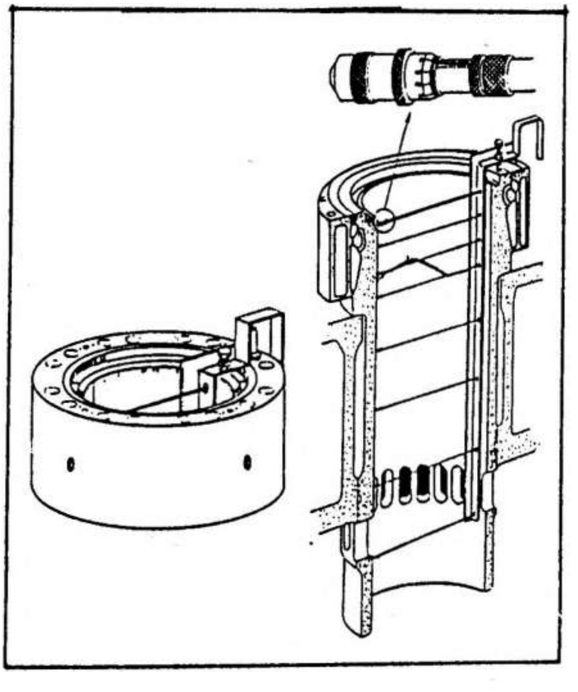
2. *Volume in Metric Tons*

MT = M^3 x Corr. S.G at 85 °C
= 86.35 M^3 x .9392
MT = <u>81.10</u>

3. *Lubricating oil in volume metric ton*

Liters ÷ 1000 = m^3
m^3 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:

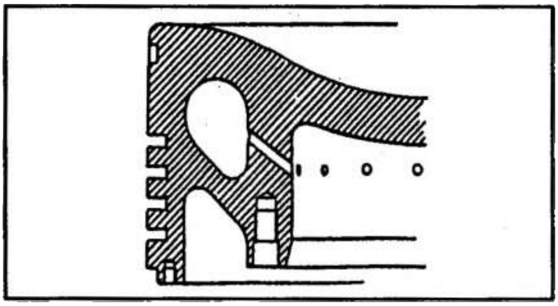
1. Check the condition of the cylinder liner and asses for scratches, micro-seize, wear ridge, carbon deposits.

   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.

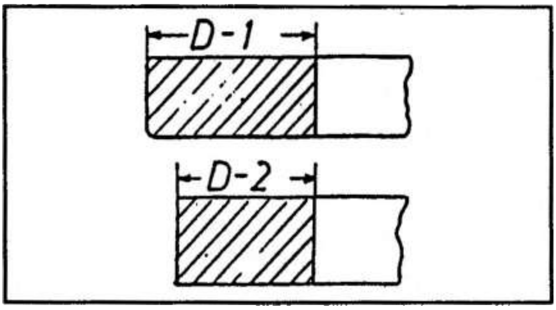
3. Check the lubricating points of the cylinder by manually pumping cylinder oil to each individual lubricating point. Clean any blocked lubricating duct.

CHECKING OF PISTON RINGS – S/L 70MC/MCE

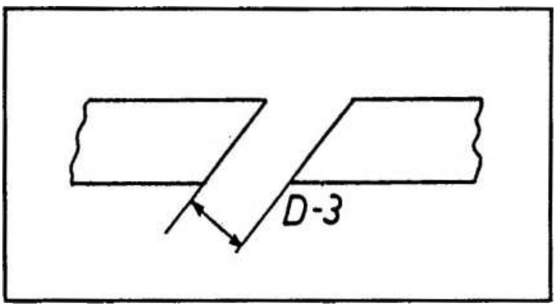


1.

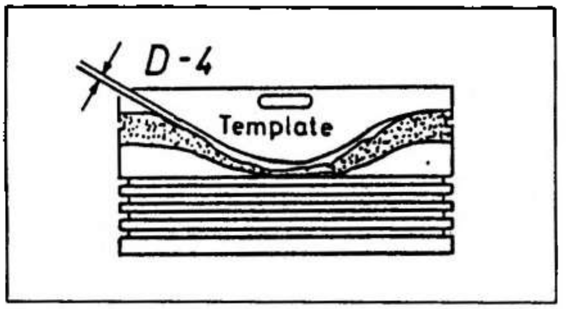
	Nominal Height	Tolerance
Piston ring grooves	12	+0.315 +0.290
Piston ring	12	–0.110 –0.135



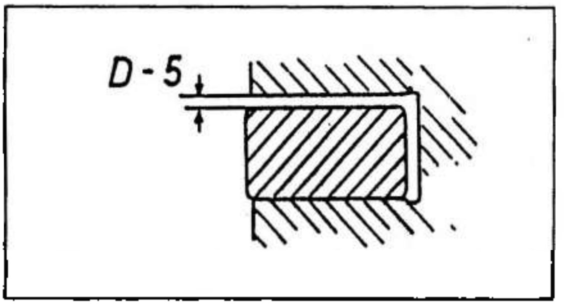
2. Worn rings to be renewed if radial width D-2 is less than 20 mm.
   New piston ring D–1=23 mm.
   Worn piston ring D–2=20 mm.



3. Effect checking of ring gap in new cylinder or at bottom of used liner.
   Minimum ring gap D–3=5 mm.



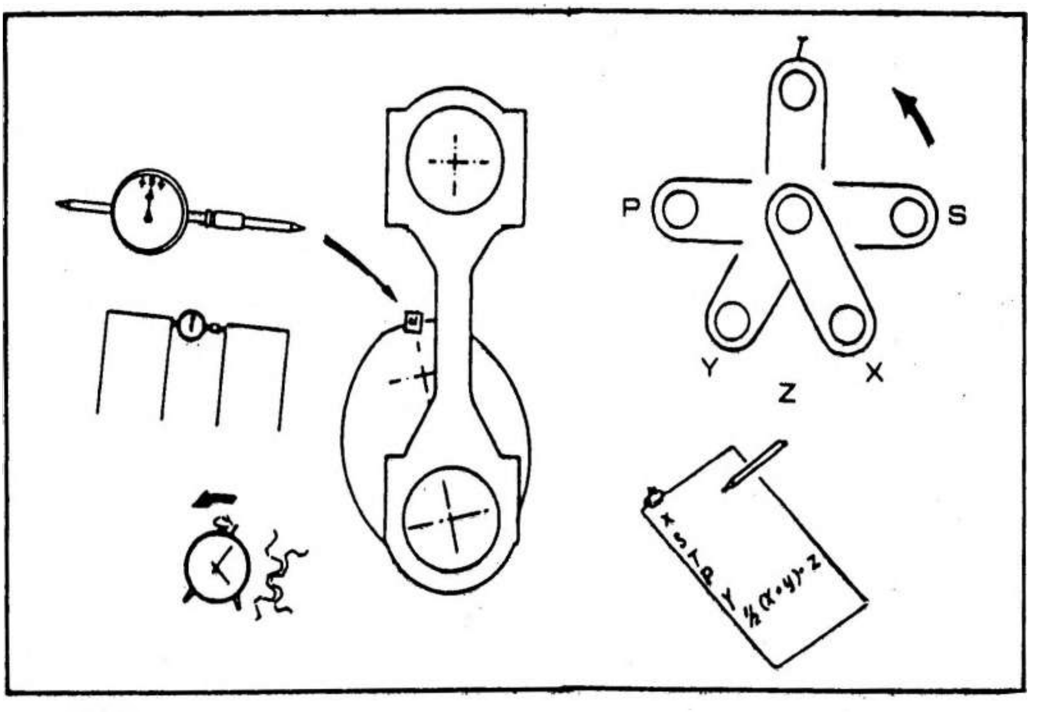
4. Maximum permissible burn-away of piston top D–4=20 mm.



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

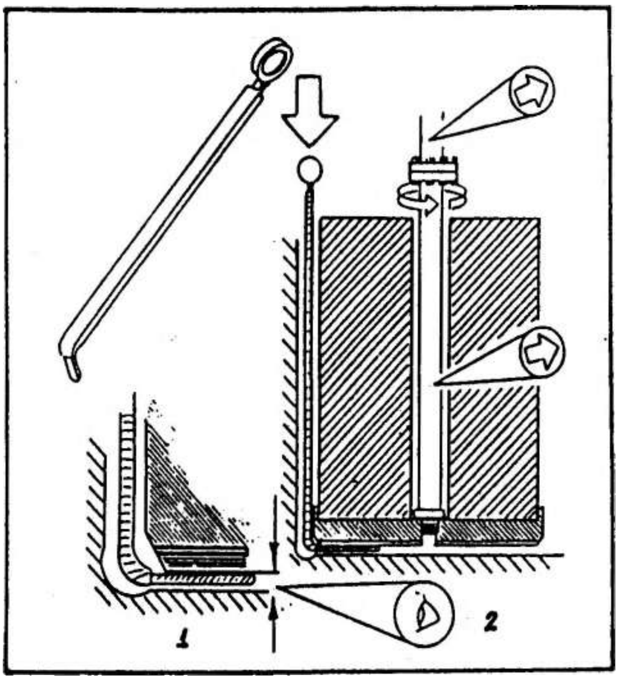
x = Bottom stbd – exhaust side
s = Starboard
p = Port
y = Bottom port – crankshaft side

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

Crank position		Cy1.No. & deflections					
		1	2	3	4	5	6
Near bottom, exhaust side	B_2	0	0	0	0	0	0
Exhaust side	E	6	2	5	4	2	2
Top	T	14	3	8	10	1	3
Camshaft side	C	7	2	5	4	-1	-3
Near bottom, camshaft side	B_1	-1	2	-2	2	-1	-2
Bottom 1/2 (B_1+B_2)		0	1	-1	1	0	-1

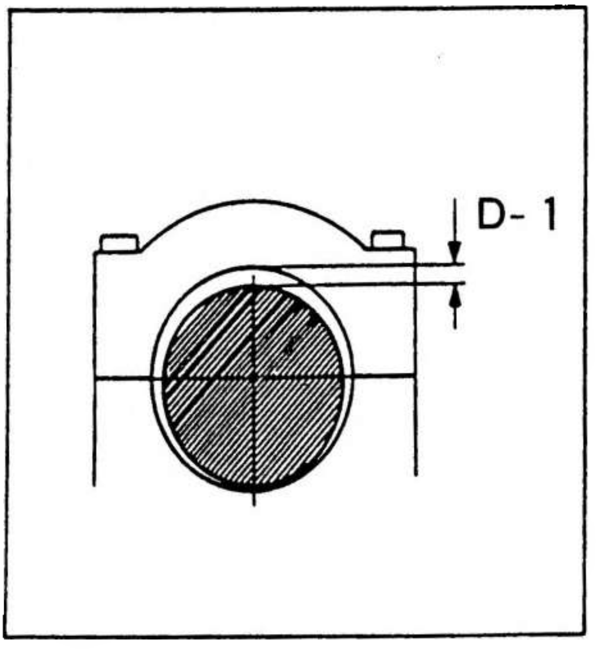
CHECKING CLEARANCE IN MAIN BEARINGS



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

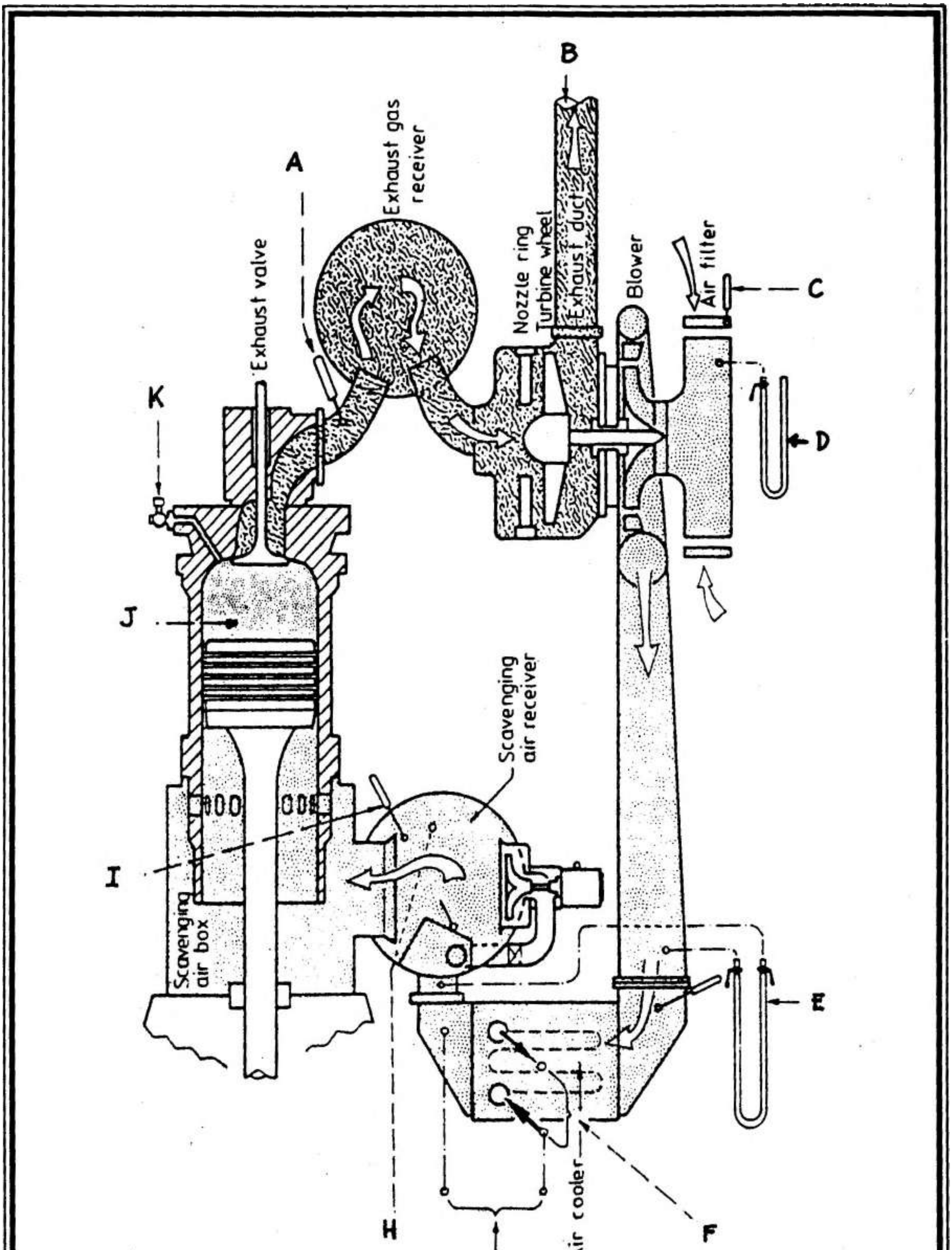


CROSSHEAD BEARING

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 blow-by, 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 combustion to be stopped	Combustion to be stopped (due to faulty exhaust valve)	All reciprocating parts suspended or out	All reciprocating parts out
Some reasons for emergency action	Blow–by at piston rings or exhaust valve. Reduction of load on bearings. Faulty injection equipment	Leaking cylinder cover or liner	Exhaust valve, or exhaust valve actuating gear, malfunction	Quickest and safest measure in the event of faults in large moving 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 with roller guide	Working	Out or lifted	Out or lifted	Out or lifted	Out or lifted
Oil inlet for actuator	Open	Pipe dismantled and blocked	Open	Open	Open
Starting valve	Working	Blanked	Working	Blanked	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

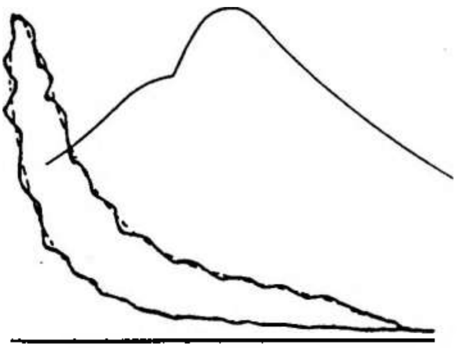


fig. 1. Vibrations in drive.
Draw–diagram not affected.

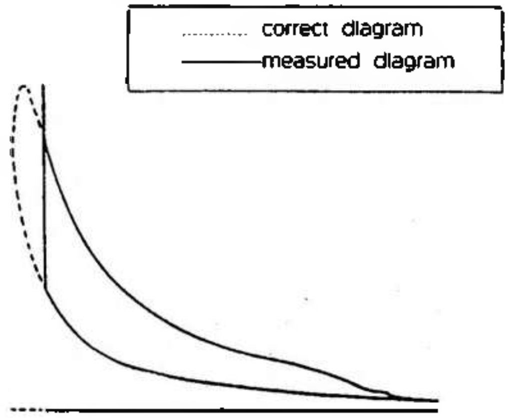


Fig. 2. Lenght of cord too long.
T.D.C.–part missing.

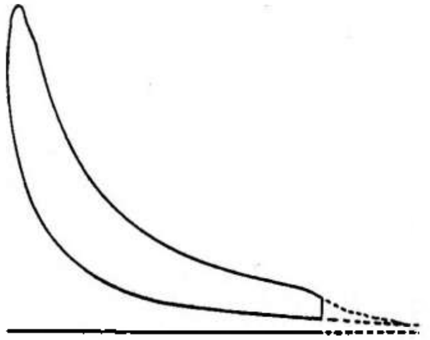


Fig. 3. Length of cord too short..
B.D.C.–part meissing.

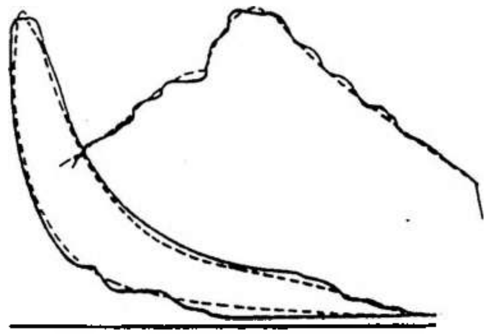


Fig. 4. Friction in indicator piston.
Draw–diagram also affected. This fault gives a too large working diagram area.

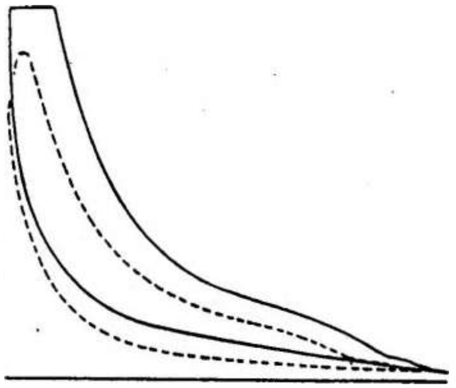


Fig. 5. Spring too weak. Indicator piston top end of cylinder.

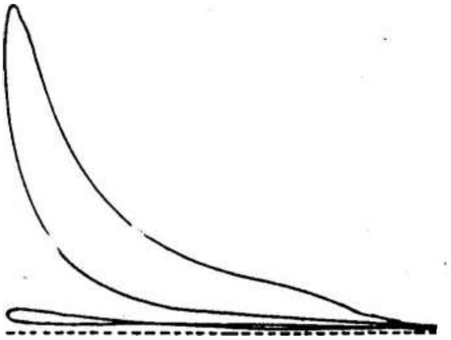
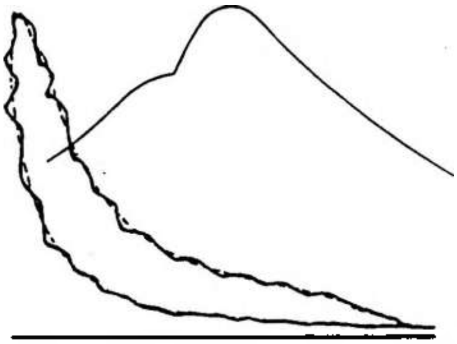


Fig. 6. Indicator cock leaking.
Atmospheric line untrue.

INTERPRETATION OF FAULTY INDICATOR DIAGRAMS

.... correct diagram
———— measured diagram



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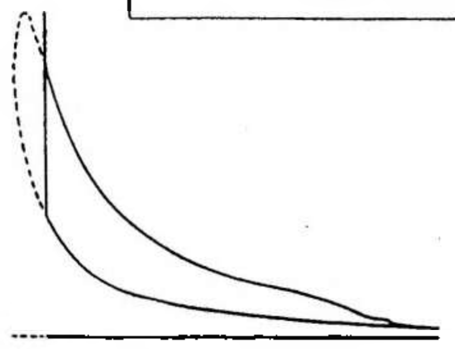

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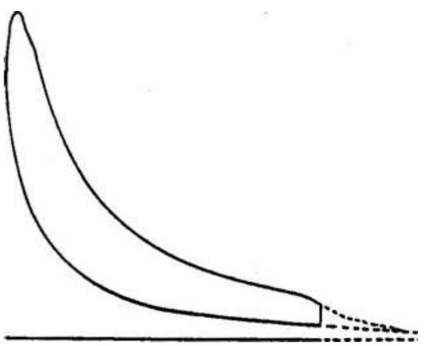

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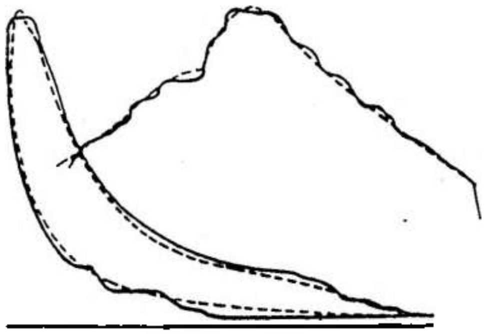

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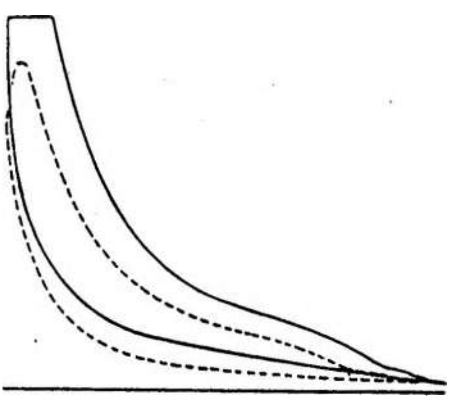

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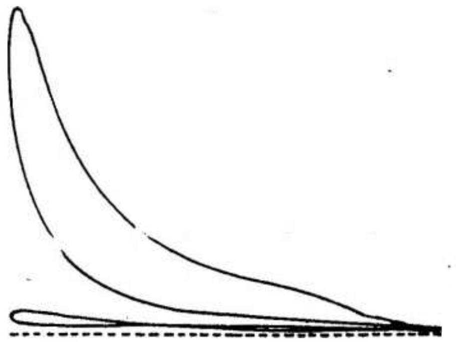


Fig. 6. Indicator cock leaking.
Atmospheric line untrue.

INFORMATION FROM DRAW DIAGRAMS

.... correct
———— measured

Fig. 1:
Fuel injection too late.

- Fuel pressure too low.
- Defective fuel valve(s) or nozzles.
- Defective fuel pump suction valve or shock absorber.
- Exceptionally poor fuel (bad ignition properties)
- VIT index wrong
- Fuel pump lead too little.

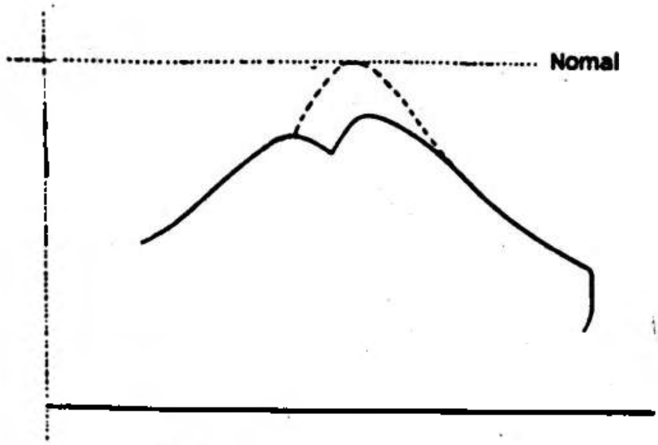


Fig. 1 P_{max} low, but P_{comp} normal

Fig. 2:
Fuel injection too early.

- VIT index wrong.
- Feel pump lead too large.

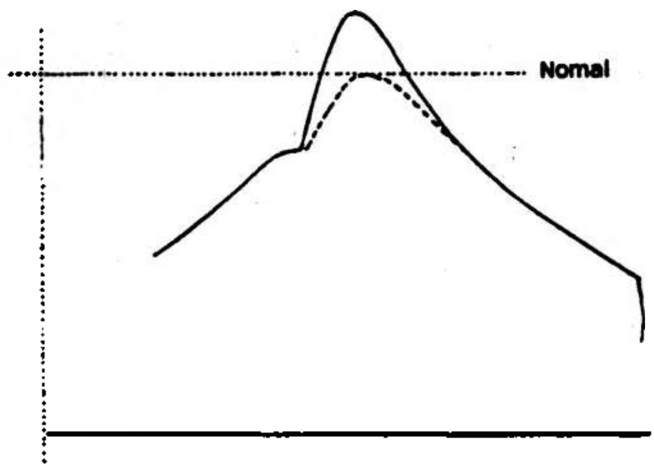


Fig.2 P_{max} high, but P_{comp} normal

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.

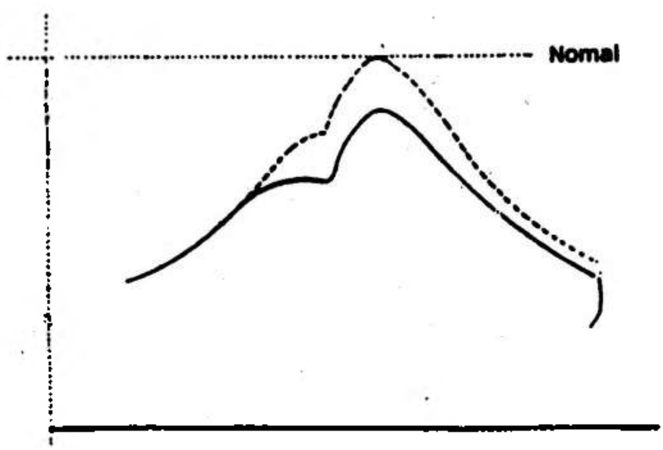
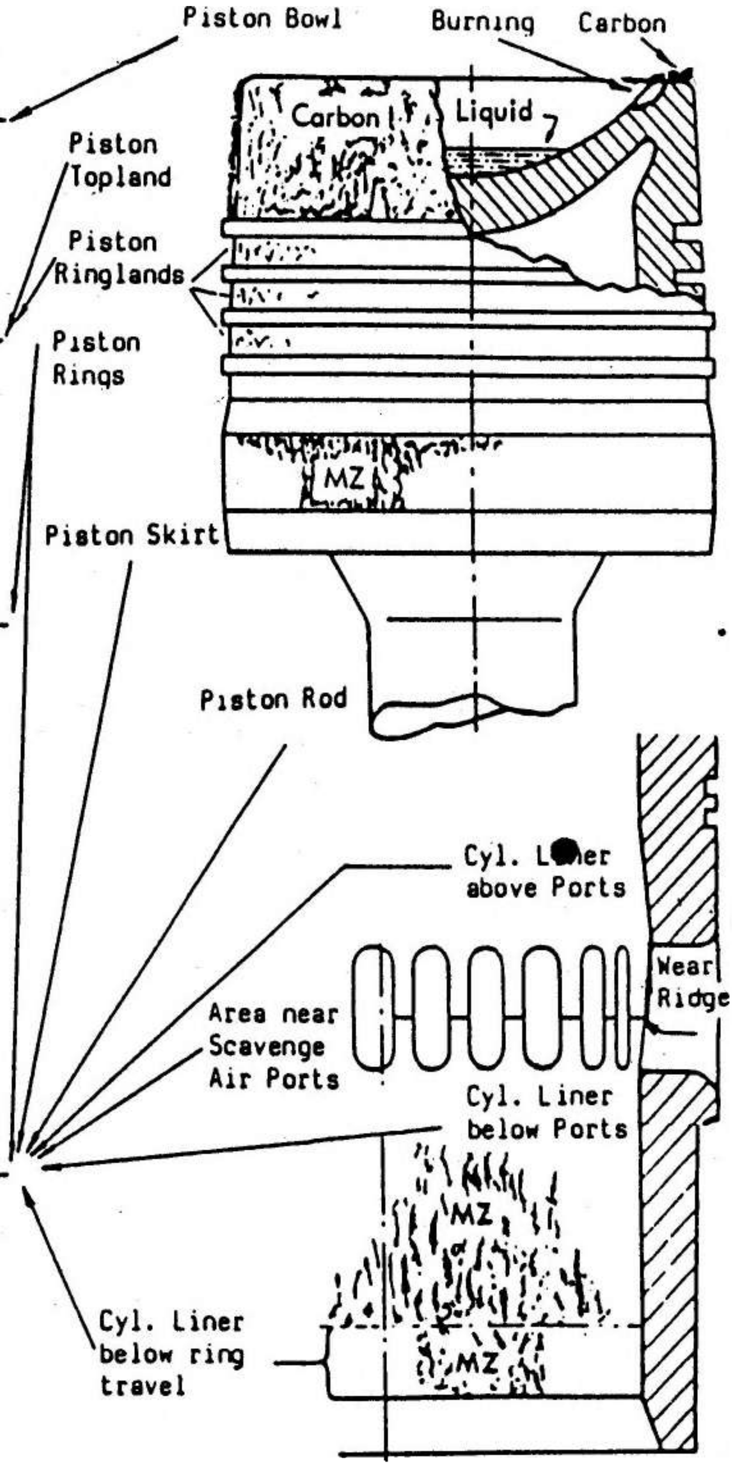


Fig. 3 both p_{cmp} and p_{max} are low.

INSPECTION THROUGH SCAVENGE PORTS: PISTON AND LINER

Condition of inspected part	
Satisfactory Carbon Deposit Burning Leakage Oil Leakage Water	Deposits etc.
Satisfactory Carbon Deposit Thick carbon deposit worn bright by rubbing against cyl. liner	Deposits
Intact Broken, opposite ring gap Broken, near ring gap Broken in several pieces Entirely missing	Broken
Loose Sluggish in groove Sticking Black running surface, overall Black running surface, partly	Sticking
Clean, smooth Vertical scratches (abrasive particles) Micro Seizures in spots (local) Micro Seizures, all over Macro Seizures still active Old (nearly recovered) MZ Wear ridges top of liner Wear ridges near scav. ports Corrosion	Surface Condition
Oil film normal Too much oil Too dry Very dry Clover-leaf wear	Lubr. Cond.



Q. Name the machineries in the engineroom of an ocean-going motorship and that of steam ship that are necessary to operate the main propulsion engine.

For Motor Ship: Aux. engines (generators), fuel oil pumps, cooling fresh water pumps cooling seawater pumps, lube oil pumps, Aux. service pumps, fuel oil purifiers clarifiers, lube oil purifiers/clarifiers, steam generators, fuel oil & lube oil transfer equipments, air supply/venting equipments, air compressors, marine growth prevention equipments heat exchangers, fresh water generators, heaters.

Fore Steam Ship: Main and Auxilliary Boilers including accesories, fuel oil burning pumps, lube oil pumps, turbo generators, lube oil purifiers/clarifiers, heat exchangers, heaters, main circulating pumps, Aux. S.W. service pumps, Air supply/venting equipments, fresh water generators, marine growth prevention equipments, condensate pumps, air compressors, de-ionization plant, air ejectors de-aerator.

Q. How would you differentiate a 2 -stroke cycle diesel engine from a 4-stroke engine in their principal parts and operation.

A two stroke is equipped with crosshead mechanism, has no intake/exhaust valve group, requires scavenging pump and every power stroke turns one revolution of the crankshaft. *A four stroke* is usually of the trunk-piston type, has intake/exhaust valves group, does not require scavenging equipment, and every power stroke turns two revolution of the crankshaft.

Q. A. Name two types of steam engines commonly used for propulsion. Describe briefly how the steam is introduced and exhausted in each type.

Reciprocating Steam Engines and Steam Turbine. In reciprocating type valve gear, actuated by the crankshaft, allows steam to enter the engine cylinder and permits exhaust steam to leave cylinder after performing a stroke, exhaust steam is lead to a condenser, while in turbine type, controlled valves and nozzles permits steam passages to blading and exhaust after, in case of multistage, exhausting steam after performing work passes through another stage or stages, before a condenser.

B. Describe the steps to adjust and measure the toppet clearance of a four stroke cycle diesel engine.

1. Open cylinder cover and check valve gears.
2. Bring the cylinder to be adjusted to its Top dead center, (combustion stroke), if possible follow according to firing order on flywheel marks or fuel oil injection pump base circle mark. If not available, observe on intake and exhaust valves, at top center, intake valves about to open and exhaust valves about to close.
3. Loosen lock nuts on each valve to be adjusted.
4. Insert feeler gauge on tappet and adjust, adjust screw if the prescribed measurement of clearance is not correct. Adjustment can be sensed for an optimum clearance (not too tight, not too loose when playing with the feeler gauge).

5. When the proper adjustment is reached, tightened lock nut to retain the new adjustment in accordance to manufacturer's designed valves.

C. What informations should you know about the fire-fighting equipments so that you can use them readily and effectively in case of fire on board?

Know their proper location, safe operation and functions of each part, particular classification of fire the equipment should be used.

Q. A. When the cylinder of a diesel engine is overhauled, what clearances and measurements are taken and recorded?

The measurements/ clearances taken and recorded are: cylinder liner bore measurements taken from certain points at top to bottom in port/starboard, forward and aft positions, between piston ring grooves and new rings, used piston ring width and thickness, burned away measurement in piston crown, gudgeon pin to piston clearances, main/journal bearings clearances individual crankpin bearing clearances and if so required the ovality of the connecting rod.

B. What are the functions of the following:

1. Fuel oil settling tanks – where fuel oil sediments and water settled down before purification or any other process, also heated.
2. Striking plates installed beneath the lower end of sounding lines – to protect the hull part fron striking weight damage the injury.
3. Wire screen and check valve installed at the end of the air vents of double bottom tanks holding fuel oil – to keep the tank free of sparks and dirt, in case of pressure build up the check valve also vents pressure.

C. What are the peak tanks for and where are they located. Beside storing water what are their other functions?

Peaktanks are used for storage of water ballast. They are located in the forward and aft of the ship. These tanks are used to achieve the proper adjustment of the end draughts of the ship, so that it will trim correctly. It also serve as collision protection in both ends.

Q. A. What are exhaust gas boilers and what are their purpose when installed in motor ships?

Exhaust Gas Boiler consist of U-tubes which utilizes exhaust gas to lower exhaust gas temperature and in so doing heating up feed water as it passes through making it in steam form on its way to boiler steam drum, thus increasing boiler efficiency. When installed on a motorship, it serve for economical purpose, to supply steam demands for heating instead of lighting on boiler continously during navigation.

B. When you observe the following appearance of the smoke from the chimney of a boiler, what are your impressions?

1. *White smoke* – too much "excess air" in the combustion process.
2. *Heavy black smoke* – combustion air is nearly to be absent in the combustion process, mechanical parts defect.
3. *Hazy Brown smoke* – complete combustion takes place, air to fuel ratio is properly adjusted.

C. What safety device is installed in a diesel generator to protect the engine from overspeeding?

Overspeeding trip device, the principle of mechanism is that, the centrifugal force exerted on a bolt in a rotating component is balanced by a spring set, so that should the engine speed exceed about 15% of the rated speed, the bolt will fly out strikes a latch which releases a plunger which shuts off fuel supply. The bolt cannot return even though speed falls and it is of mechanically actuated.

Q. A. What are the four basic course you have learned under the STCW upgrading program of the IMO and what are the additional courses for the deck and engine officers?

Four basic courses are: a) Fire fighting and fire prevention; b) First Aid; c) Personal Survival Technique; d) Lifeboatman and lifeboat handling Additional courses: Radar observers course, Radar Simulator Course, ARPA Radiotelephony, Cargo Handling Course, Tanker Safety, Inert Gas System and Crude Oil Washing Course, Instrumentation, Amos-D computer system.

B. What important life-saving equipment should you take with you when you abandon ship at sea?

You must wear an approved life jacket equipped with reflector, portable light and a whistle, enough thick clothes and documents.

C. Why are ocean-going vessels required by Marpol to install oil separator in the engine room.

Oil-water separator is installed as a requirement in every engine room in order to separate oil and water and reduce oil content of bilge water, before it is discharged overboard thus preventing oil pollution at sea.

Q. In what type of ships are pressure–Vacum relief valve installed? Why?

Pressure– vacuum relief are installed on vent lines on cargo tankers. Pressure side prevents a pressure from being built in the cargo tanks as it is being filled. Vacuum side prevents a vacuum from being created in the tank as it is being pumped out.

Q. What could.possibly wrong when you observe knocking at the end of the stroke of a stream reciprocating pump? What is the remedy?

a. Moving parts are loose, check and fightened.
b. Stroke out adjustment, check for proper adjustment.
c. Check cushion valves.

Q. In a conventional stern tube with lignum bearings, how is sea water prevented leaking through the bulkhead where the tailshaft is passing through?

There is stuffing box/ gland housing, a flax packing is inserted and is tightened through a packing gland until a considering leak is ascertained.

Q. When a vessel is in dry dock, what is the usual way of measuring the clearance if the rudder pintle bearings and the tail shaft bearing without dismantling the rudder or tailshaft.

A wedge is driven into the space between the parts, whose clearance is to be measured. It has different thickness where measured valves are based from.

Q. Give one reason why it is necessary to fit charge air coolers when a diesel engine is turbo charged?

Compressed air temperature is high and it is lower to proper temperature by means of charge air coolers, thus cause an increase in density at lower induction temperature raising also scavenge efficiency through medium cooling sea water.

Q. Why is it necessary to chemically treat boiler water? If the PH. value of the boiler is between 7 & 8 what does it indicate?

a. To prevent scale formation in the boiler and feed system by using distilled water, precipitating all scale forming salts into the form of a non-adherent sludge.
b. To prevent corrosion in the boiler and feed system by maintaining the boiler in an alkaline conditions and free from dissolved gasses.
c. Control of the sludge formation and prevention of carry over with the steam.
d. Prevention of entry into the boiler of foreign matters such as oil, waste, mill-scale, iron oxides, copper particles, sand, weld spatter etc, Seven and eight ph valve indicates boiler water in an alkaline condition.

Q. Why is if necessary to fit a scavenging pump to a 2-Stroke cyle diesel engine which is not turbo-charged?

Scavenging pump for a two-stroke cycle diesel engine not turbo charged is the one to expel burnt exhaust gases, supplying fresh air charge to the cylinder thus improving volumetric efficiency. For forcible expelling and suction action of an up and down stroke of a piston on a 4-stroke cycle diesel engine will itself largely-accomplish this with no scavenging assistance can charge itself through natural aspiration.

Q. How do you check the power generated by each cylinder of a multi-cylinder diesel engine? How are the cylinders balanced.

Power generated by each cylinder can be checked by taking indicator diagrams such as power diagram, compression diagrams, out of phase diagram and light spring diagram, using an engine indicator. From these diagrams power is calculated, operating cycle conditions are checked. From comparing the power cards take in each cylinder, a power balancing can be carried out through adjustment of fuel pump controls each cylinder to increase/decrease fuel pump control to increase/ decrease fuel quantity injected tending a raise/ lower power produced in each cylinder.

Q. Describe the burning system of the boiler. What is the purpose of the bypass valve?

Fuel oil pumped into settling tank, water settled out, when required for use the high suction valve is on service, allows passage to the cold filters on the suction side of the fuel burning pump which is positive displacement type delivering at constant pressure. A relief valve is fitted in case of over pressure. The fuel oil temp. is raised as it passed temperature controlled fuel oil heater, making easier to filter and atomized. Fuel passes to hot filters of an auto-clean type, being fine preventing wear and chokage of fine passages in the atomizing tip of fuel oil burner. Fuel oil after passes through flow meter where fuel is consumption is based upon. The heated and filtered oil passes through an automatic pneumatically operated control valve which varies oil supply pressure to burner in response to variation of steam demand transmitted to a master controller air/ fuel ratio. Emergency shut off valve is fitted in the system which will activate to close fuel oil flow in cases of emergency or trips. The oil is now ready to enter the individual pipe supplying oil to burners, variable in design. A bypass valve is fitted in the system which enables recirculation of fuel oil through the main ring back to pump suction, so as to bring fuel or temperature quick and maintained at desired operating valve. This valve is closed when burners are in operation. Individual burners are ignited by means of paraffin torch, but in many case auto-igniting devices are fitted. In this case it is advisable that a flame failure alarm/cut off should be provided.

Q. As watch engineer either at sea or in port, what are the minimum knowledge you should have regarding the engine room machineries fire fighting and life saving equipment, emergency alarms and the operation machineries to enable you to perform your duties by using properly for the safety of the vessel?

Know the station bill, location of machines, emergency equipments, know their proper operation and function of each, safety precautions in using and limitations. Keep a common sense about emergencies and the Do's and Dont's.

Q. What equipment has to be installed in the engine room of an ocean going ship to comply with the Marpol Regulation on oil pollution prevention.

An oil water separator capable of discharging bilge water of not more than 15% ppm oil content. A warning notice should be place near the system access to read of all personal on board.

DISCHARGE OF OIL PROHIBITED

The federal water pollution control act prohibits the discharge of oil waste into or upon the navigable waters of the United States or the waters of the contagious zone, if such contigous discharge causes a film or sheen upon or discolouration of the surface water or causes a sludge or emulsion beneath the surface water, violators are subject to a PENALTY of $5000.

Q. What is the working principle of float alarm switch?

One permanent magnet forms part of a float assembly which rises and falls with changing liquid level.

One second permanent magnet is positioned within the switch or air pilot valve head so that the adjacent poles of the two magnets repel each other through a non-magnetic diaphragm.

A change of liquid level which moves the float through its permissible travel will cause the float magnet to move and repel the other magnet to give the snap action operation.

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_1, 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.

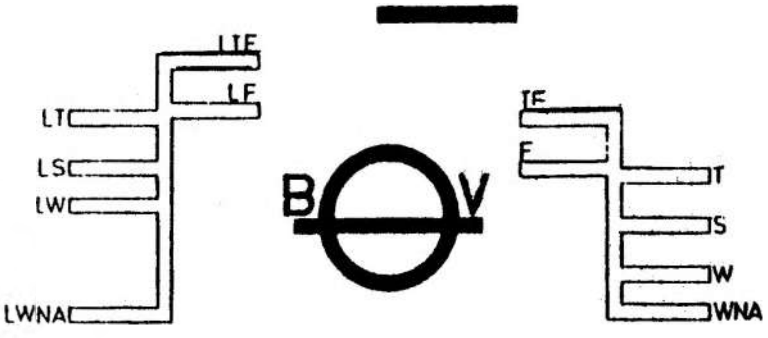
LIMBER BOARDS – are the boards covering the bilges in the ship's hold from the tank margin plate to the ship's side and are usually fitted inclined to the ship's side. These boards keep the cargo from coming in contact with the bilge water.

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 open-heart 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.
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.

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.

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.

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.

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

– 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

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.

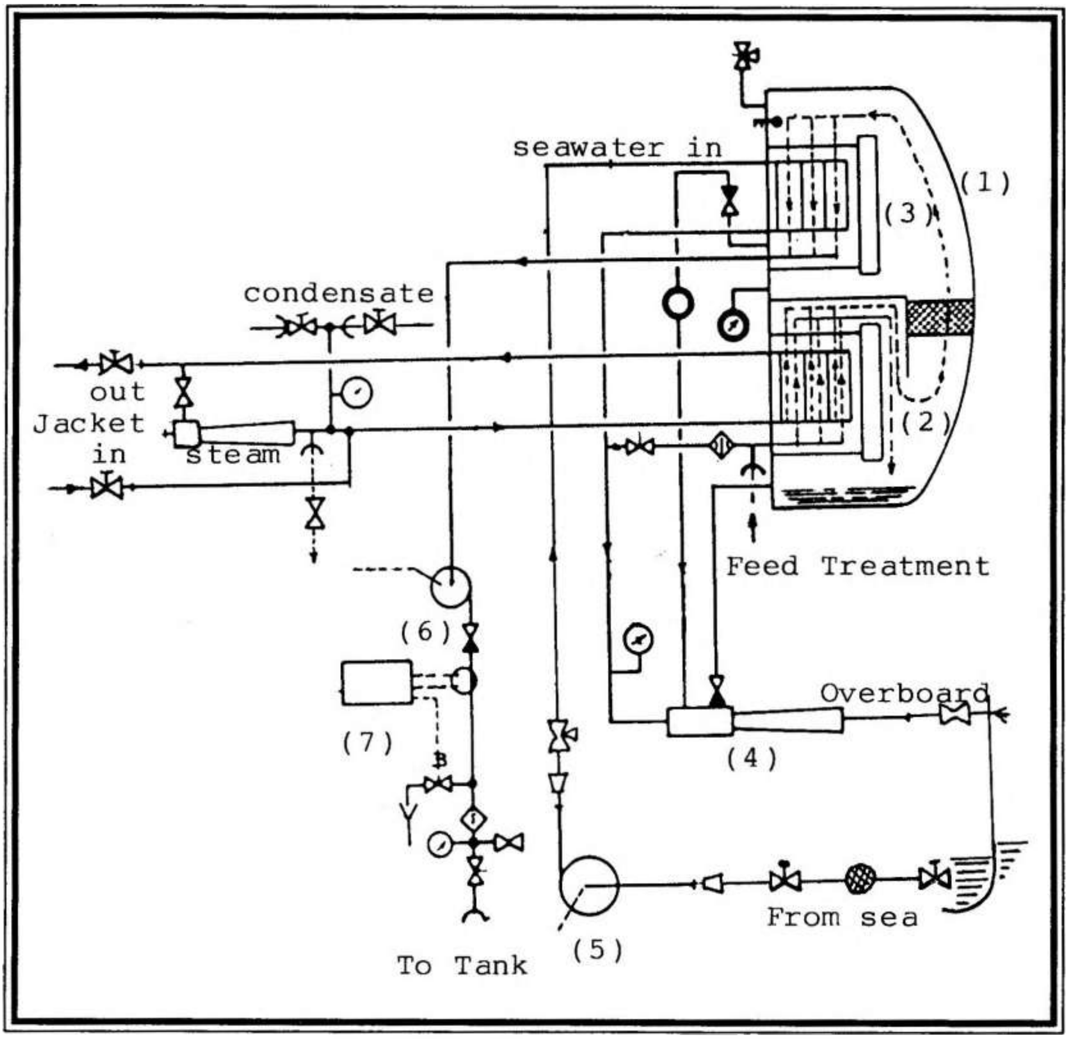
Having passed a demister (filter) the steam enters every second plate channel in the condenser section

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.



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.

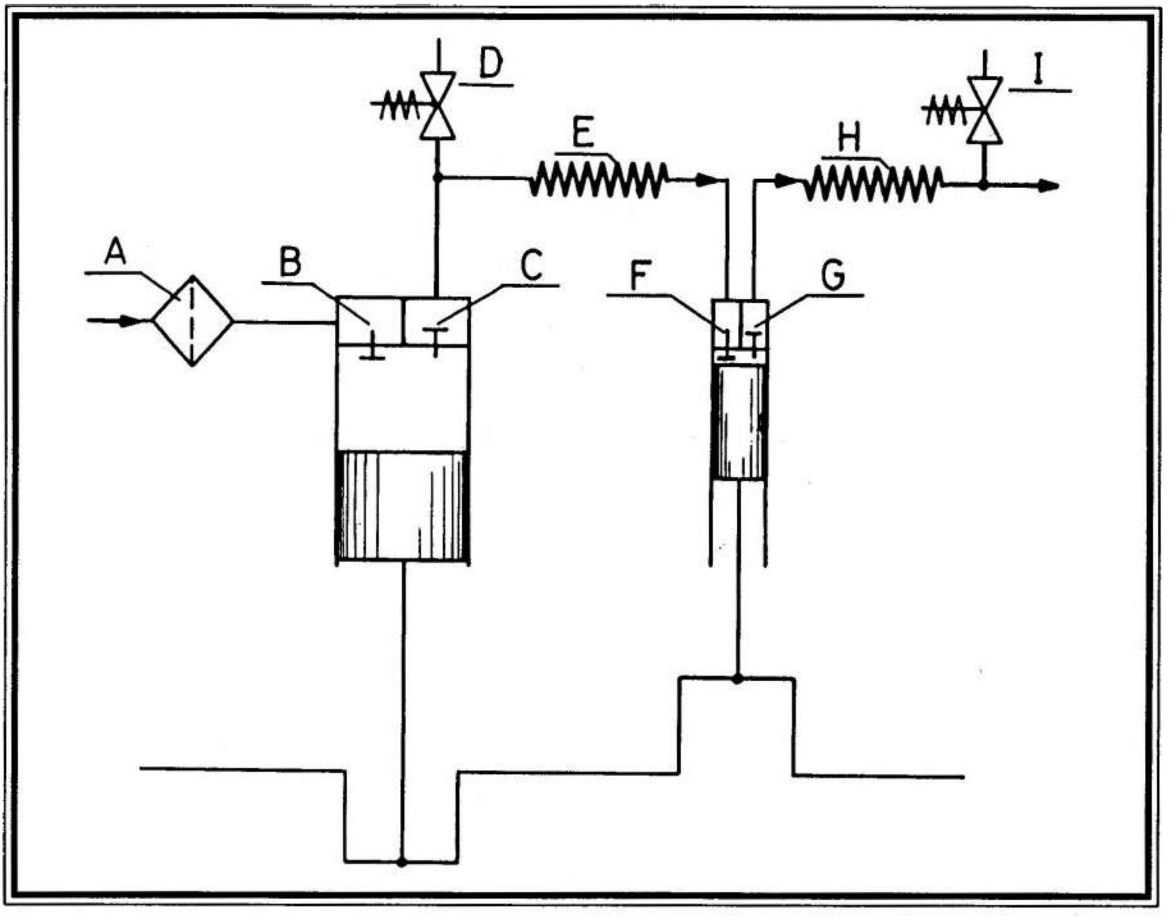
2. Two replaceable tube-type coolers are fitted in the compressor cylinder block. The first serves to cool the air after first-stage compression. The second proceeds cooling after second stage compression. The cooling water inlet and outlet are located so that the water circulates through the cylinder 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 crahkshaft 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 correct lifting pressure.

4. Defective gasket between crankcase and cylinder block — Replace gasket

5. Air filter blocked — Clean filter

B. LP safety valve blows.

1. HP valves damaged or dirty — Check and clean valves. Replace defective 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 recommended 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 A — *Daily*

Check:
- Lube oil pressure
- Lube oil
- Cooling water circulation and temperatures
- Automatic functions
- Drain condensate

Routine B· *Every 500 hours*

Check:
- LP delivery valve
- HP delivery valve
- Compressor bedplate bolts

Routine C *Every 1000 hours*

Check:
- LP suction valve
- HP suction valve
- Cylinder through valve apertures
- Pipe connections

Overhaul:
- LP delivery valve
- HP delivery valve

Replace:
- Lube oil after cleaning crankcase
- Lube oil filter

Routine D *Every 3000 hours*

Check:
- Big-end bearings
- Piston and cylinder walls through valve apertures
- Flexible couping
- Safety valves

Overhaul
- LP suction valve
- HP suction valve
- Air filter (clean)

Routine E *Every 9000 hours*

Check:
- Coolers (clean)

Routine F *Every 12000 hours*

Check:
- 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

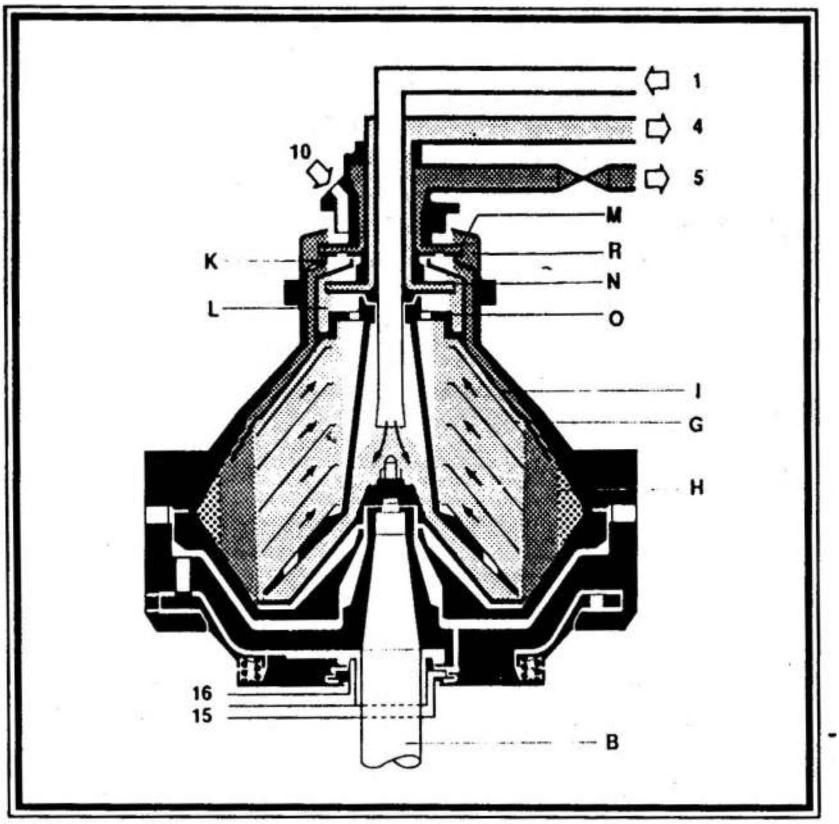
Principle of Centrifugal Separation:

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.

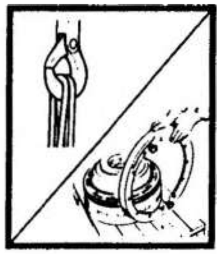
e. Speed too low / high

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

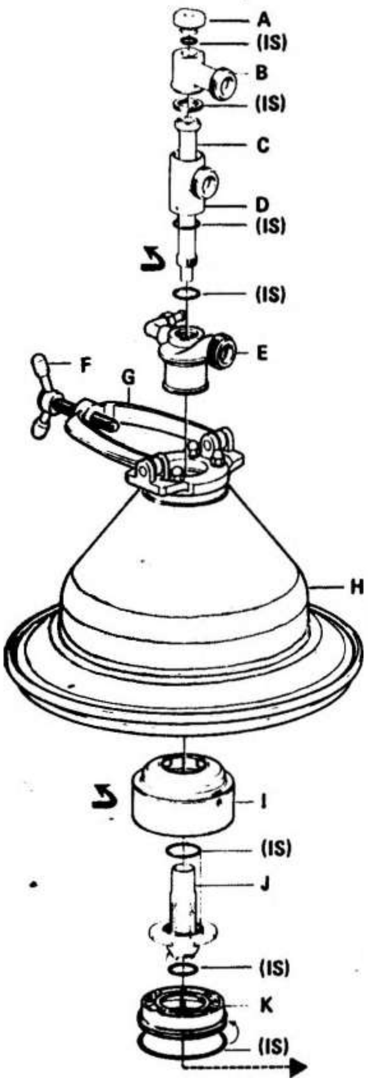
BOWL DISMANTLING – FOPX 605



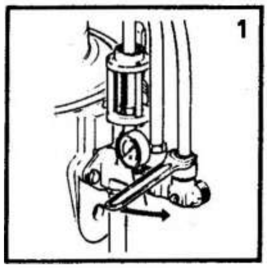
Important! Never start dismantling until the bowl has come to a **complete standstill**.

The heavy bowl parts must be lifted by means of a hoist. Position the hoist very exactly. Use a lifting hook with catch.

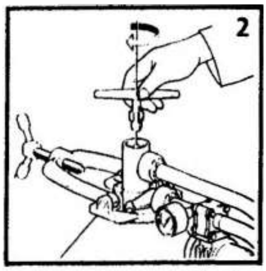
Don't place parts directly on the floor, but on a clean rubber mat, fibreboard or a suitable pallet.



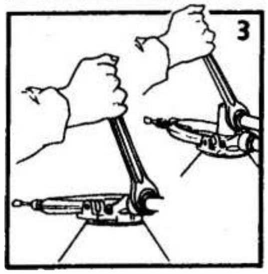
1. Loosen clamp screw (F) and lower clamping stirrup (G). Remove plug (A) and support (B). Undo the coupling nuts of inlet and outlet piping at the pipe support.



2. Unscrew inlet pipe (C) using the special pin spanner and lift out the pipe.



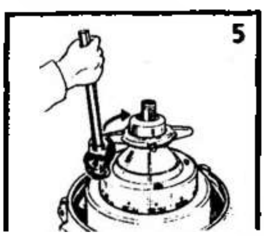
3. Disconnect the oil outlet pipe and remove support (D). Undo water outlet coupling nut of connection housing (E).



4. Remove connection housing and lift out frame hood (H). If necessary, use a hoist.

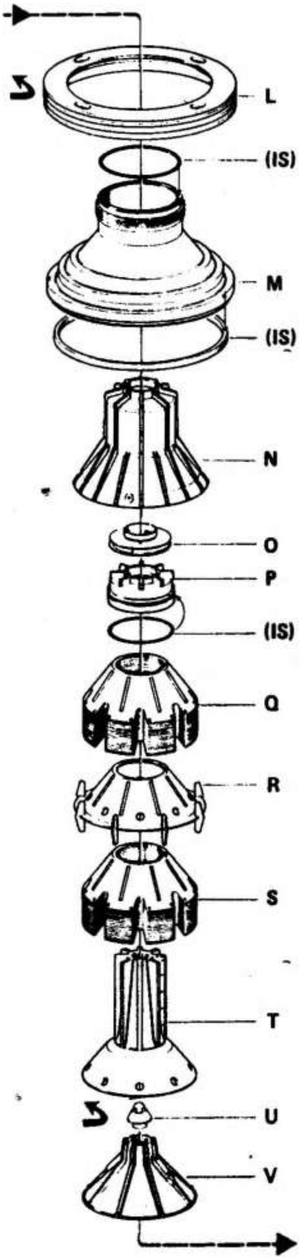
5. Unscrew small lock ring (I) using the special spanner.

   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)
J. Upper paring disc
K. Flow control disc

Left-hand thread



L. Large lock ring
M. Bowl hood
N. Top disc
O. Lower paring disc
P. Level ring
Q. Bowl disc
R. Wing insert
S. Bowl disc
T. Distributor
U. Cap nut
V. Distributing cone

6. Unscrew large lock ring (L) using the special spanner.

7. 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.

8. Remove top disc (N). Then screw inlet pipe (C) in lower paring disc (O), located in top disc. **Note. Left-hand thread!**

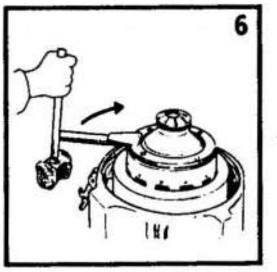
   Put a piece of wood (a) between the tin hammer and the pipe and force out level ring (P) and lower paring disc from top disc.

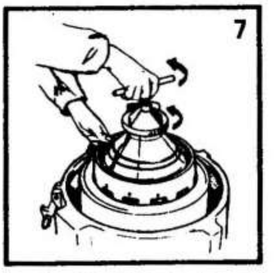
9. Lift out distributor (T) with bowl discs (Q,S) and wing insert (R). Use the special lifting tool.

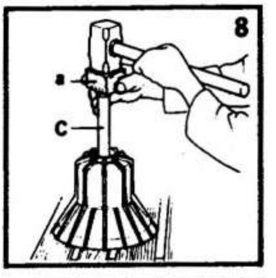
   - Soak the bowl discs and the wing insert in suitable cleaning agent, see 7.1.1.

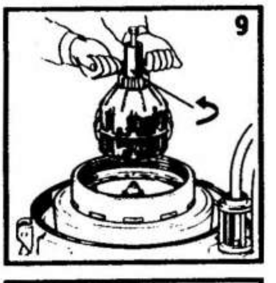
10. Unscrew cap nut (U).

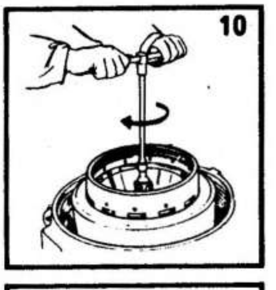
11. Lift out distributing cone (V) by means of the special tool.

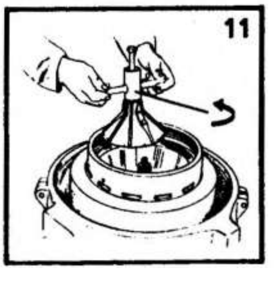


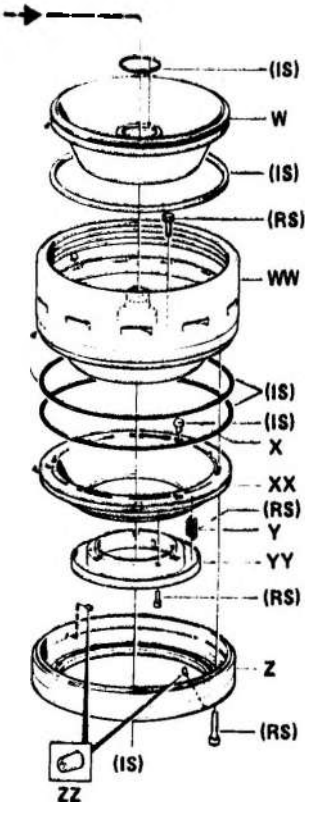












12. Lift out sliding bowl bottom (W) using the special tool.

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. If necessary, 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).

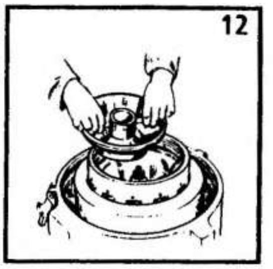
   e. Lift dosing ring and operating slide (XX) with two of the dosing ring screws (a). If necessary, prize loose the dosing ring as shown in figure. Place the operating slide with the valve plugs (X) facing upwards in order not to scratch the sealing surface of the plugs.

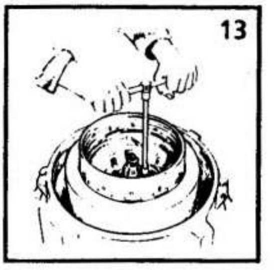
- Clean all parts thoroughly in suitable cleaning agent.

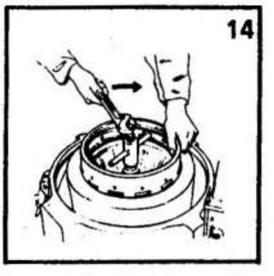
Check for damage, corrosion and erosion prior to assembly.

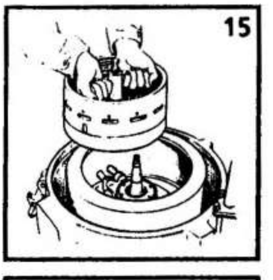
Clean nozzles (ZZ) in dosing ring with a soft iron wire:

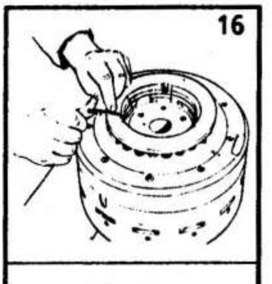
W Sliding bowl bottom
WW Bowl body
X. Valve plug
XX Operating slide
Y. Spring
YY. Spring support
Z. Dosing ring
ZZ. Nozzle



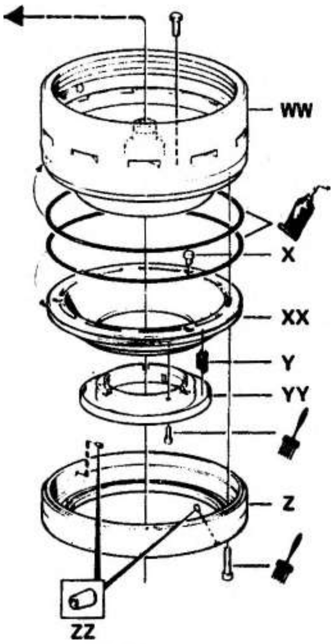




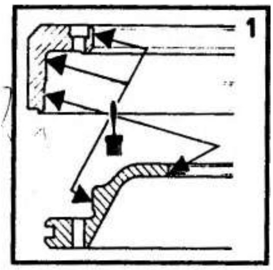




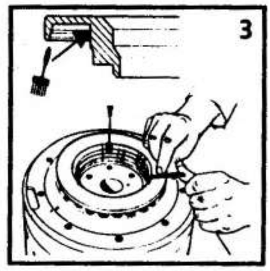
BOWL ASSEMBLY:



1. Apply lubricating paste* on the locating surfaces of operating slide (XX) and dosing ring (Z).

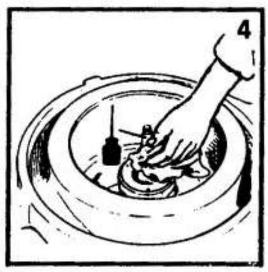


2. Fit operating slide and dosing ring.
   - Note that only a **thin** film of paste is to be applied on the dosing ring screws. If too much paste, the surplus would collect between operating slide and bowl body with risk for operating trouble.
   - It is imperative to use a torque meter when tightening these screws. First tighten diametrically, then all around. The tightening torque should be 7 Nm.

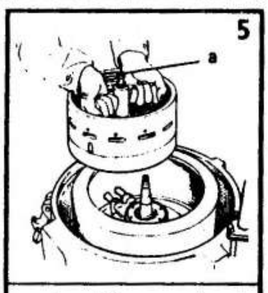


3. Apply lubricating paste* on the locating surface of the spring support (YY). Fit springs (Y) and spring support.

   Tighten the screws of the support successively a little at a time. Finally tighten firmly (by hand).

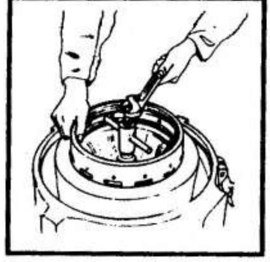


4. Wipe off spindle top and nave bore in bowl body. Apply oil onto the tapered end of the spindle to prevent the bowl seizing on the spindle. Use a few drops of oil only, smear it over the surface and wipe it off with a cloth.

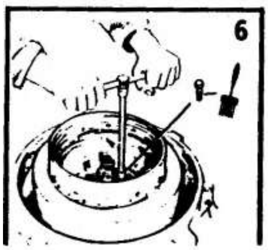


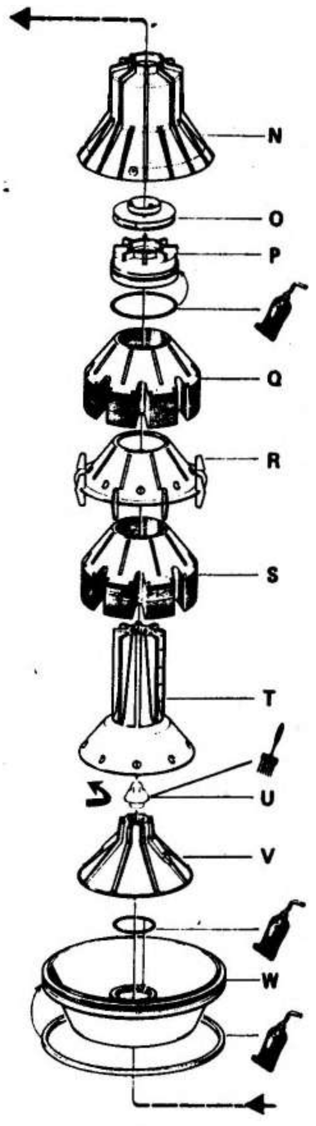
5. Fit bowl body (WW) on the spindle. Proceed as follows:

   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.



6. 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.





7. Apply lubricating paste* on the locating surfaces of bowl body (WW) and sliding bowl bottom (W). Fit sliding bowl bottom.

8. 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.

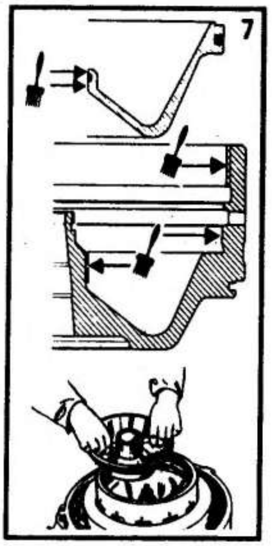
10. Slip bowl discs (S,Q) and wing insert (R) on to distributor (T).

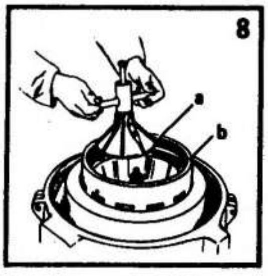
    Number of discs:
    (S):40 (Q):40 - 42

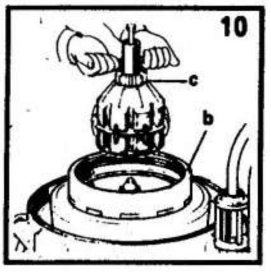
    Fit distributor with disc stack in bowl. Recesses in underside of distributor must fit over guide pins of distributing cone.

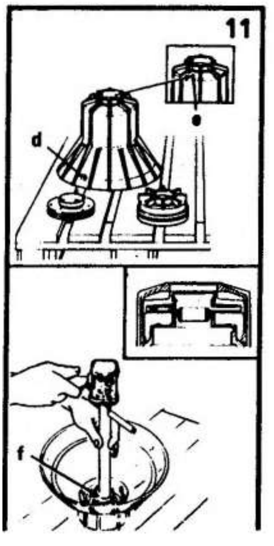
11. Check that the small hole (d) on top disc (N) is not clogged. Fit lower paring disc (O) and level ring (P) in top disc. Be sure to turn the paring disc the right way round. Fit top disc on distributor (drill mark (c) on disc must face guide lug (b) of bowl body.)

* These surfaces are to be primed with lubricating spray Molykote 321 R with Major Service (MS) - see Operator's Service Manual (OSM).

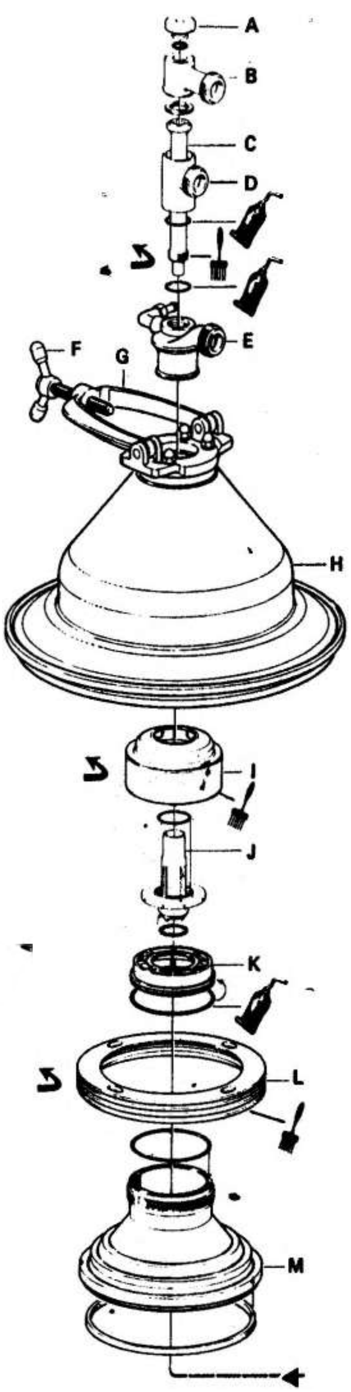








a Drill mark on distributing cone
b Guide lug in bowl body
c Guide rib on distributor
d Small hole in top disc
e Piece of wood



12. Put bowl hood (M) in place. The guide lug on bowl body must enter recess in hood.

13. 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).

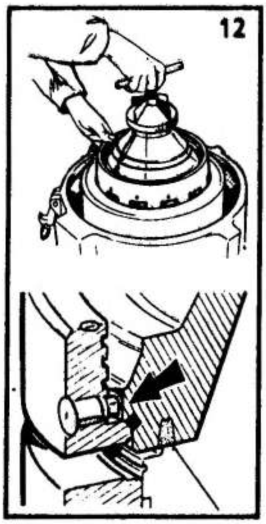
14. Check that the small holes in upper paring disc (J) and in flow control disc (K) are not clogged. Fit paring disc and flow control disc in small lock ring (I).

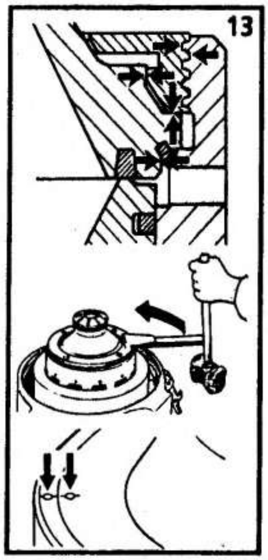
Tighten small lock ring.

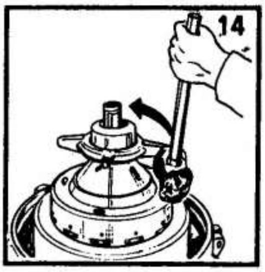
15. Put frame hood (H) in place and clamp it with the hinged bolts. Then fit connection housing (E) (note its angular position) and connect water outlet pipe. Fit support (D) and connect oil outlet pipe.

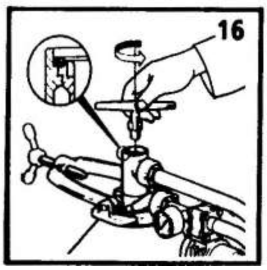
16. Fit inlet pipe (C). Tighten the pipe using the special pin spanner.

17. 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).

Molykote 1000 Paste *Silicone grease* *Left-hand thread*

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^3/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^3 at specified temperature normally at 15°C.

Viscosity – Fluid resistance against movement. Normally expressed in centistoke ($cSt=mm^2/s$), 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.

BOARD QUESTIONS

FOURTH, THIRD, SECOND, CHIEF ENGINEERS *MAY– JULY 1992*

Practical Questions

1. If the lips of a drill are of different lengths:

   A. The drill will not cut
   B. The hole will be larger than the drill
   C. The hole will be smaller than the drill
   D. none of the above

2. A brazed joint is:

   A. Stronger than a soldered joint
   B. Weaker than a soldered joint
   C. The same strength as a soldered joint
   D. Three times as strong as a soldered joint

3. Brazing requires:

   A. Hard solder B. Soft solder C. More heat D. A and C

4. Lead is used in solder because:

   A. It has a high melting point
   B. It has a low melting point
   C. It is cheap
   D. B and C

5. The name of the taper shank used on drills is:

   A. Mitler B. Morse C. Starrett D. Stanley

6. The higher the melting point of the solder, the:

   A. Stronger the solder joint
   B. Softer the solder joit
   C. Weaker the solder joint
   D. Harder the solder joint

7. If the angle on a drill is less than 59 degrees:

   A. The drill will make a larger hole.
   B. The drill will make a smaller hole
   C. The hole will take longer to drill and more power
   D. The drill will not center properly

8. Soda added to water is used for cooling instead of plain water because:

   A. it reduces the amount of heat generated
   B. It improves the finish

C. It overcomes rusting
D. All of the above

9. If a drill speed is too great, it will:

A. Cut faster   B. Lose its temper   C. Cut slower   D. Not cut

10. The lip clearance of a drill should be approximately:

A. 12-15 degrees
B. 5-10 degrees
C. 20-25 degrees
D. 15-20 degrees

11. If the cutting edge of a drill are cut at different angles:

A. The drill will not cut
B. The hole will be larger than the drill
C. The hole will be smaller than the drill
D. None of the above

12. A "pillar" file has:

A. One safe edge
B. Three safe edges
C. Two safe edges
D. A or C

13. In general, files are divided into two classes called:

A. Single cut and double-cut
B. Fine and coarse
C. Rough and smooth
D. Shapes and sizes

14. The length of a file is measured from:

A. End to end   B. Point to heel   C. Point to end   D. Heel to end

15. A "pillar" file is used for:

A. Filing slots
B. Filing keyways
C. Filing against a shoulder
D. Any of the above

16. A flexible hackshaw blade has a tendency to :

A. A snap easily
B. Buckle or run out of line when too much pressure
C. Cut too fast
D. Cut too slow

17. Soldering is the process of:

A. Joining two metals by a third soft metal that is applied in a molten state.
B. Holding two metals together by heating.
C. Holding two different kinds of metals together by heating.
D. Joining two metals together by heating.

18. When soldering, flux is used to :

A. Keep the solder from running off the metal
B. Keep the metal from getting too hot

C. Keep the tip of the soldering iron clean
D. Remove and prevent oxidation of the metals

19. One of the most important factors that is often overlooked when soldering is the fact that:

    A. The surfaces to be soldered must be clean.
    B. The two metals to be soldered must not be the same.
    C. The two metals to be soldered must be the same.
    D. All surfaces around be dipped in acid first.

20. A surface should be prepared for soldering by:

    A. Filing the surfaces
    B. Scraping the surfaces
    C. Acid-cleaning the surfaces
    D. Any of the above

21. The hand tool used for cutting threads on round stock is the:

    A. Stock and die B. Die wrench C. Stock D. stock cutter

22. A tappered piece of stock is 2" long, 1 1/8" diameter at one end and 3/4" at the other end. The taper per foot is:

    A. 2" B. 2-1/2" C. 2-1/4" D. 2-1/6"

23. The correct cutting angle on a drill for ordinary work is:

    A. 59 degrees B. 50 degrees C. 45 degrees D. 65 degrees

24. A piece of stock 8" long is 4" diameter on one end and 1" diameter on the other end. The taper per foot is:

    A. 4" B. 4-1/2" C. 4-1/4" D. 41/16"

25. A piece of stock 8" long is 3" diameter at one end and 1-1/2" diameter at the other end. The taper per inch is:

    A. 3/16" B. 3/4" C. 1/2" D. 5/16"

26. A piece of stock 6" long is 2" diameter at one end and is cut with a taper of 1/2" to the foot. The diameter of the small end will be:

    A. 1-1/2" B. 1-3/4" C. 1-1/4" D. 2"

27. If a piston ring is to be made 1/64" larger in diameter per inch diameter of the cylinder which it to fit, the required diameter or apiston ring to fit an 8" cylinder will be:

    A. 8-1/8" B. 8-1/4" C. 8-3/16" D. 8-5/32"

28. In the above problem, if a gap clearance of .003" is to be left for each inch diameter of the cylinder, the required amount to be cut from the ring will be:

    A. .750" B. .675" C. .500" D. 4167"

29. When cutting, a drill will "squeal" dued to:

A. A drill being ground improperly
B. Drill being too hot
C. Insufficient lubrication
D. Any of the above

30. "Center drilling" is the operation of:

A. Drilling a center in an odd-shaped piece of metal
B. Drilling and counters sinking with one tool
C. Centering with one tool and drilling with another
D. Drilling a center in a piece of stock in a drill press

31. In referring to threads, "pitch" is:

A. The distance from a point on one thread to a corresponding point on the next thread measured parallel to the axis.
B. The distance of the full length of the thread.
C. The distance from the top of one thread to the bottom of the next thread.
D. The distance from the bottom of a head on a bolt to the first thread.

31. A tool bit for cutting an American National thread should be ground with a:

A. 45 degrees angle
B. 90 degrees angle
C. 60 degrees angle
D. 30 degrees angle

32. An approximate safe rule for cutting new pistons for steam pumps is to allow:

A. .001" between piston and cylinder for each inch diameter of piston.
B. .002" between piston and cylinder for each inch diameter of piston.
C. .010" between piston and cylinder for each inch diameter of piston.
D. .0001" between piston and cylinder for each inch diameter of piston.

33. An approximate safe rule for cutting new piston rings for steam pumps is to make the ring:

A. 1/32" larger in diameter per inch diameter cylinder.
B. 1/16" larger in diameter than that of the cylinder.
C. 1/16" larger in diameter per inch diameter of cylinder
D. .005" larger in diameter per inch diameter of cylinder.

34. The gap clearance for new piston rings for steam pumps should be approximately:

A. .003" for each inch diameter of cylinder.
B. .001" for each inch diameter of cylinder.
C. .010" for each inch diameter of cylinder.
D. .050" for each inch diameter of cylinder.

35. Sweating is the process of:

A. Tinning two surface, applying flux between them, and holding the two together and heating.
B. Separating the two pieces of metal that have been soldered together.
C. Soldering two different kinds of metal together
D. None of the above.

36. If muriatic acid is used as a flux, the sodered area, must be cleaned thoroughly afterwards to prevent:

A. Anyone touching it from getting burned.
B. Remaining acid from eating the metal.
C. The acid from evaporating and the solder disintegrating.
D. None of the above.

37. Solder will not unite with a metal surface that has:

A. Grease on it
B. Dirt on it
C. It overcomes rusting
D. Any of the above

38. Prepared solder paste flux is most popular but if you did not have any, you could use:

A. Hydrochloric acid
B. Sulphuric acid
C. Nitric acid
D. Any of the above

39. Another name for hydrochloric acid is:

A. Muriatic acid
B. Sulphuric acid
C. Nitric acid
D. Acetic acid

40. Hard solder is made of:

A. Copper and zinc
B. Tin and zinc
C. Tin and copper
D. Tin and lead

41. Soft solder is made of:

A. Tin and lead
B. Copper and zinc
C. Tin and copper
D. Tin and zinc

42. Soft solder melts at approximately:

A. 250 degrees
B. 350 degrees
C. 450 degrees
D. 550 degrees

43. What does 3/8-16 mean to you?

A. 16 pieces, 3/8" long
B. 3/8" square, 16" long
C. Gear with 16 teeth and a 3/8" arbor hole
D. 3/8" diameter, 16 threads per inch

44. When using a drill press, the work should be held with:

A. A vise or clamp
B. A gloved hand
C. The hand
D. Pliers

45. Tapered shanks are used on large drill presses so that:

A. The drill can be centered more easily.
B. The drill can be easily forced out of the sleeve with a drift.

C. The shank will not turn when cutting.
D. The shank can be reground when worn.

46. Which of the following is not a common drill shank?

A. Fluted B. Taper C. Straight D. Bit

47. The cutting angle on a drill for drilling mild steel should be:

A. 39 degrees B. 49 degrees **C.** 59 degrees D. 69 degrees

48. When installing a new grinding wheel, always use:

A. Blotting paper gaskets on each side of the wheel.
B. Copper gaskets on each side of the wheel.
C. Only the steel washers provided with the machine.
D. None of the above

49. The operation of "truing" a grinding wheel is known as:

A. Centering **B.** Dressing C. Sizing D. Rounding

50. The stool used to check external pipe threads is called a:

A. Ring gage B. Thread gage C. Pitch gage D. Plug gage

51. The tool used to check internal pipe threads is called a:

A. Plug gage B. Gear hob C. Gear center D. Gear threader

52. The flux usually used for hard solder is:

A. Borax B. Rosin C. Barium C. Aluminum

53. Straight muriatic acid is often used as flux on:

A. Galvanized iron
B. Cast iron
C. Sheet steel
D. Any of the above

54. Special solders used for aluminum usually require:

A. More heat
B. Less heat
C. The same heat as copper wire
D. The same heat as sheet metal

55. Copper is annealed by heating to a cherry red color and:

A. Dousing in cold water
B. Cooling slowly in air
C. Dousing in oil
D. Dousing in hot water

56. A piece of mild steel held against an emery wheel will give off:

A. Light straw-colored sparks
B. Bright shiny sparks
C. No sparks
D. Green sparks

57. A gear wheel making 158 RPM has 58 teeth. It drives another gear at 91 Rpm. The number of teeth on the second gear is:

A. 65 B. 90 C. 50 **D.** 96

58. Tool steel can be hardened by:

A. Heating red hot and plumging into water.
B. Heating red hot and cooling in a blast dry air.
C. Heating red hot and plunging into linseed or cottondseed oil.
D. Any of the above, depending on type and use.

59. A scriber is made from:

A. Carbon steel
B. Cold-rolled steel
C. Tool steel
D. Hot-rolled steel

60. The tool used to cut gear is called a:

A. Gear hob B. Gear cutter C. Gear center D. Gear threader

61. If you use a dry grinding wheel for sharpening tool bits, dip the end of the bit in water frequently to prevent:

A. Burning your fingers
B. Annealing the cutting edge of the bit
C. Hardening of the tip
D. Green sparks

62. A piece of tool steel held against an enemy wheel will give off:

A. White sparks with stars on the ends.
B. Yellow sparks
C. No sparks
D. Green sparks

63. Grinding wheels have a range of soft to hard abrassive materials depending on the use. Most manufacturers letter their wheels from A to Z. The hardest is marked:

A. E B. A C. Z D. E1

64. The main difference between a planer and a shaper is that:

A. The table of a planer has a reciprocating motion past the tool head while the table of the shaper is stationary and the tool head has a reciprocating motion.
B. The shaper has a rotating table and the planer has a horizontal table.
C. The planer has an offset table and the shaper has a horizontal table.
D. One is larger than the other.

65. One of the factors involved in the choice of a grinding wheel is:

A. The kind of material to be ground
B. The amount of stock to be removed
C. The kind of finish required
D. All of the above

66. The "tang" of a file is the part that:

A. Fits into the handle
B. Does the cutting
C. Has no teeth
D. Is opposite the handle

67. Before applying layout blue on a piece of metal, it must be:

A. Clean B. Hot C. roughened D. Cold

68. A drill bit has:

A. 4 flutes B. 3 flutes C. 2 flutes D. No flutes

69. When facing off a piece of material in the lathe chuck, the tool bit must be set:

A. At the center B. Above center C. Below center D. Off center

70. The jaws of a standard vise are:

A. Soft B. Semihard C. Hard D. Semisoft

71. When a lathe tool bit burns, it means that the:

A. Speed is too fast
B. Speed is too low
C. Facing
D. Any of the above

72. A Universal chuck cannot be used to cut:

A. An eccentric B. Grooving C. A cam D. A and C

3. The lathe compound is used for:

A. Angle cutting B. Grooving C. Facing D. Any of the above

74. When the dial on the cross-feed is turned .010", you remove from the diameter of the stock being cut:

A .010" B. .020 C. .005 D. .015

75. Which of the best way to combat a fire on the open deck of a vessel if you are using a dry chemical fire extinguisher?

A. Approach the fire from the windward side
B. Direct the extinguisher discharge at the base of the fire
C. The discharge steam should be moved back and forth in a rapid sweeping motion.
D. All of the above

76. The first course of action in fighting a fire in a cargo or fuel oil tank is to:

A. Secure all openings to the tank
B. Discharge an initial charge of CO_2 with a hand portable extinguisher
C. Direct a fire hose into the tank and energize the fire main
D. Spray the tank boundaries with a fire hose to promote cooling

78. Which fire fighting agent is the least hazardous to personnel?

A Water B. Steam C. CO_2 D. Carbon Tatrachloride

79. You have just extinguished an oil on the floor plates of the engine room with a 15 pound CO_2extinguisher. What danger should you now be prepared for?

A. Complete lack of oxygen in the engine room
B. Chemical reaction of the CO_2 and oil, forming carbonic acid

C. Sudden stoppage of the main engine
D. Rekindling of the fire

80. The best way to combat a bilge fire is through the use of a:

A. Foam extinguisher and low velocity water fog
B. Dry chemical extingusiher and solid stream water
C. Foam extinguisher and solid stream water
D. Foam and soda acid extingusiher

81. When fighting a spreading fire resulting from a broken fuel line, you should first:

A. Look for a CO2 extinguisher
B. Use a soda-acid extinguisher
C. Shut off the fuel supply
D. Smother the fire with rag

82. The flexible type hachsaw blade is best suited for work on:

A. Channel iron
B. Tubing
C. Aluminum
D. Any of the above

83. A flexible back hacksaw blade is one that has:

A. Only the teeth hardened
B. Flexible ends
C. A movable back
D. Only the back hardened

84. Hacksaw blade are made of:

A. Tool steel
B. High-speed steel
C. Tungsten alloy steel
D. Any of the above

85. Hacksaw blade with a 24 TPI is best suited for cutting:

A. Tubing
B. Sheet metal over 18 gage
C. Brass and copper
D. Any of the above

86. An all hard hacksaw blade is one that:

A. Has the entire blade hardened
B. Has a flexible back and hard teeth
C. Has a hard back and flexible teeth
D. Will only fit a sloid frame hacksaw

87. If a fire starts in the engineroom due to a high pressure oil leak, you should FIRST:

A. Secure the ventilation
B. Find a soda-acid extingusiher
C. Shut off the oil supply
D. Secure the generators

88. At the first indication of fire aboard ship, you must FIRST:

A. Sound the alarm
B. Determine which type of fire is burning
C. Locate the fire
D. Fight the fire

89. A hand portable CO2 extinguisher is effective on burning oil only:

A. If applied promptly
B. If applied in connection with foam

C. To prevent rekindling
D. If attempts to extinguish the fire with low velocity fog fail

90. When using a dry chemical extinguisher to fight a fuel fire, you should:

A. Direct the chemical discharge across the burning fuel surface
B. Direct the chemical discharge into the burning fuel surface.
C. Attack the fire from the leftward side
D. Invert the dry chemical extinguisher before starting to fight the fire.

91. Which statement is true concerning Halon 1310 fire extinguisher equipment?

A. The agent is highly toxic at normal roon temperature
B. The agent pound for pound is more effective than CO_2
C. Halon extiguishes the fire by smothering
D. The agent can't be used on electrical fires as it leaves residue

92. In fighting fire in a fuel tank, the first action you should attempt is to:

A. Secure all sources of fresh air to the tank
B. Begin transferring the fuel to other tanks
C. Top off the tank to force out all vapors
D. Station someone at the fixed CO_2 release controls

93. The most effective method of extinguishing a class "A" fire is by:

A. Quenching and cooling
B. Using a sodium based dry chemical
C. Blanketing and smothering
D. Using non-conducting extinguishers

94. What is the correct method to use when applying CO_2 from a portable extinguisher?

A. Apply CO_2 to the base of flames in a sweeping motion
B. Bounce the CO_2 off the bulkhead
C. Apply the CO_2 to the center of the flames with a beating motion
D. Direct the CO_2 in as near a vertical upward direction as possible

95. Rekindling of a fire occurs when a fire which has been extinguished by smothering is resupplied with oxygen.

A. Low velocity fog
B. High velocity fog
C. Chemical foam
D. Dry chemical

96. Halogenated extiguishing agents such as Halon 1310 operate by:

A. Breaking the chain reaction
B. Producing excess CO_2
C. Cooling
D. Foaming motion

97. As soon as you hear the fire and emergency signal, you should ensure that:

A. Fire pumps are started
B. Engines are stopped

C. Ring buoys are thrown overboard
D. Everyone is suited in an approval life preserver

98. One use for low velocity fog is to:

A. A help produce mechanical foam
B. Break apart class "A" combustibles
C. Sweep burning liquids overboard
D. Act as a heat shield to protect the fire fighter

99. Which type of fire should be extinguished with a straight stream of water?

A. Mattress fire
B. Bilge fire
C. Galley range fire
D. Switchboard fire

100. If centrifugal pump fails to deliver, the cause may be:

A. Impeller passages plugged
B. Disharged head too high
C. Any of these
D. Pump speed too low

101. The tool used to cut threads in a hole is called a:

A. Bit
B. Tap
C. Reamer
D. Top

102. Which drill size is the smallest

A. A
B. No. 1
C. No. 80
D. Z

103. How are globe and angle valves always installed in the line?

A. With hand wheel pointing down
B. Makes no difference
C. With pressure acting on the top of the disc
D. With pressure acting on the bottom of the disc

104. Soot blowers should be used in proper sequence so that:

A The decks will not be covered with soot
B. The soot will be swept toward the uptakes
C. There will be less of steam pressure
D. Excess sresses will not be set up in the boiler

105. Chemical foam is most suitable for use on fire involving

A. Electrical machinery
B. Burning insulation
C. Hot bulkheads
D. Oil

106.A grinding wheel is "trued" with a

A. Round file
B. Late tool
C. Garnet stone
D. Dressing tool

107. The device used on the discharge side of many reciprocating pumps to provide a continuous discharge is:

A. Snifter
B. Air chamber
C. Cushioner
D. Absorbing tank

108. To remove metal stock rapidly with a file, use a:

A. Double-cut bastard
B. A or C
C. Double-cup course
D. Rasp

109. If you notice oil on the water near your vessel while loading bunkers, which action should you take first?

A. Deploy an oil containment boom
B. Personally notify the Coast Guard
C. Notify the terminal superintendent to stop loading your vessel
D. Close the deck filling valve.

110. The best instrument for measuring thousandths of an inch is the:

A. Caliper
B. Tachometer
C. Micrometer
D. Pyrometer

111. The best chisel for cutting a keyway is the:

A. Round nose chisel
B. Diamond point chisel
C. Flat cold chisel
D. Cape chisel

112. The smallest graduation on a machinist rule is:

A. 1/8 inch
B. 1/16 inch
C. 1/32 inch
D. 1/64 inch

113. A tool used in cutting external thread is called a:

A. Tap
B. Die
C. Reamer
D. Thread gauge

114. If a fire occurs in the fire room as a result of fuel leaking from the boiler fuel manifold, the first action taken should be:

A. Pressurize the fire main
B. Activate the CO2 system
C. Secure the fuel supply
D. Sound the general alarm

115. If a fire occurs in the boiler room because of a leaking fuel line, you should FIRST:

A. Notify the engineer on watch
B. Shut off the fuel supply to that line
C. Throw sand on the fire
D. Extinguish the fire using a combination nozzle with applicator

116. A strait elbow has:

A. Male threads only
B. Female threads only
C. Both male and female threads
D. Is a tubing fitting

117. On a new ocean-going ship of 10,000 gross tons equipped with an approved 100 ppm oily-water separator and bilge monitor, the bilge monitor continuous record must be:

A. Kept readily available for 1 year
B. Detached monthly for enclosure in the Oil Record Book

C. Maintained onboard for not less than 3 years
D. Initialled after each engineering watch by the watch engineer

118. You are replacing a section of heavy piping on deck and you are using a chain fall to lift the pipe. What precaution should you take to prevent personal injury?

A. Position several men under the pipe so they can catch it if it falls
B. Attach lines to the ends of the pipe and have your helpers steady the load
C. Place an old mattress under the hoist to prevent the load from hitting the deck
D. Have a first aid kit at the job site

119. During fueling operations if oil is detected in the water adjacent to your vessel but is determined to be free from some source other than your vessel, you should:

A. Secure operations until the exact source is determined
B. Make an entry in the oil record book to that effect
C. Notify the Coast Guard
D. All of the above

120. More than six short blasts and one long blast of the ship's whistle, along with the same signal on the general alarm bell is the _______________ signal:

A. Fire and emergency
B. Boat recall
C. Man overboard
D. Boat stations (abandon ship)

121. What is the emergency signal for fire aboard ship?

A. More than six short blasts and one long blast on the whistle
B. Continuous blast of the ship's whistle for a period of not less than 10 seconds supplemented by the same signal on the general alarm

122. If a vessel loses its reserve buoyancy, it will:

A. Float upright with the main deck awash
B. Capsize and float on its side
C. Remain unaffected if the hull remains intact
D. Most likely sink

123. One complete revolution of the micrometer thimble will move the spindle:

A. .001 inch B. .005 inch **C.** .025 inch D. .050 inch

124. To drill using the lathe, the drill must be mounted in the:

A. Headstock **B.** Tailstock C. Lathe dog D. Drive plate

125. Heat from a fire will pass through a bulkhead or deck by:

A. Conduction B. Radiation C. Convection D. Advection

126. The spreading of fire by heat carried through a vessel's ventilation system is an example of heat transfer by:

A. Conduction **B.** Convection C. Radiation D. Ventilation

127. The lowest temperature at which the vapors of flammable liquid will ignite and cause self-sustained combustion in the presence of a spark or flame is the:

A. Auto ignition temperature
B. Vaporization temperature
C. Flash point
D. Fire point

128. The depth of thread being cut on a lathe is dependent upon the:

A. Adjustment of the cross slide
B. Positions of the quick-change gear levers
C. Alignment of the cutting tool with the lathe center
D. Adjustment of the thread cutting stop

129. Which way(s) can be used when cutting a taper?

A. Tailstock set over
B. Compound rest
C. Using faceplate
D. Use both A and B above

130. Which device is designed to prevent flames from entering fuel tank vents?

A. A safety cap
B. A flame screen
C. A spark arrestor
D. A flame inhibitor

131. Part of the required equipment for a lifeboat includes:

A. A boathook
B. Life preservers
C. A sea painter
D. All of the above

132. If an oil spill occurs in deck you should:

A. Cover the area with foam
B. Cover the area with absorbent materials
C. Wash down immediately with a fire hose
D. Wash down immediately with an oil dispersing solvent

133. A vessel which is subjected to "sagging":

A. Has its main deck under tensile stress
B. Has its bottom plating under tensile stress
C. Is supported on a wave whose crest is amid ships
D. Is said to be under a form of transverse bending

134. An instrument used to detect explosive gas/air mixture that usually measures concentration in terms of the lower explosive limit is known as a:

A. Toxic vapor meter
B. Flame safety lamp
C. Gas absorption detector
D. Combustible gas indicator

135. The longer an oil fire burns, the:

A. Harder it is to extinguish
B. Easier it is to extinguish
C. Less change there is of reignition
D. Easier it is to control

136. The best means of combating an oil, fire on the water surrounding a vessel tied to the pier is to use:

A. Waterfog over the fire
B. Solid water streams into the fire
C. Dry chemical around the fire
D. Foam directed against the vessel's side

137. The best emergency repair to a crack in the hull would be:

A. Driving wedges into the crack
B. Drilling the ends of the crack and applying a concrete patch
C. Welding a doubler plate over the crack
D. Welding a metal box over the crack and applying air pressure

138. If a vessel losses its reserve buoyancy, it will:

A. Float upright with the main deck awash
B. Capsize and float on its side
C. Remain unaffected if the hull remains intact
D. Most likely sink

139. The reserve buoyancy of a ship is considered to consist of:

A. The void portion of the ship below the waterline which is enclosed and water tight
B. All cofferdams, double bottoms and wing tanks that are slack
C. The part of the enclosed and watertight portion of a vessel above the waterline
D. The percentage of the volume of a compartment which can be occupied by water if flooded

140. When the engine room fixed CO2 system is activated, what should be your first action if the automatic fuel oil and ventilation shutoffs failed to operate?

A. Manually operate the pressure switches
B. Fire off an additional CO2 bottle to increase pressure on the pressure switch plunger
C. Send someone down to manually secure the fuel oil pumps and ventilation fans
D. Discharge extra carbon dioxide into the engine room

141. When you are combating a fire on deck, which is the result of a leaking cargo line you should FIRST:

A. Blanket the cargo spill with foam
B. Apply CO2 on the burning fuel at its surface
C. Stop the transfer of cargo
D. Prevent the spread of fire with a foam dam

142. The center of volume of the immersed portion of the vessel is the:

A. Center of flotation
B. Metacentric height
C. Center of buoyancy
D. Center of gravity

143. The tool used when working with large sizes of pipe is called a:

A. Chain pipe wrench
B. Chain tongs
C. Chain holder
D. A or b above

144. The steam that is discharged from the safety valves goes to the:

A. Auxiliary condenser
B. Main condenser
C. Bilges
D. Atmospheric line

145. The purpose of "tempering" is to make a metal:

A. Harder
B. Softer
C. More brittle
D. Less brittle

146. In the event of an exhaust duct fire, most dry chemical and carbon dioxide, galley range, extinguishing systems are automatically activated through the action of a stainless steel cable, spring, and a:

A. Stack switch
B. Thermostat
C. Pyrostat
D. Fusible ink

147. A Stilson wrench is used for:

A. Nuts and bolts
B. Gaskets
C. Tightening piping and pipe fittings
D. Tubing

148. The advantage of a centrifugal pump as compared with a recirpocating pump is:

A. It has no internal valves
B. The discharge is continuous
C. All of these
D. Upon accidental closing of discharge valve, excessive pressure will not build up

149. The most important characteristic of a fire extinguishing agent to be used on electrical fires is for the agent to be

A. Easily removable
B. Flame resistant
C. Nonconducting
D. Wet

150. What type of hammer will not mark a surface?

A. Brass hammer
B. Chipping hammer
C. Rawhide hammer
D. Sledge hammer

151. The pumping capacity of a reciprocating pump is determined by the:

A. Difference between the max. pressure developed during the discharge stroke and the minimum pressure
B. Area of the piston and its rate of travel
C. Capacity of the steam cylinder and its bore
D. Effective pressure in the liquid end during the complete cycle of operation

152. All arrow cast into the valve body indicating the direction of flow is common to:

A. Check valves only
B. Globe and check valves
C. Globe valve only
D. Gate valves only

153. To join two pieces of pipe by turning, you would use a:

A. Tea B. Union C. Nipple D. Coupling

154. What three hazards are the most common in any enclosed space such as a cargo tank?

A. Lack of oxygen, inadequate ventilation, toxic atmosphere
B. Falling rust, pockets of gas, open holes
C. Lack of oxygen, toxic atmosphere, explosive atmosphere
D. No lighting, pockets of gas, open holes

155. The process used to retard corrosion on iron pipe is called:

A. Soldering B. Annealing C. Galvanizing D. Tempering

156. The twist drill gauge can be used to measure the drill:

A. Clearance angle
B. Length
C. Web thickness
D. Diameter

157. A fuel tank is considered to be gas-free when the tank is

A. Free of dangerous concentrations of flammable or toxic gases
B. Inerted with carbon dioxide for 24 hours
C. Thoroughly ventilated for at least 24 hours
D. Free of all flammablegas concentrations

158. What kind of tap should be used to finish the treading operation in a blind hole?

A. A bottoming tap
B. A short tap
C. A plug tap
D. A taper tap

159. The tool which is a combination drill and countersink is called:

A. Boring bit
B. Plug tap
C. Center drill
D. Reamer

160. When you have completed bunker operations, the hoses should be

A. Steam cleaned and flushed with hot water
B. Blown down with inert gas
C. Drained into drip pans or tanks
D. Stowed with their ends open for venting

161. The tool use to prepare copper tubing of fitting is the:

A. Reaming tool
B. Bending tool
C. File
D. Flaring tool

162. To use a portable CO2 fire extinguisher, you must first

A. Pull the locking pin
B. Open the valve on the side of the tank

C. Shake thoroughly
D. Turn the tank upside down

163. What should you put on a major burn?

A. Petroleum jelly
B. Salt water and zinc ointment
C. Wash with lukewarm water and apply a gauze dressing
D. Cold water as long as possible

164. Hydrogen sulfide is the constituent that gives your crude oil the characteristic odor of rotten eggs. One hazard associated with hydrogen sulfide is

A. Addiction to the highly toxic fumes
b. high toxicity that can cause death
C. Irritation of the intestinal tract
D. Chemical burns of the skin

165. What precaution should be observed when taking on diesel fuel?

A. Display black triangle during daylight hours
B. Provide a portable fan to blow away fumes
C. Secure all lighting to the main deck
D. Prohibit smoking in the area

166. Combustible gas indicators are used to detect flammable gases or vapors in the he atmosphere. They are also equiped with

A. Audible signaling devices
B. An inflatable bag
C. Pressure relieving devices
D. Flame arrestors

167. When a vesel is taking on fuel, the scuppers should be plugged

A. Only if fixed ccontainment drains is not used
B. Always
C. Only if fixed containment drains are open
D. Only if portable containment is not used

168. What is the purpose of a gas rubber in an inert gas generation system?

A. Maintains the water seal on the gas main
B. Cools the inert gas
C. Drains off static electricity in the inert gas
D. Maintains the oxygen content at 5% by volume

169. What is the correct procedure to follow when launching an inflatable life raft by hand from an ocean going vessel?

A. Connect the stainless steel link (float free link) to the vessel
B. Remove the raft from the container to permit complete inflation
C. Pull the line (painter) from the container and make it fast to the cleat provided
D. Open the canopy relief valves

170. Safe welding practice requires

A. That a fire watch be posted
B. All of these
C. A check for explosive gases be made
D. Checking the area for items that may catch fire

171. Standard pipe wall thickness is reffered to as:

A. Schedule 40
B. NPSC.
C. Schedule 120
D. Schedule 80

172. What is the boiling on the centrigrade thermometer

A. 212 deg. centigrade
B. 200 deg. centigraade
C. 180 deg. centigrade
D. 100 deg. centigrade

173. The snifter valve on reciprocating pumps does which of the following:

A. Automatically replaces the air in the air chamber
B. Relieves excess pressure on the pump
C. Lubricates the piston rods while in operation
D. Acts as a pressure regulator

174. With a reciprocating pumps fail to obtain proper discharge pressure may be caused by :

a. Liquid plunger packing which is too tight.
B. Steam pressure which is too low.
C. Worn piston rings.
D. Any of these

175. Before drilling a hole in a piece metal, it should be:

A. Marked with chalk
B. Protracted
C. Scribed
D. Center-punched

176. The fuel-oil heater is located

A. On the suction side of the service pump
B. On the discharge side of the service pump
C. Between the settling tank and the service pump
D. On the discharge side of the transfer pump

177. A fuel-oil meter placed between the fuek-oil service pumps and the fuel-oil heaters would be a:

A. Hot-type meter
B. Cold-type meter
C. Supermeter
D. Vertical meter

178. Which of the following cannot be considered for use as an emergency bilge pump?

A. General service pump
B. Main bilge pump
C. Fire pump
D. Main curculation

179. A segregated ballast system is system where ____________.

- **A.** Ballast is taken on and discharged through the oily water main deck riser
- **B.** All ballast is processed through the oily water separator
- **C.** All ballast lines, tanks and pumps are independent of those used for oil
- **D.** Ballast and cargo tanks are separated by confferdams

180. Which motion is most likely to cause damage to cargo being stowed on the main deck?

A. Hogging B. Sagging **C.** Rolling D. All of these

181. If a hole in a piece of metal was 1/2 inch deep what would you use to measure the diameter accurately?

- **A.** Inside calipers
- **B.** Outside micrometer
- C. Inside micrometer
- D. Telescoping gauge

182. Which of the following tools would be most useful when taking leads on bearings?

A. Center gage B. Outside calipers **C.** Micrometer D. Dividers

183. When ordering bolts, the information necessary is:

- **A.** Diameter, threads per inch, and length
- **B.** Diameter, and threads per inch
- C. Diameeter, threads per inch, length, material and head size
- D. Diameter, threads per inch, length and head size

184. How can extra feedwater be obtained for the boilers when the ship is at sea?

- **A.** By opening the extra feed valve on the main condenser
- B. By using the steam injector
- C. By taking suction from the potable water tanks
- D. By putting both feed pumps into operation

185. The highest concentration of a harmful substance to which a person may be exposed without danger to health is termed the:

A. Vapor pressure B. Tolerance point C. Odor threshold **D.** Threshold limit

186. Wire inserted packing is used on:

- A. Lube oil pumps
- **B.** Main steam stops
- C. Fuel oil service pumps
- D. Circulating pumps

187. What would a centrifugal pump with a volute and diffuser do the liquid pressure?

A. Increase B. Decrease C. Keep the same D. None of these

188. Before drilling a hole in a piece of metal, the location of the hole center should be:

- A. Marked with chalk
- B. Scribed
- C. Blued
- **D.** Marked with a center punch

189. If a centrifugal pump fails to deliver the cause maybe

- A. Impeller passage plugged
- B. Discharge head too high
- C. Pump speed top slow
- **D.** Any of these

190. An exccellent stimulant beverages for a person suffering from shock is

A. Medicinal brandy B. Hot coffee C. Warm water D. Cold water

191. 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

192. The pressure remaining constant a rise in temperature would cause a liquid to:

A. Condense B. Contract C. Vaporize D. Expand

193. 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
C. Be down by the head
D. Float

194. The annealing of a cutting bit is usually done by what means?

A. Cooling of the cutting bit
B. None
C. Heating of the cutting bit from the grinder
D. At the factory before you receive it

195. The proper treatment for shock is:

A. Raise the head
B. Give the victim warm liquids
C. Keep the body cool
D. Raise the feet

196. If liquid freon should come in contact with your skin, you should:

A. Wash with sterile mineral oil
B. Wash with salt and water
C. Treat it like any burn
D. Treat it like frostbite

197. What is the freezing point on the Centigrade thermometer?

A. 15 degrees B. 32 degrees C. 0 degrees D. 30 degrees

198. 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

199. 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

200. 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
B. control the bleeding
C. remove him from the compartment
D. begin artificial respiration

PART VI

DRAWING

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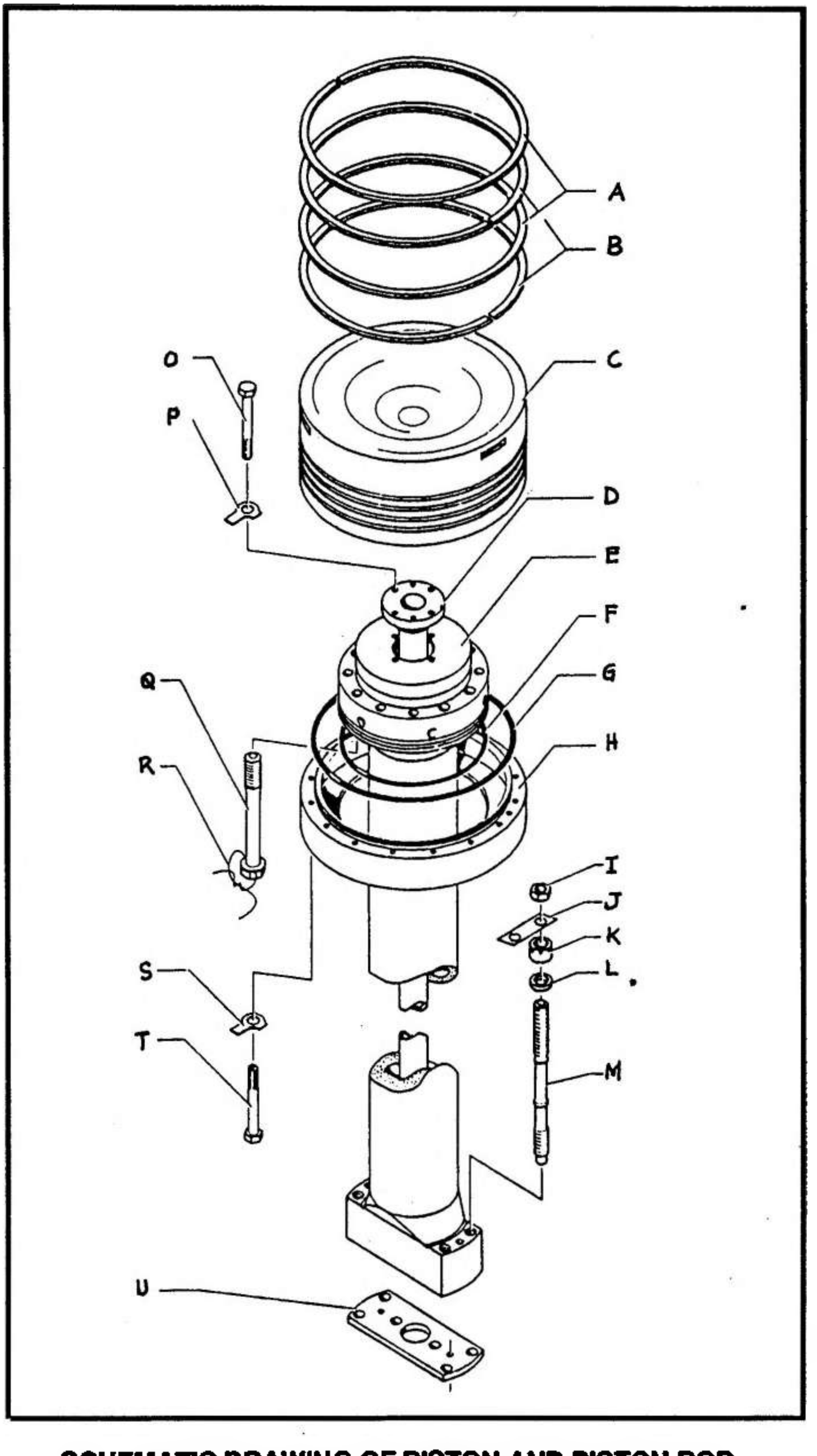
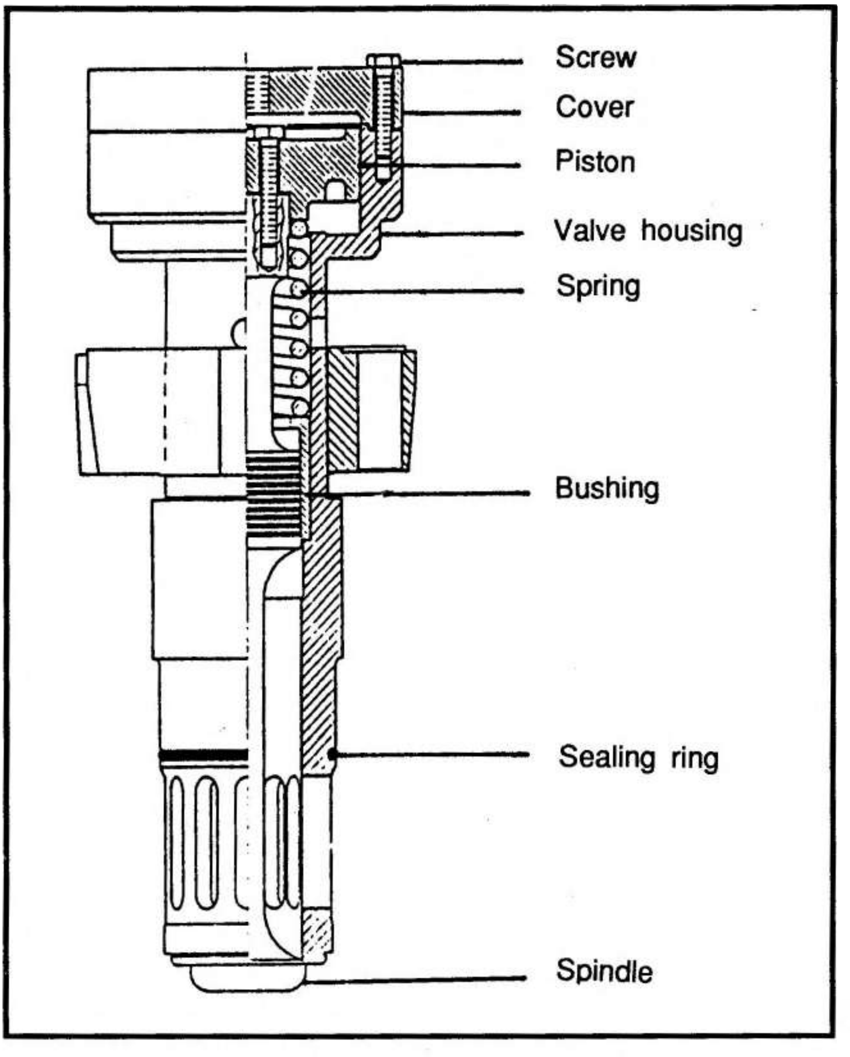


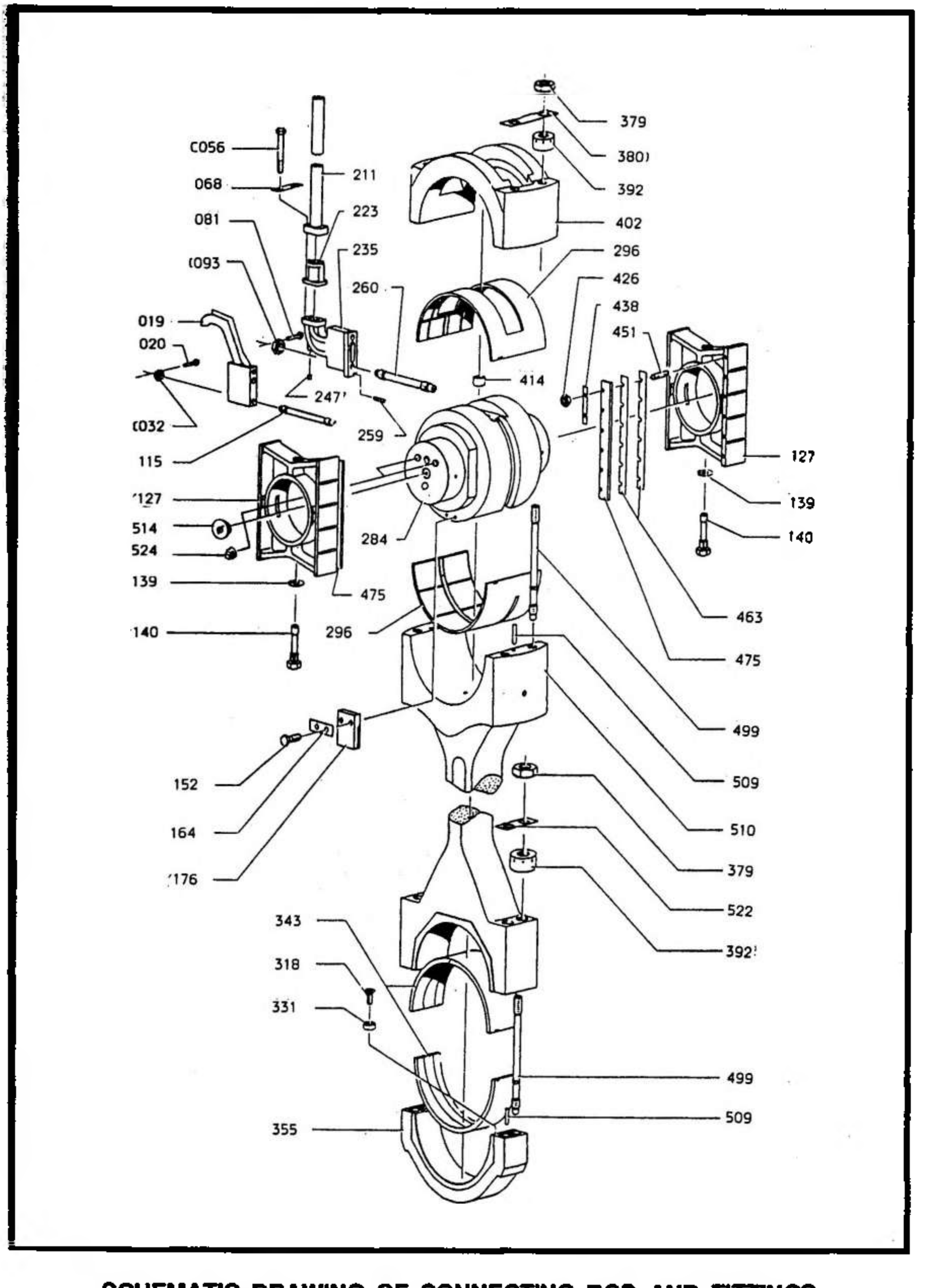
SCHEMATIC DRAWING OF PISTON AND PISTON ROD

A.	Piston ring, right	K.	Nut
B.	Piston ring, opposite	L.	Washer
C.	Piston crown	M.	Stud
D.	Cooling oil pipe	O.	Screw
E.	Piston rod	P.	Lock washer
F.	O-ring	Q.	Screw
G.	O-ring	R.	Locking wire
H.	Piston Skirt	S.	Lock washer
I.	Lock nut	T.	Screw
J.	Locking	U.	Shim

Part Description of B & W Piston and Piston Rod



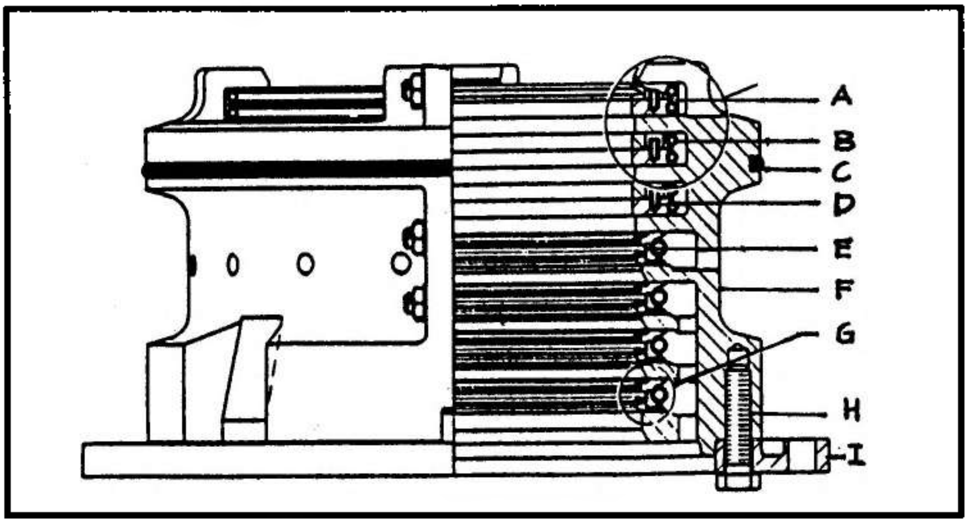
SRATING VALVE – B & W Engine



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 0.25-0.50mm
235	Bracket		
247	Plug	475	Guide pin
259	Guide pin	499	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:

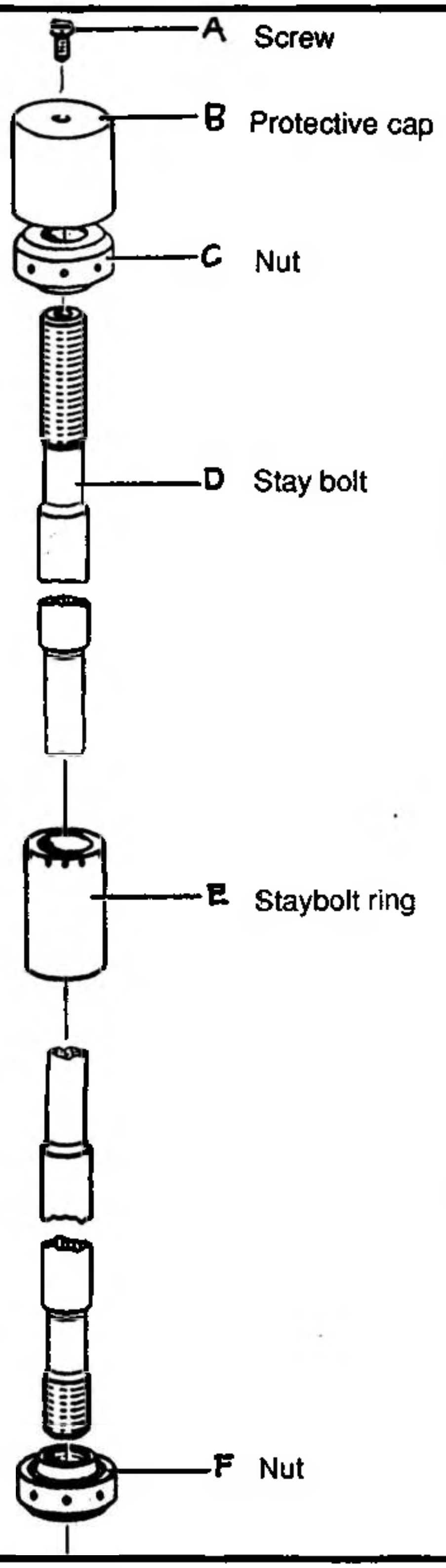
A. Top Scraper ring
B. Cover–Pack Sealing ring
C. O-ring
D. Guide pin
E. Scraper ring
F. Stuffing housing
G. Spring
H. Screw, washer
I. Flange

PISTON ROD STUFFING BOX

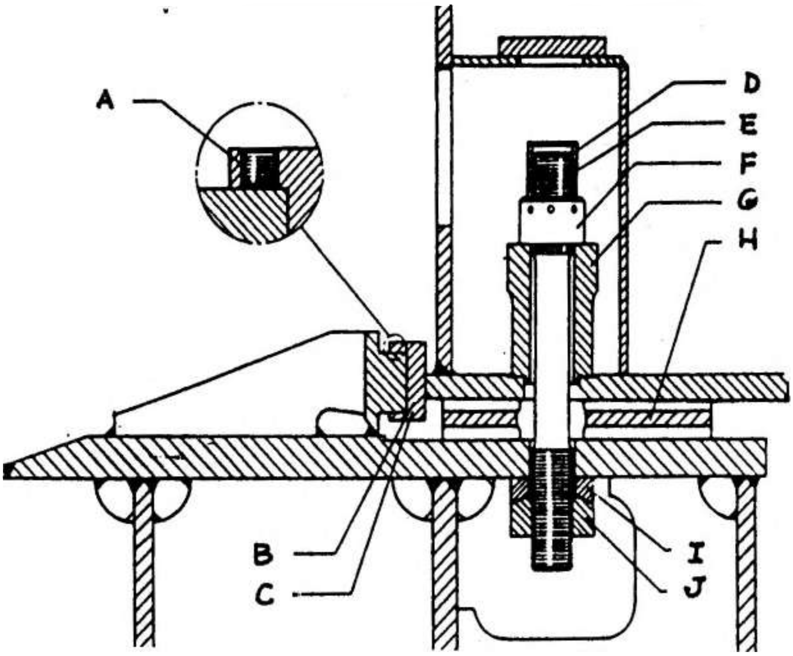
Parts:

A. O-ring
B. Valve head
C. O-ring
D. Thrust spindle
E. Disc
F. Spring
G. Guide pin
H. Spring guide
I. Thrust Foot
J. Holder
K. Spindle guide complete
L. Nozzle
M. Union nut
N. O-ring

FUEL INJECTOR VALVES

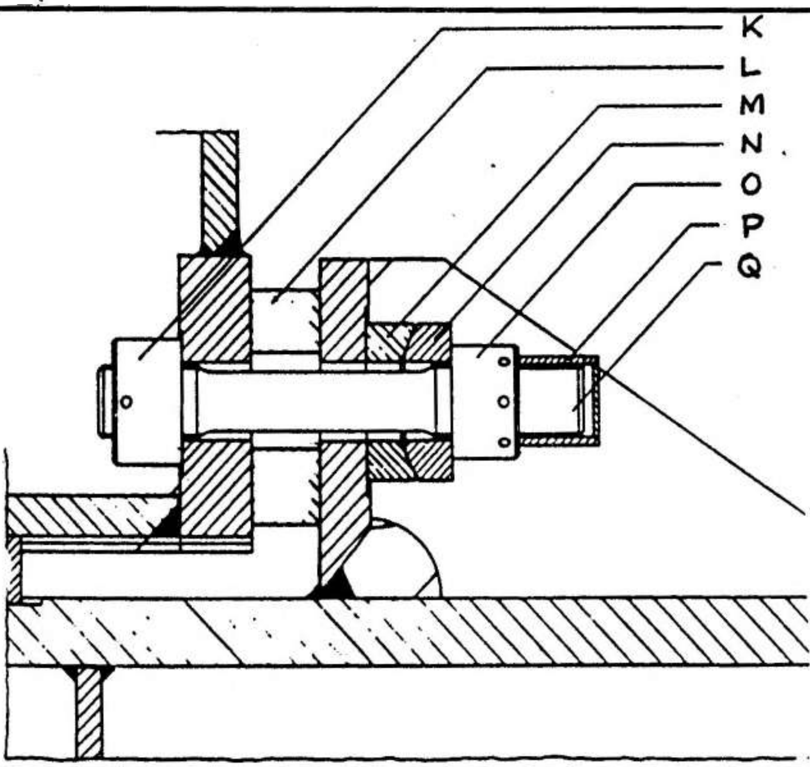


ARRANGEMENT OF STAYBOLTS
ME B & W S70 MC



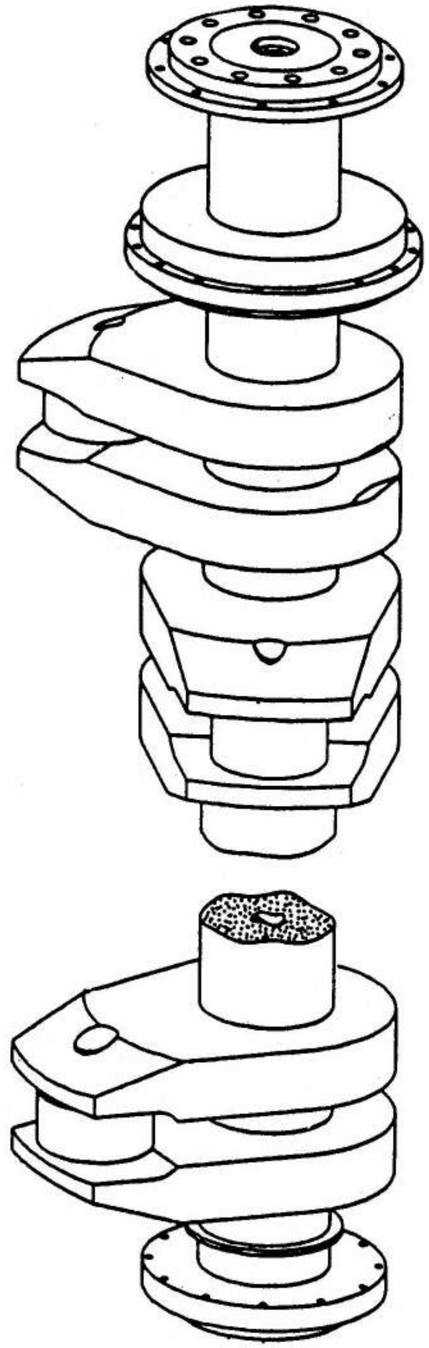
Parts:
A. Grub screw
B. Liner, port side
C. Liner, stbd. side
D. Stud
E. Protective cap
F. Nut
G. Distance piece
H. Liner
I. Spherical washer
J. Spherical nut

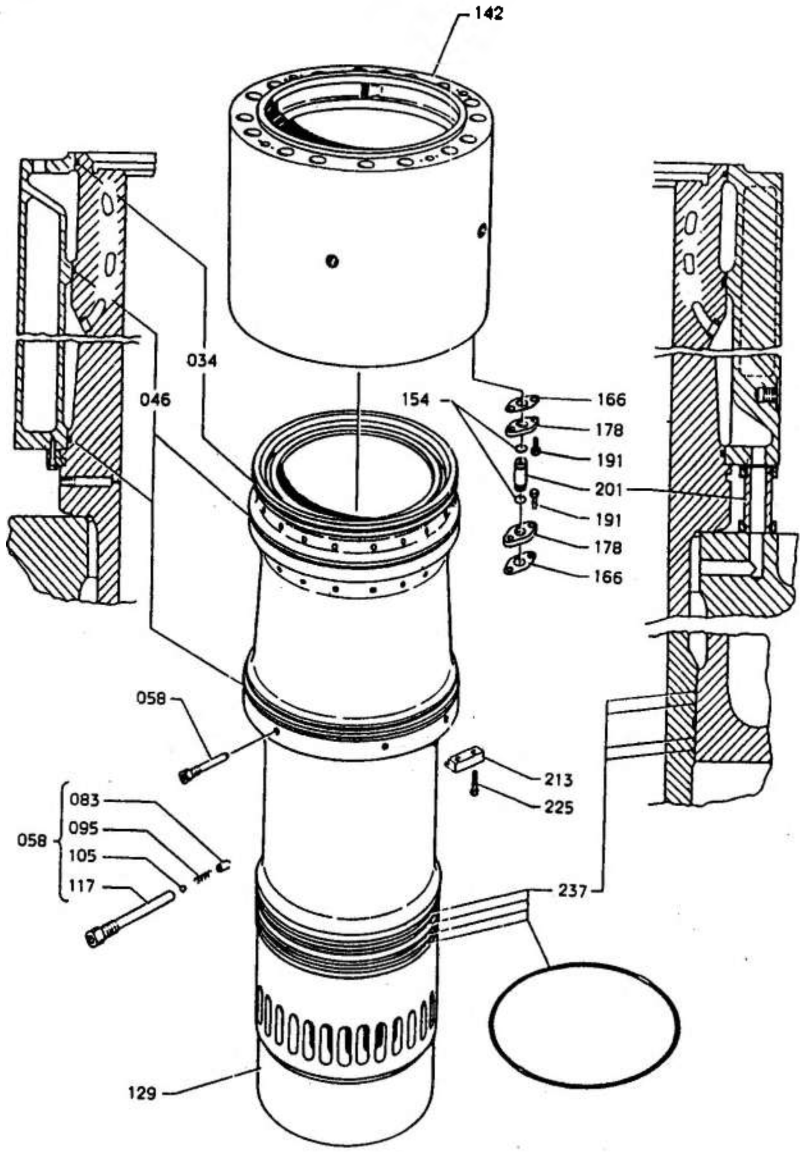
HOLDING–DOWN BOLTS (B & W)



Parts:
K. Nut
L. Liner
M. Spherical washer
N. Spherical washer
O. Nut
P. Protective cap
Q. Stud.

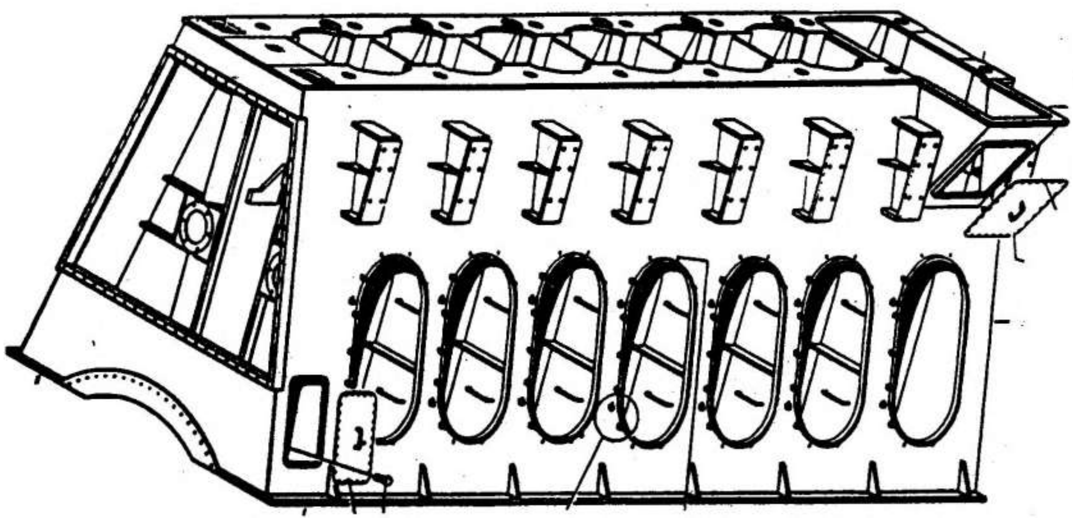
END CHOCK BOLTS (B & W)





010	Plug Screw	105	Ball	191	Screw
022	Gasket	117	Valve housing	201	Pipe
034	O-ring	129	Cylinder liner	213	Clamp
046	O-ring	142	Cooling jacket	225	Screw
058	Non-return valve	154	O-ring	237	O-ring
083	Thrust piece	166	Gasket	240	Plug screw
095	Spring	178	Flange		

CYLINDER LINER



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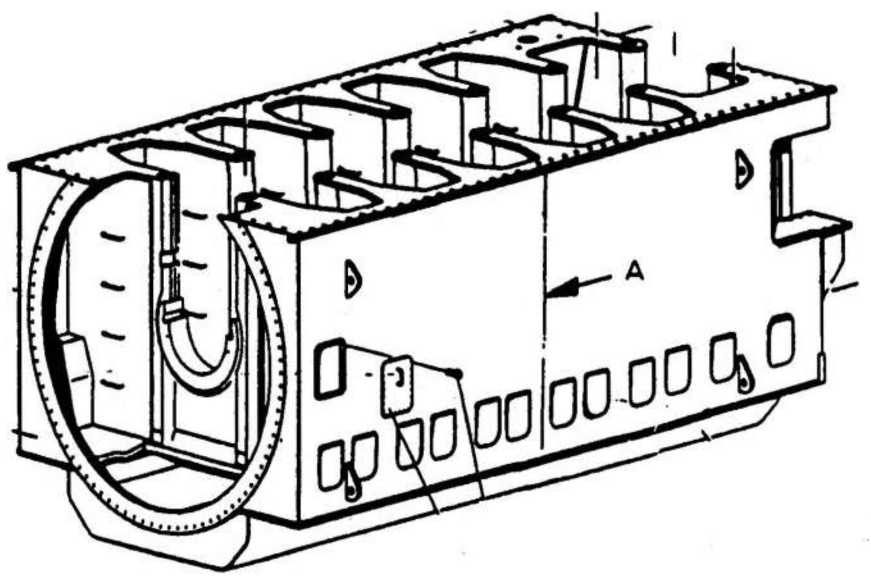
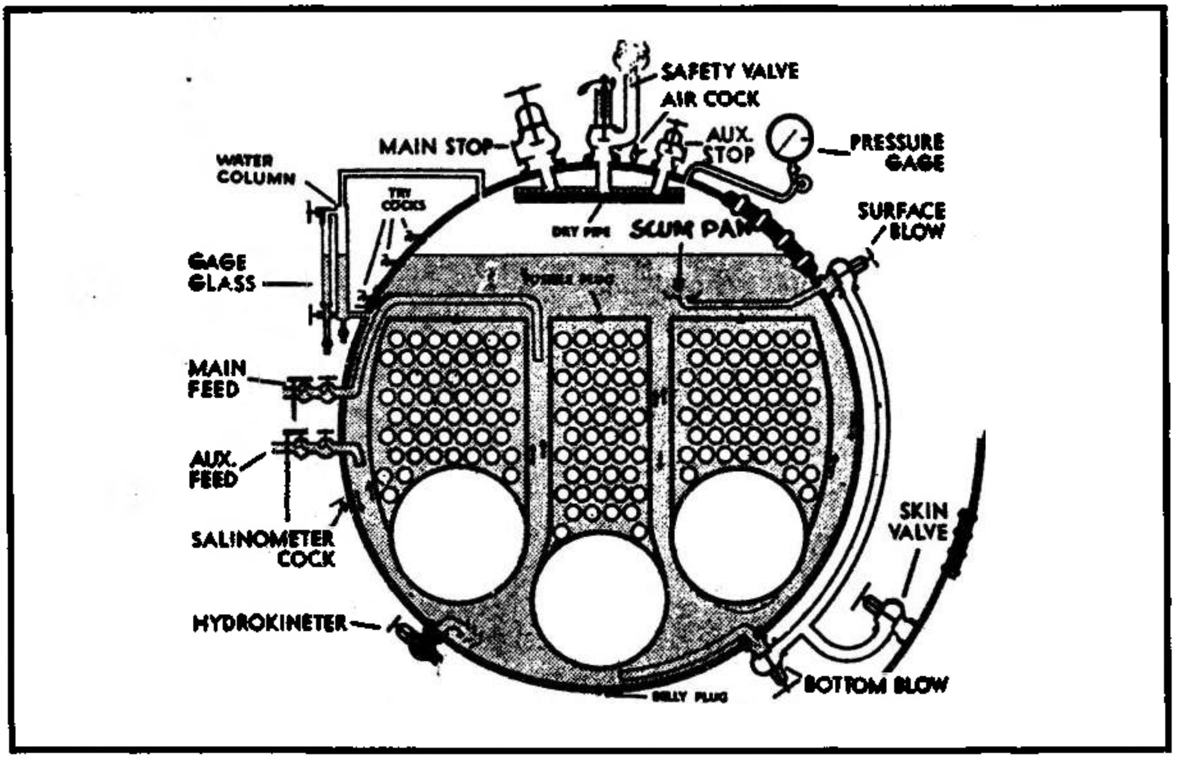
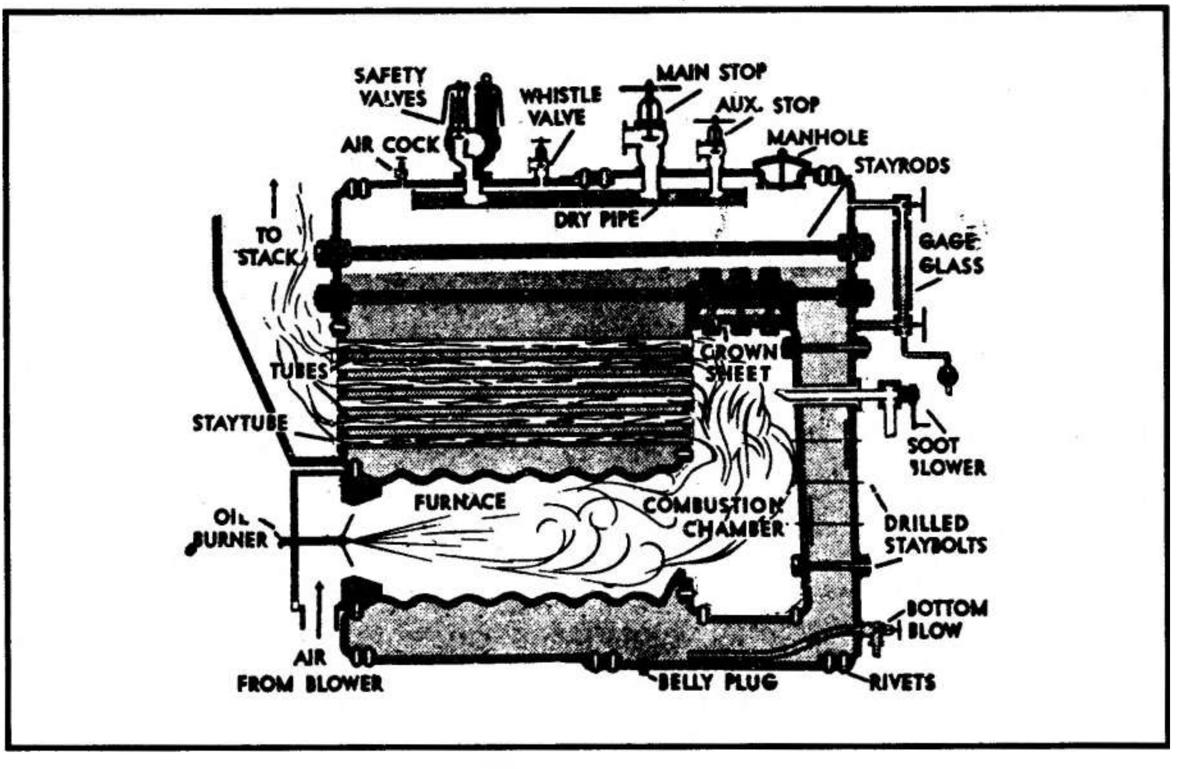


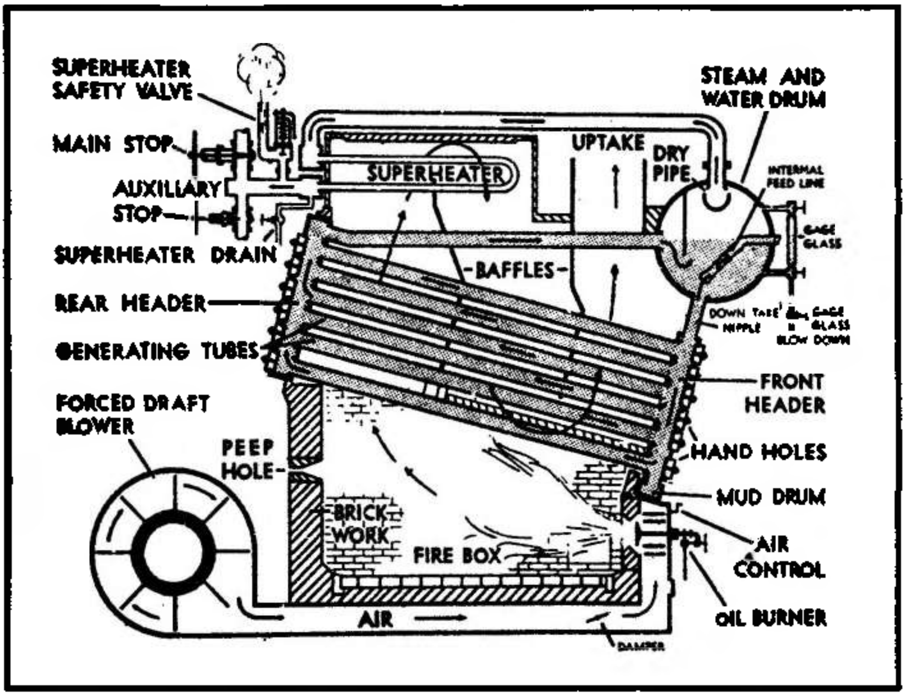
BEDPLATE



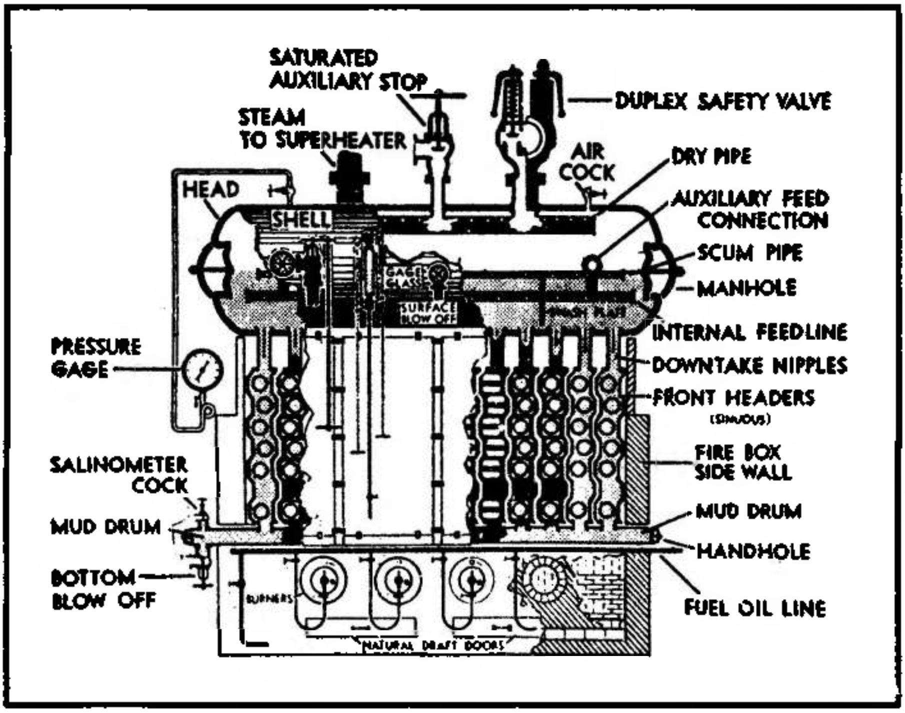
FRONT VIEW OF SCOTH BOILER



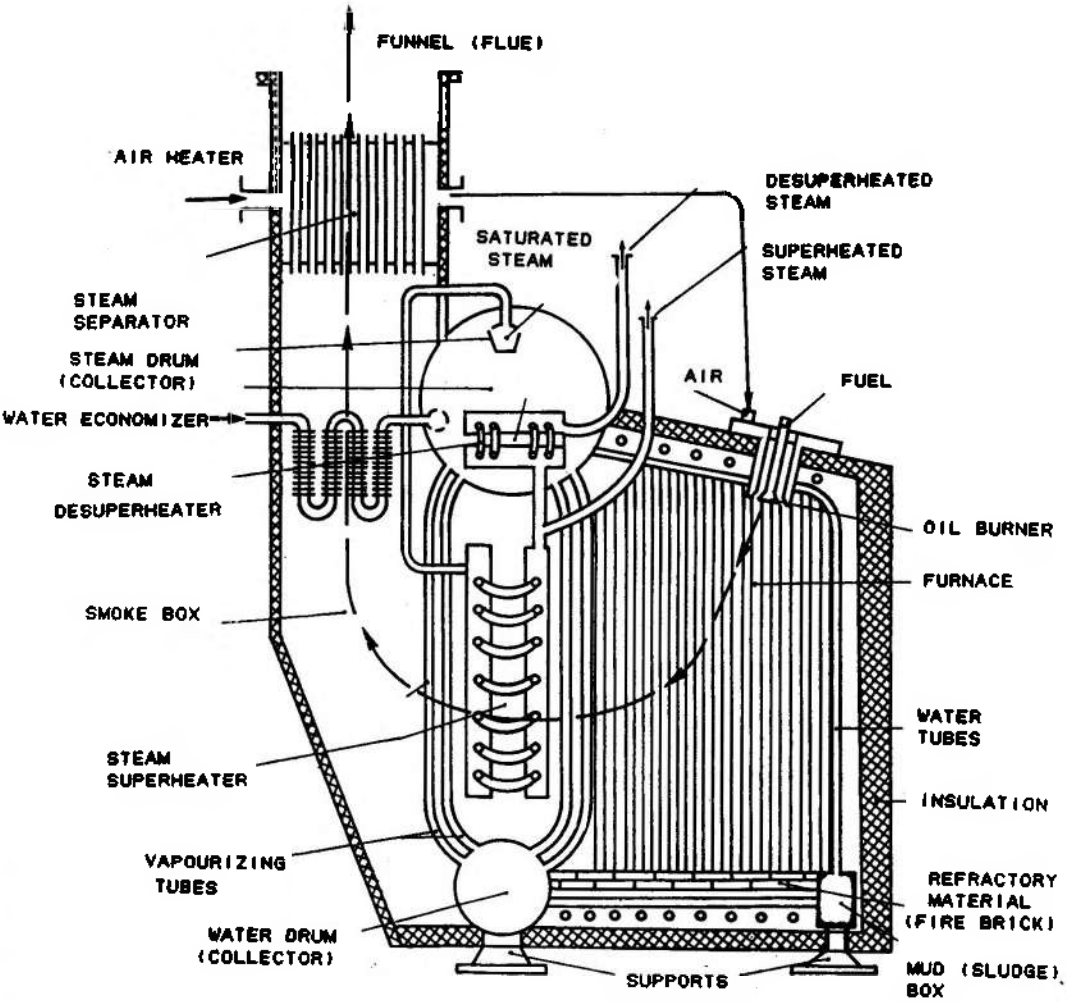
SIDE VIEW OF SCOTH BOILER



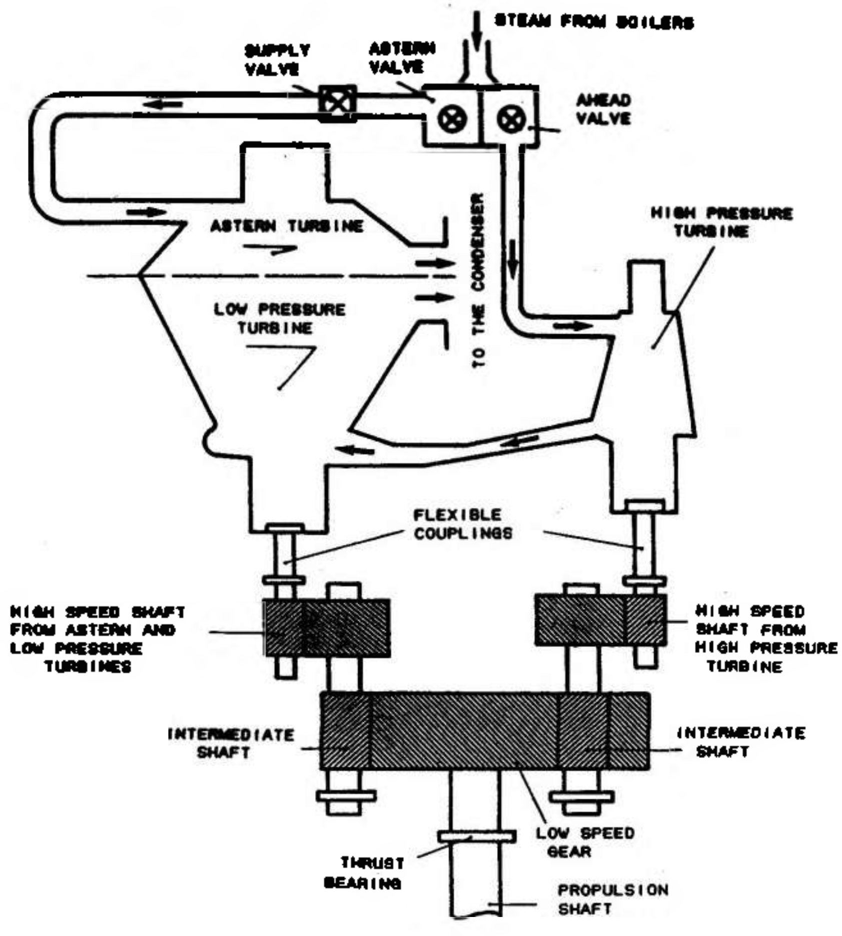
SIDEVIEW OF B & W STRAIGHT TUBE, CROSS DRUM WATER TUBE BOILER – SECTIONAL HEADER



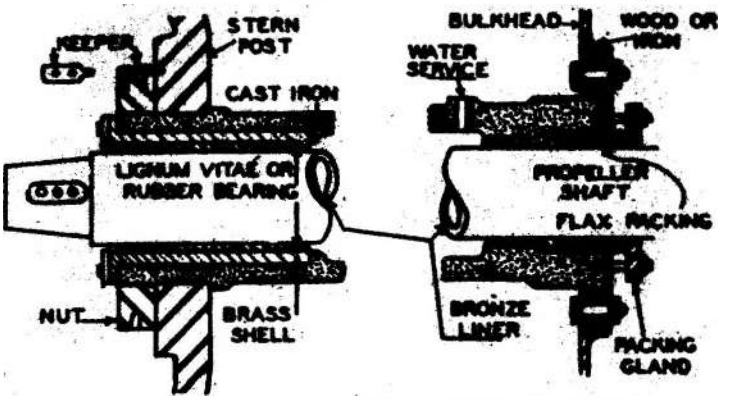
FRONT VIEW OF B & W STRAIGHT TUBE, CROSS DRUM WATER BOILER



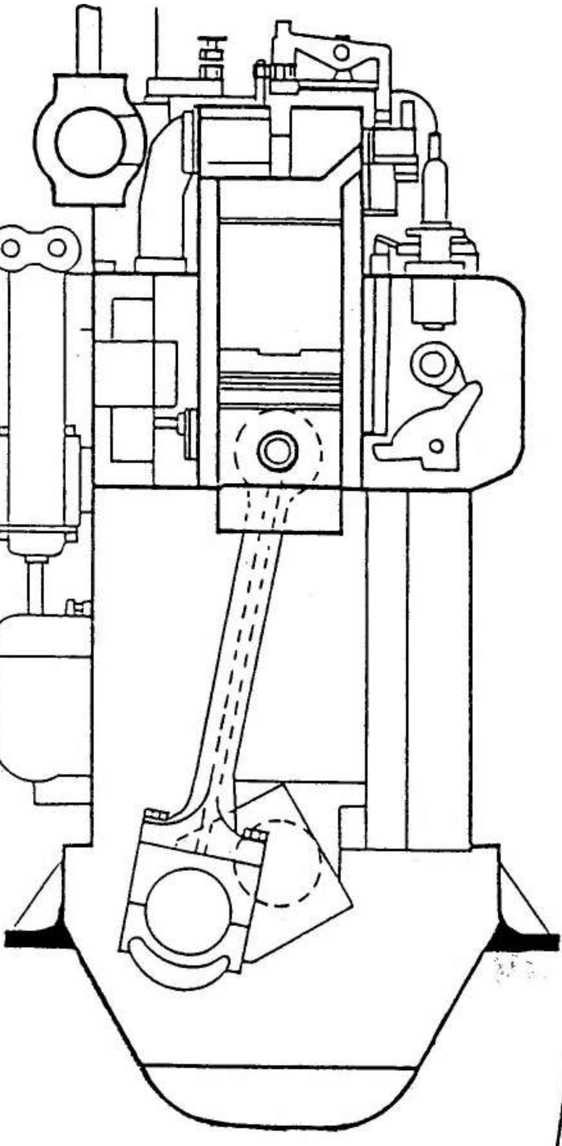
SCHEMATIC DIAGRAM OF MARINE BOILER



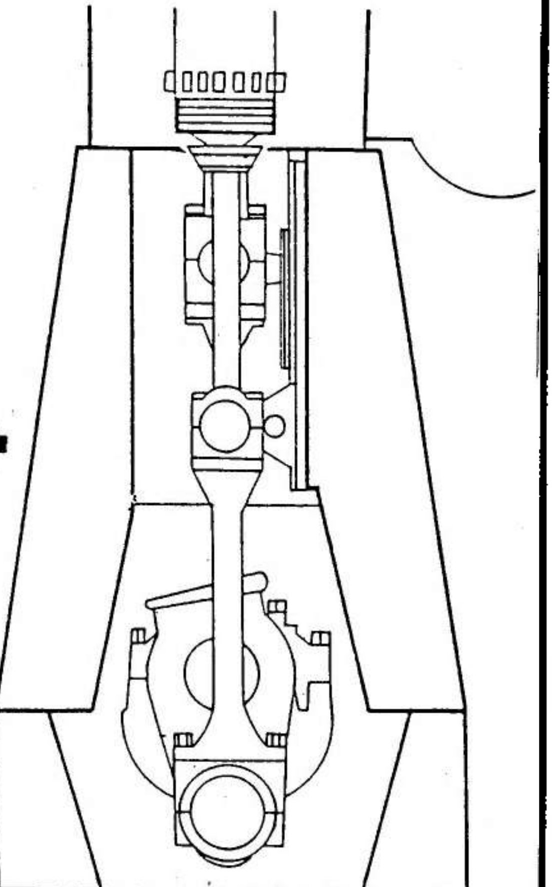
MAIN PROPULSION STEAM TURBINE



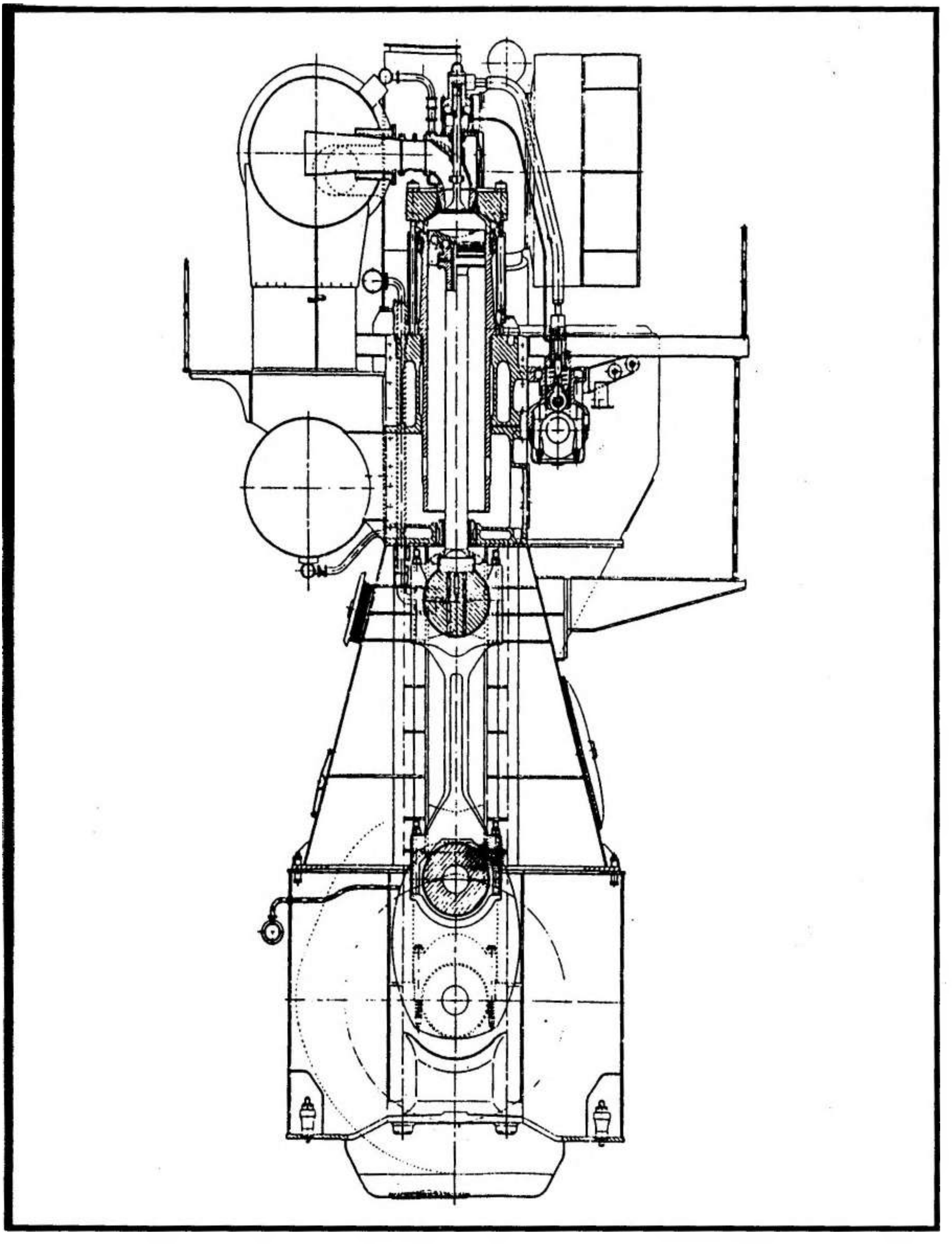
STERN TUBE AND PROPELLER SHAFT



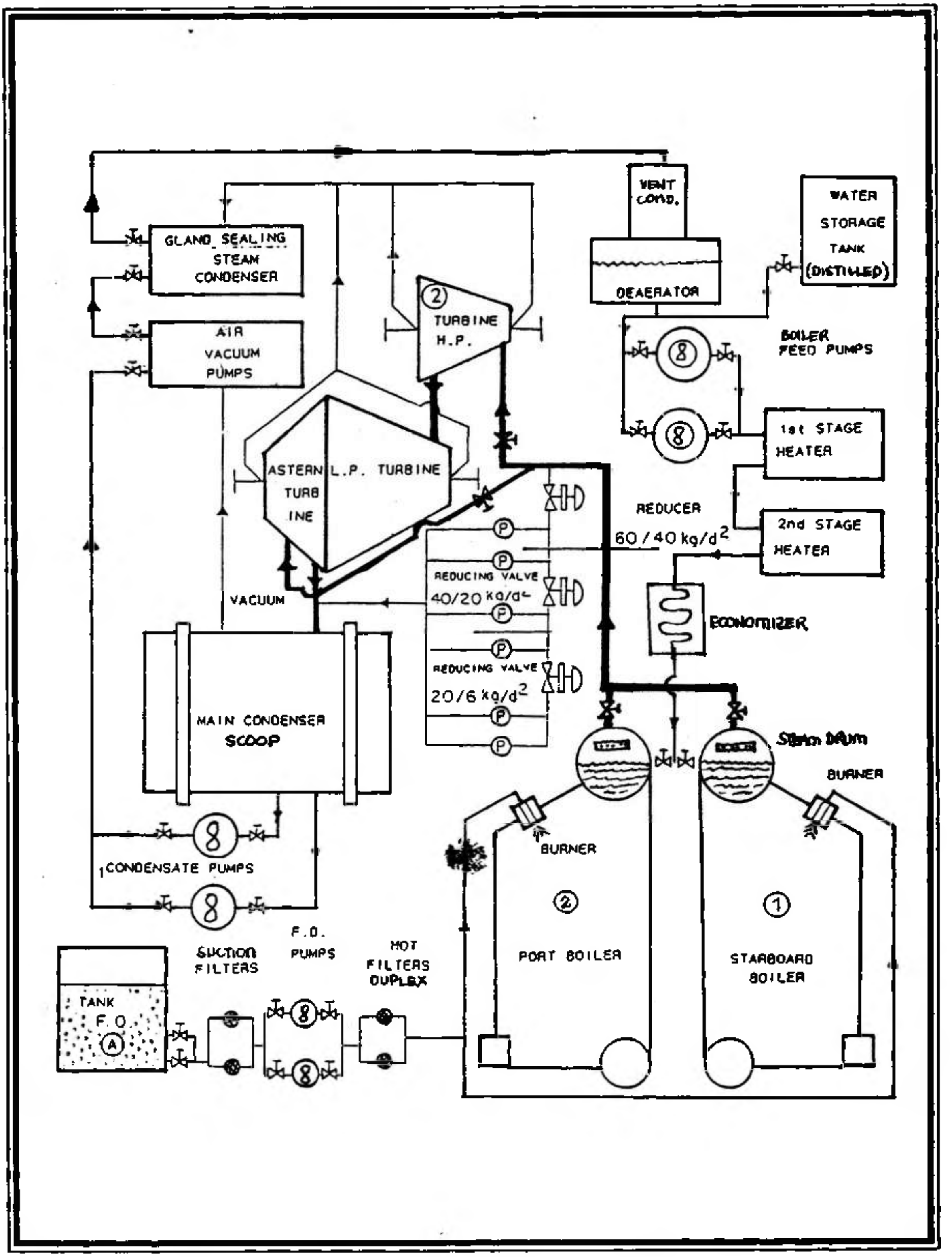
FOUR STROKE ENGINE
TRUNK TYPE



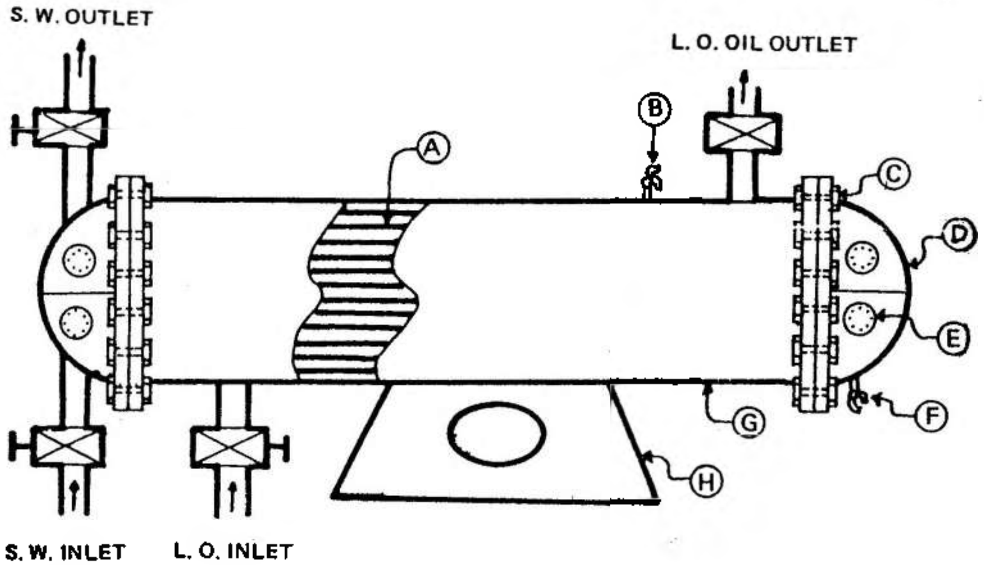
TWO STROKE ENGINE
CROSSHEAD TYPE



Two STroke Cycle, Hydraulic, Supercharged, Superlong Stroke, 20590 BHP. In Line Engine
CROSS-SECTIONAL VIEW B & W S70 MC/MCE



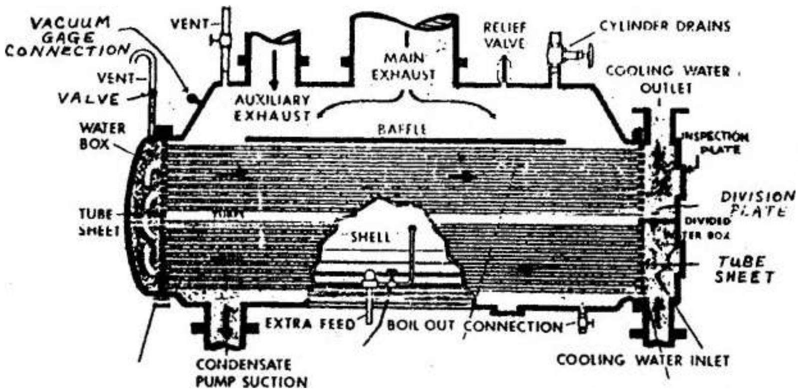
SCHEMATIC DIAGRAM OF STEAM TO WATER CYCLE



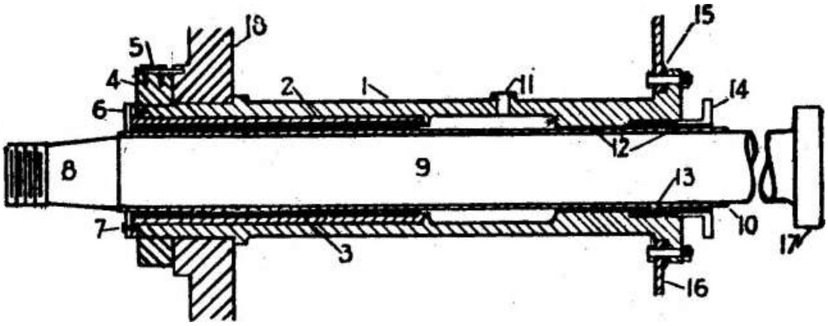
Parts:

- A. Copper Tubes
- B. Oil Purging Cock
- C. Bolt & Nut
- D. End Cover
- E. Inspection Hole
- F. S.W. Drain Cock
- G. Condenser Shell
- H. Base

LUBE OIL COOLER – SHELL TYPE



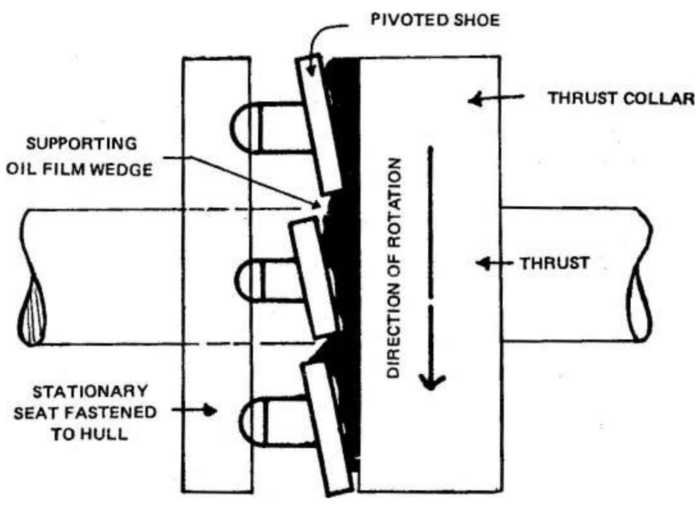
TWO–STAGE STEAM CONDENSER



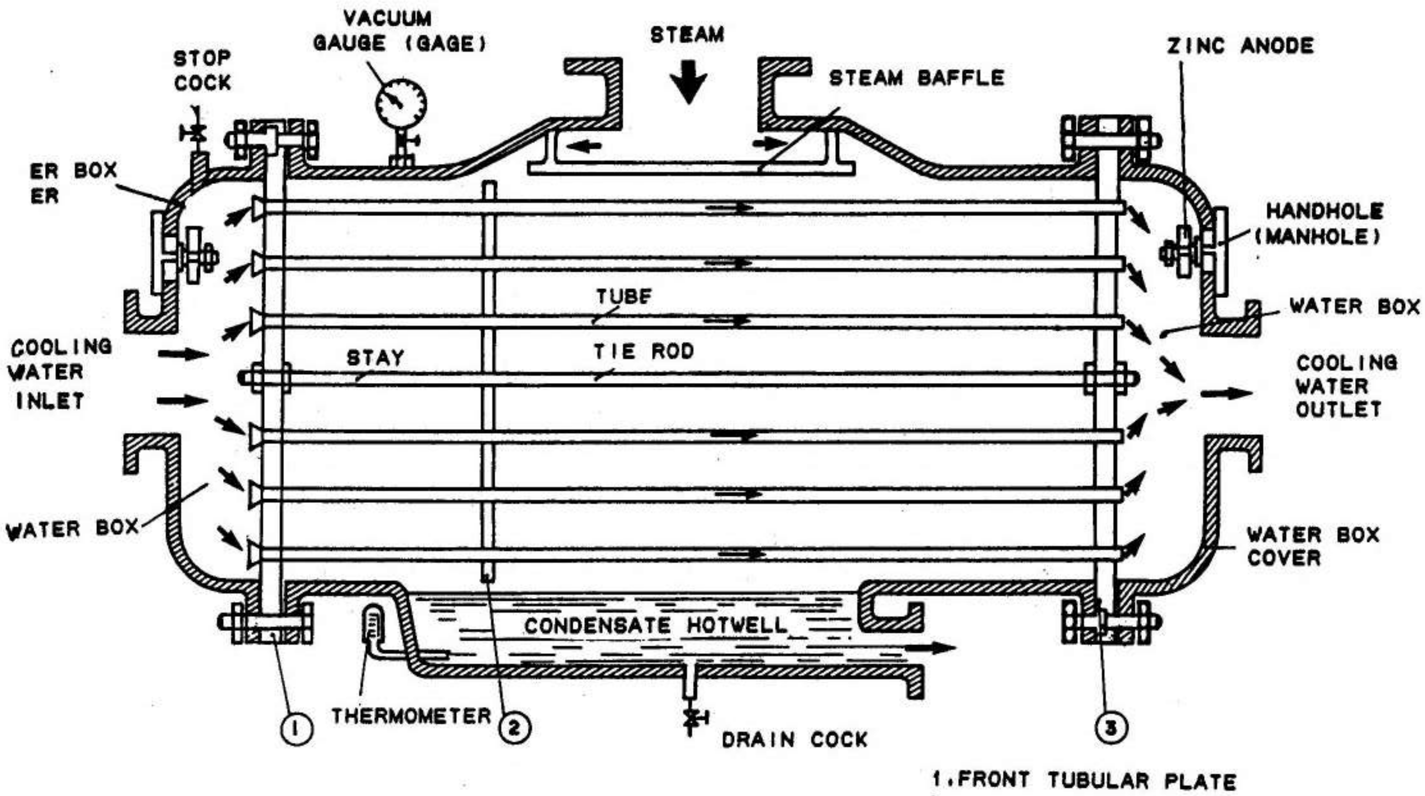
Parts:

1. Stern tube
2. Bronze bushing
3. Lignum-vitae
4. Nut
5. Keeper
6. Retaining ring
7. Cap-screw
8. Propeller taper
9. Tail shaft
10. Continuous brass liner
11. Water service
12. Brass-bushing
13. Packing
14. Packing gland
15. Wood liner
16. Bulkhead
17. Coupling
18. Stern post

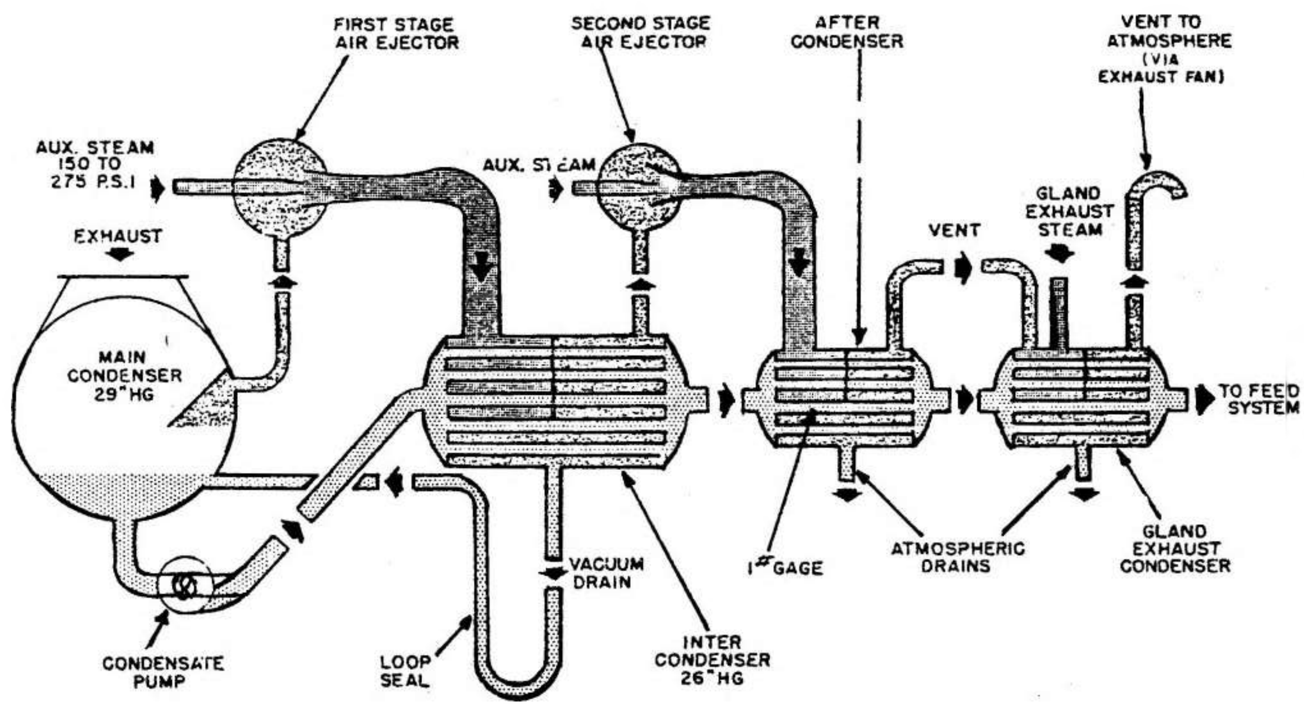
TAILSHAFT IN STERN TUBE



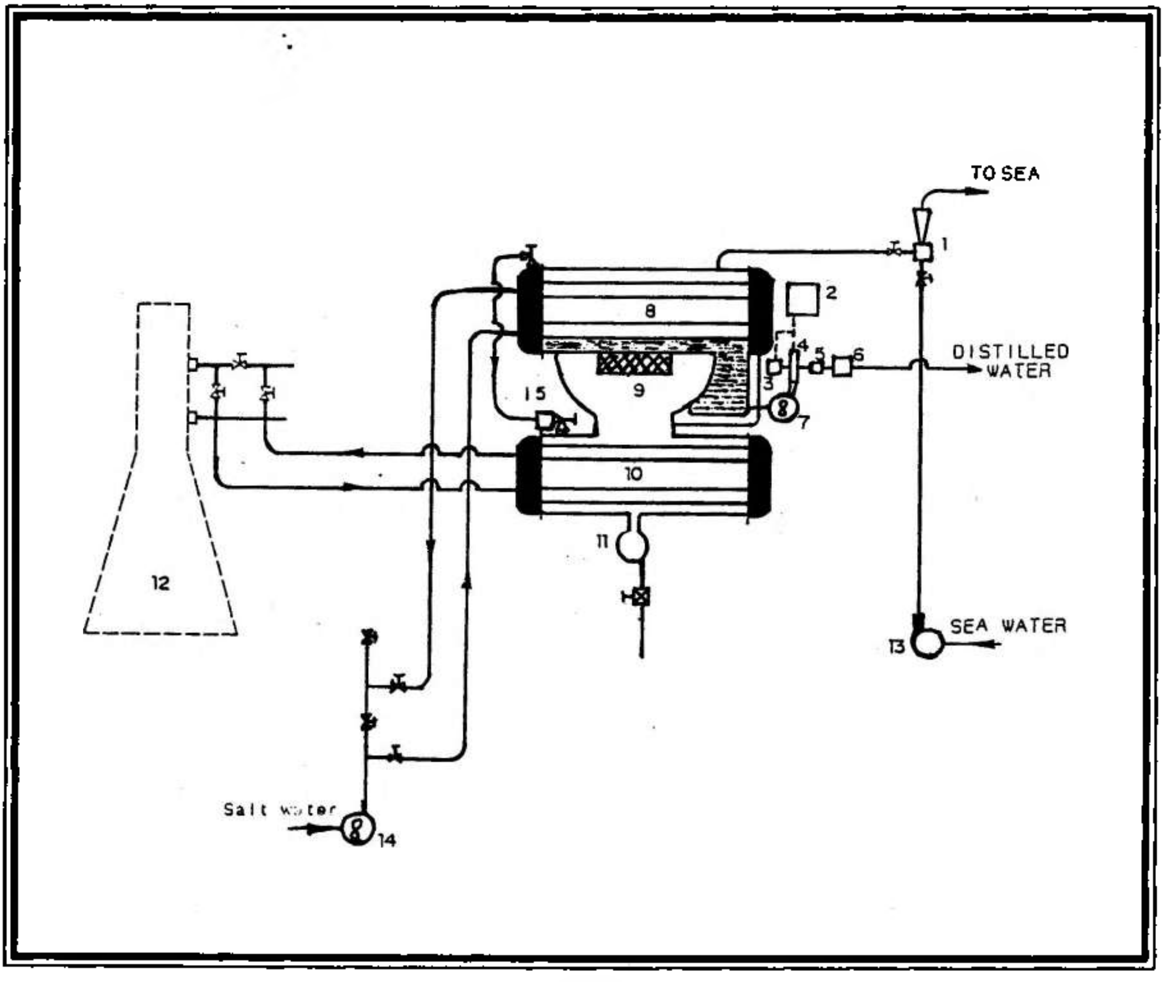
KINGSBURY THRUST BEARING



SCOOP TYPE MAIN CONDENSER



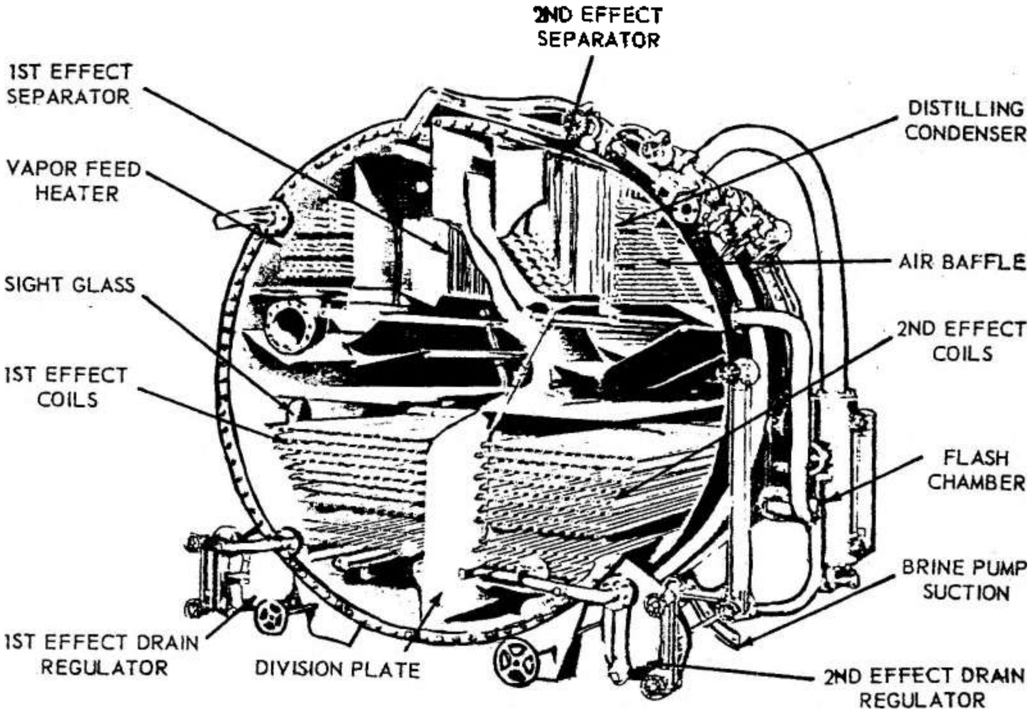
TWO–STAGE AIR EJECTOR SYSTEM



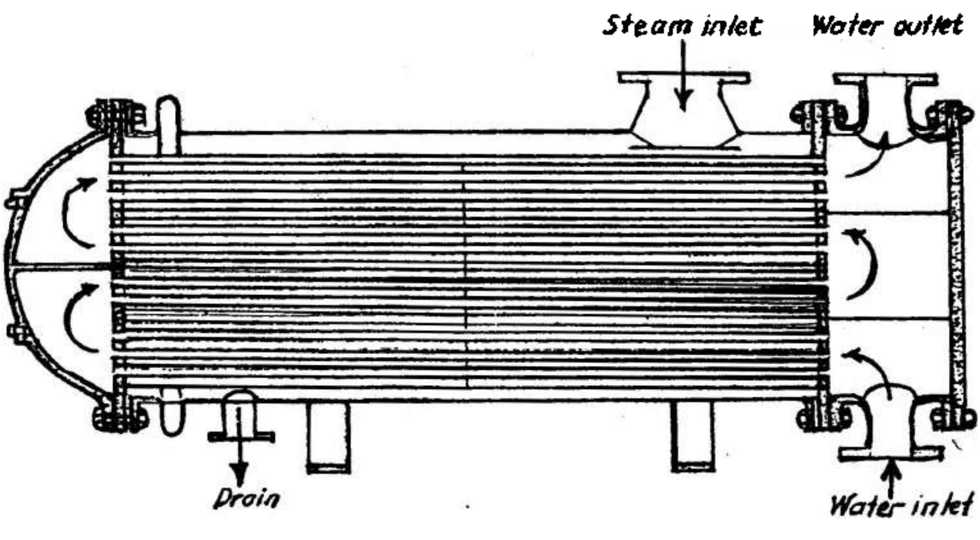
FRESH WATER GENERATOR (ATLAS)

Parts:

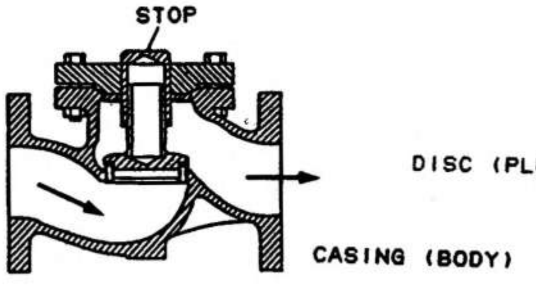
1. Ejector
2. Salinometer
3. Solenoid Valve
4. Salinity Sensor
5. Strainer
6. Meter
7. Distillate Pump
8. Condenser
9. Separator
10. Heater
11. Brine Pump
12. Diesel Engine
13. Ejector Pump
14. Circulating Pump
15. Salt Water Feed



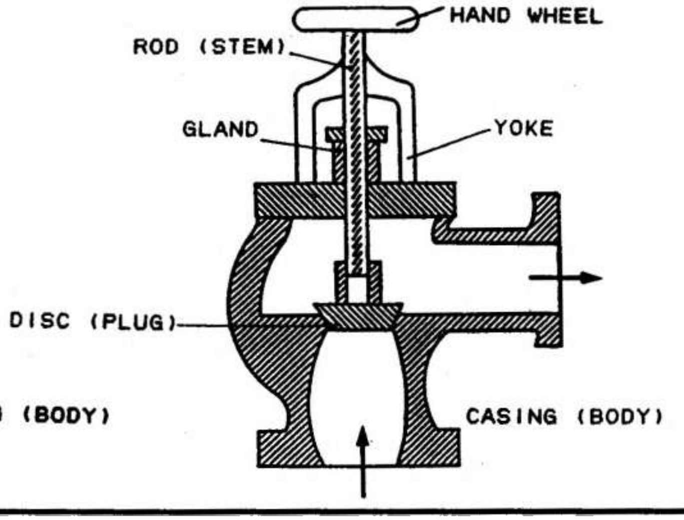
SOLO SHELL TYPE EVAPORATOR



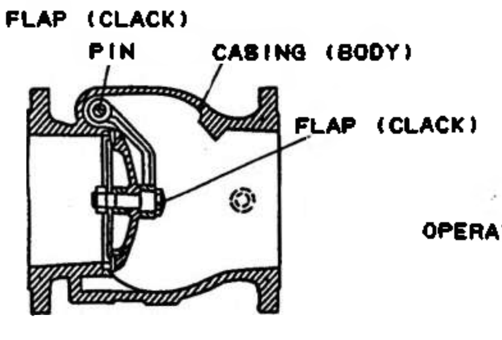
FOUR STAGE FLOW– CLOSED FEEDWATER HEATER



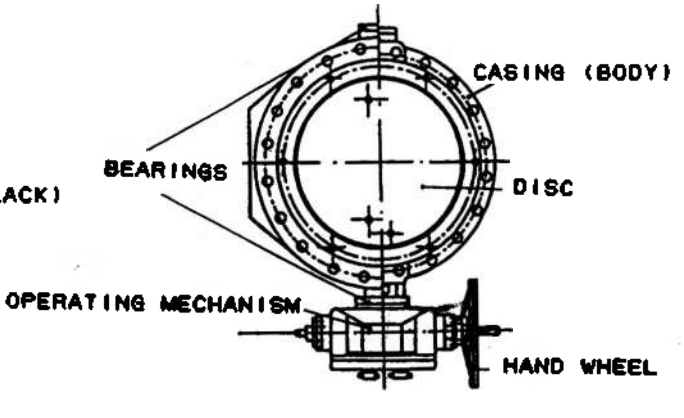
NON-RETURN (CHECK) VALVE



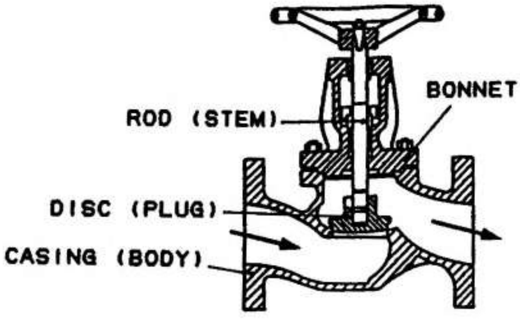
STOP (SHUT-OFF) AND NON-RETURN (CHECK VALVE



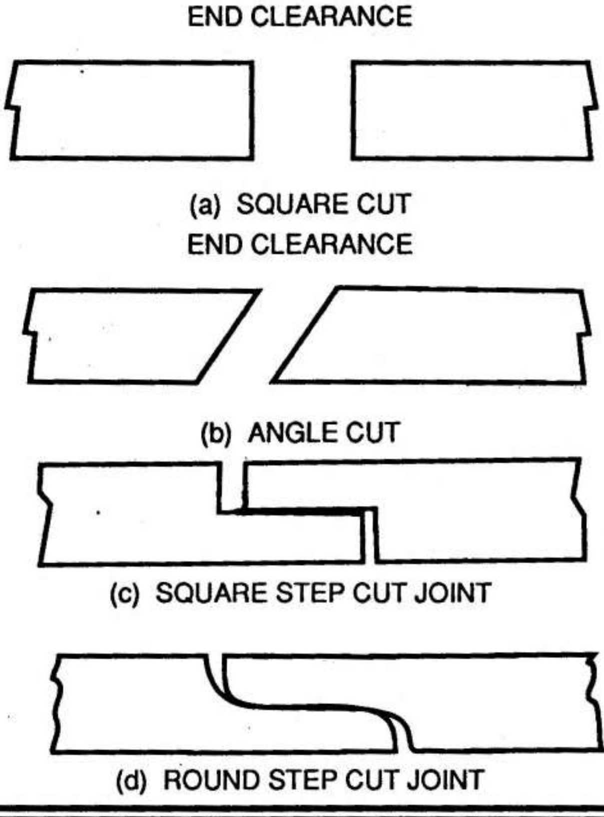
FLAP (CLACK) VALVE



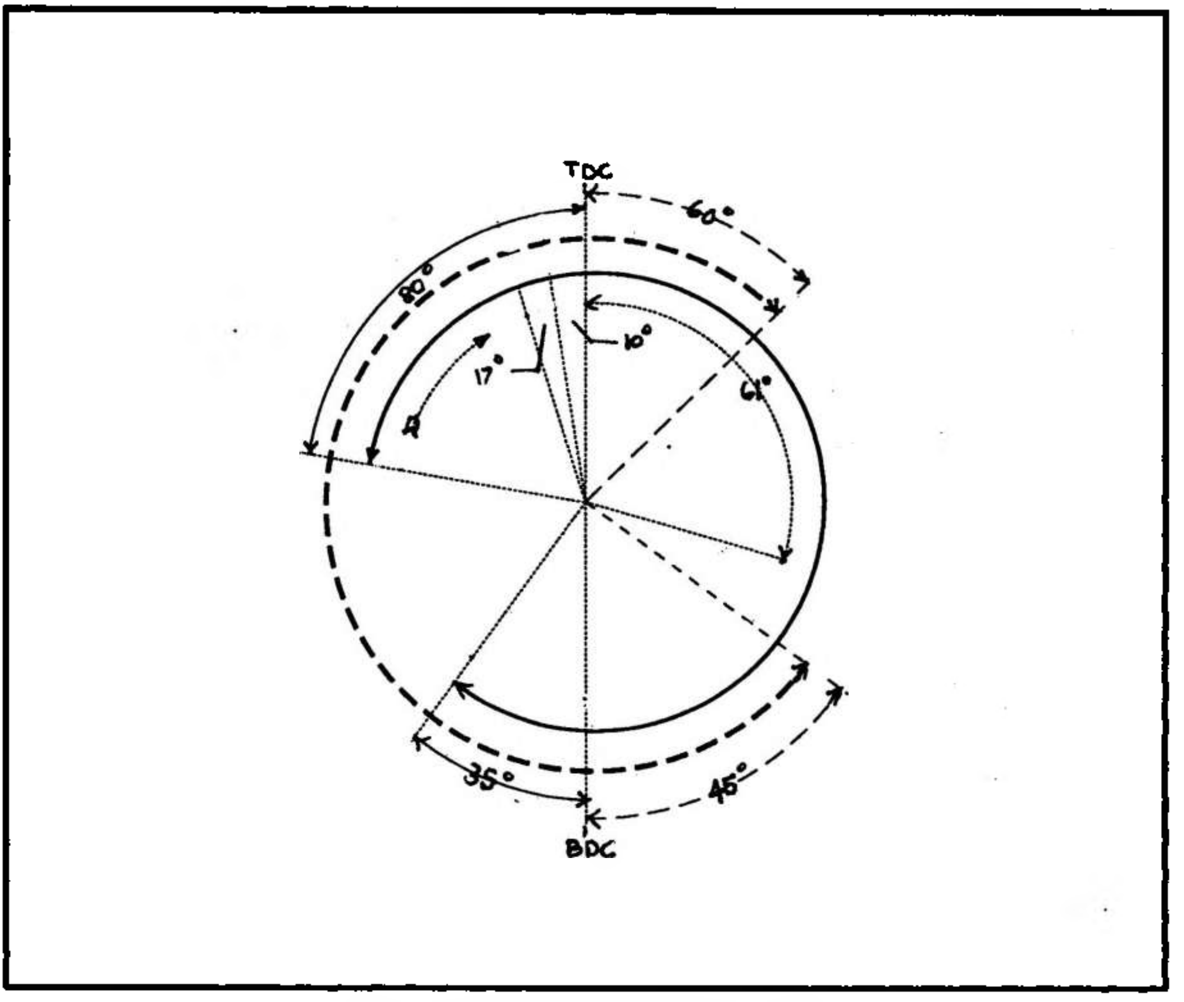
BUTTERFLY VALVE



SECTION THROUGH A GLOBE VALVE

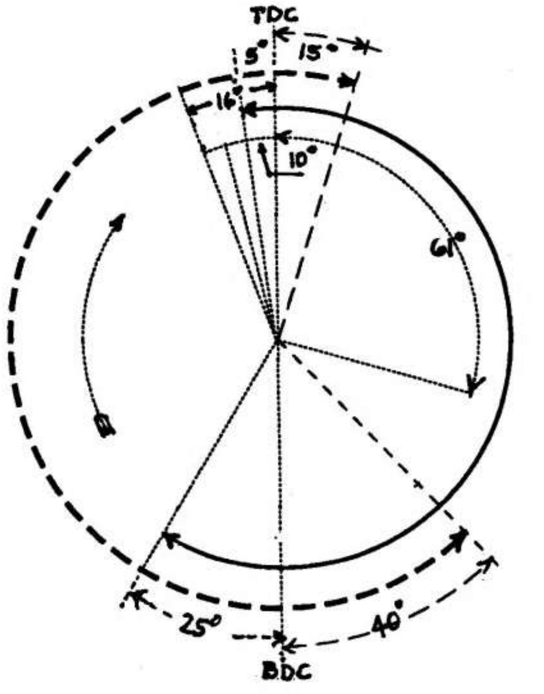


TYPES OF PISTON RING CUTS



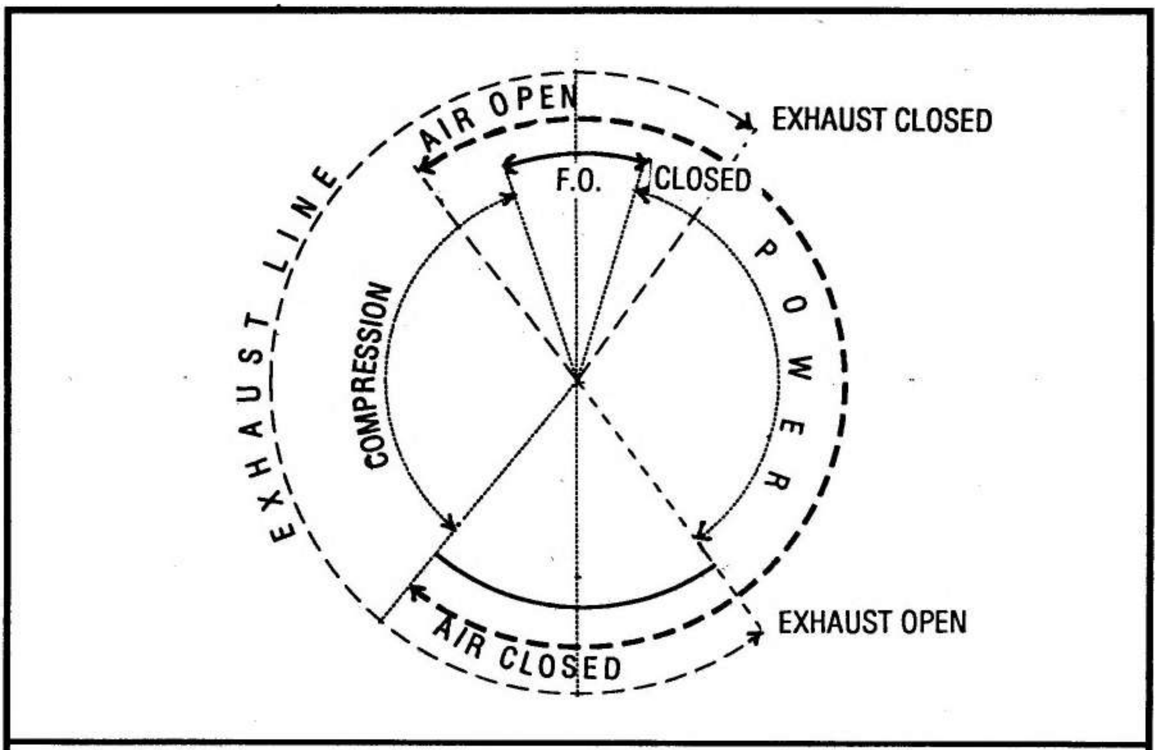
DIESEL ENGINE TIMING DIAGRAM
(Pressure Charged and Intercooled)

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. } Open for 71°
Starting air valve closes, 61° B.B.C.
Fuel injection starts, 17° B.T.C. Pressure, 3,000 lb.
Inlet valve opens, 80° B.T.C. } Open for 295°
Inlet valve closes, 35° A.B.C.
Exhaust valve opens, 45° B.B.C. } Open for 285°
Exhaust valve closes, 60° A.T.C.
Scavenge period= 80° + 60° = 140°
Inlet valve open = 80° + 180° + 35° = 295°
Exhaust valve open = 45° + 180° + 60° = 285°

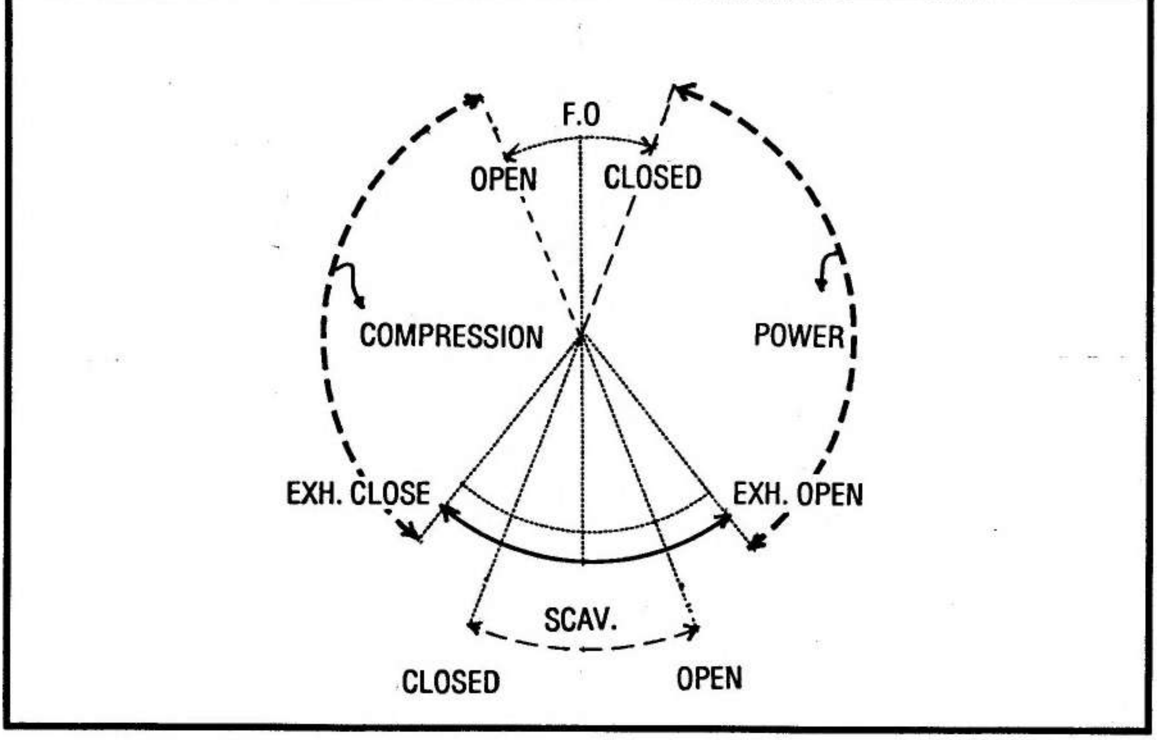


DIESEL ENGINE TIMING DIAGRAM
(Normal Aspirated)

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. } Open for 71°
Starting air valve closes, 61° B.B.C.
Fuel injection starts, 16° B.T.C. Pressure, 3,000 lb.
Inlet valve opens, 5° B.T.C. } Open for 295°
Inlet valve closes, 25° A.B.C.
Exhaust valve opens, 40° B.B.C. } Open for 285°
Exhaust valve closes, 15° A.T.C.
Overlapped period inlet and exhaust = 5° – 15° = 20°
Air admission period = 5° + 180° + 25° = 210°
Exhaust period = 40° + 180° + 15° = 235°



4 STROKE TIMING DIAGRAM



2 STROKE TIMING DIAGRAM

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.

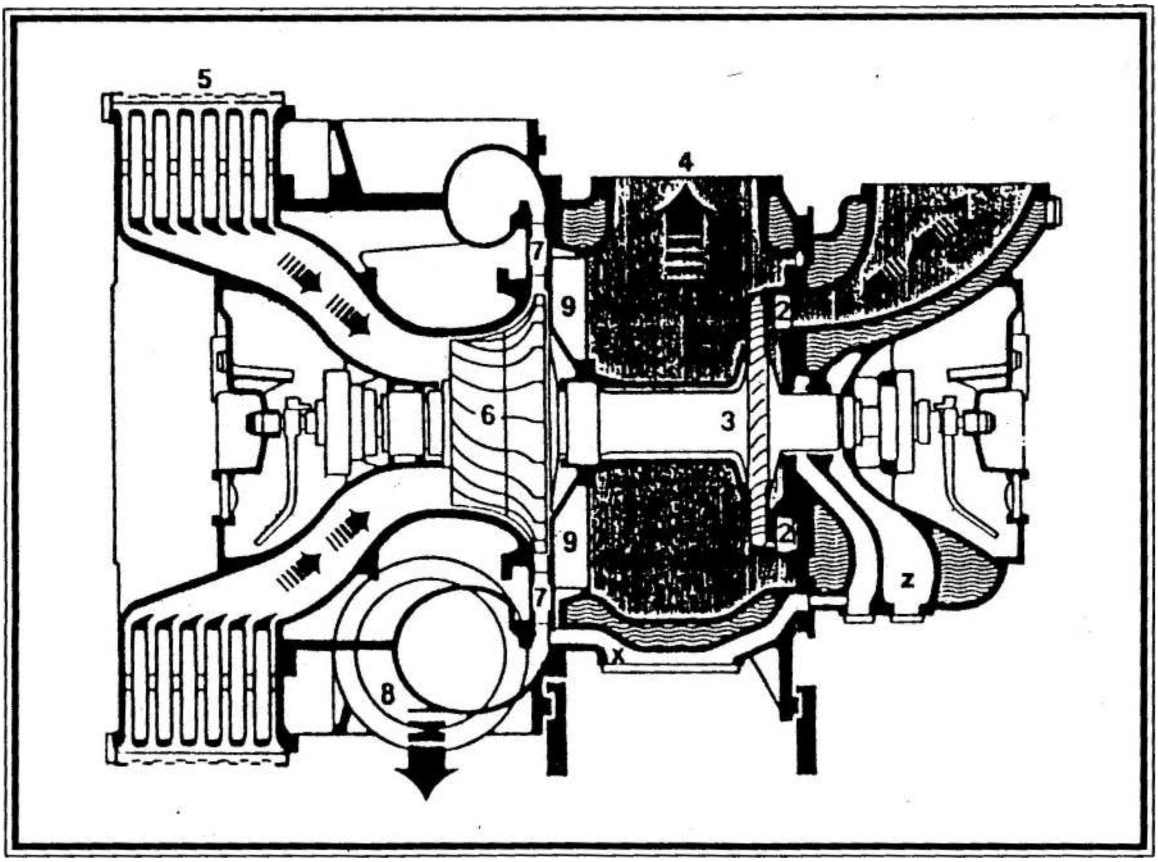
The air required by the engine is drawn through a suction pipe or combined filter/ silencer (5) to the compress (6). It then flows through the diffuser (7) and finally leaves the turbocharger via the pressure pipe of the compressor casing (8).

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.



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:
   a. fillet weld
   b. plug or slot welding
   c. double vee welding
   d. spot weld
   e. flash or upset weld
   f. surfacing weld
   g. backing weld or back
   h. flare vee bevel groove
   i. flange edge weld
   j. melt through weld (one side)

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.

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

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.

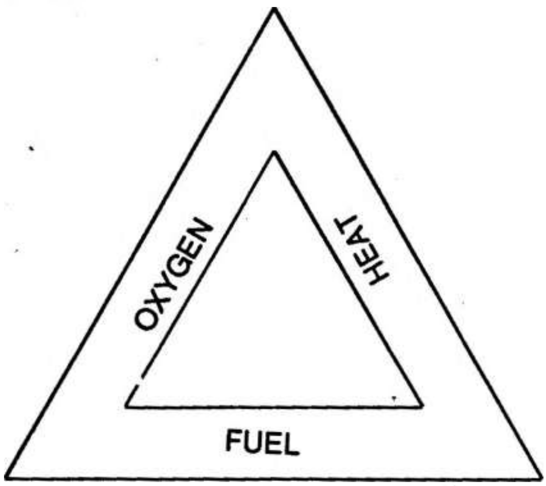
The heat that is radiating back to the fuel is termed as Radiation Feed Back and this plays a very important role to keep the fire going. This heat releases more vapour and raises the vapour to its ignition temperature. At the same time air travels in the area where vapour and flames meet. So the newly 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.

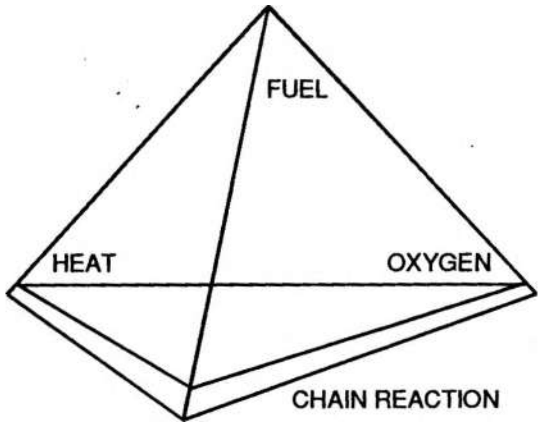
II. SKETCH OF A FIRE TRIANGLE

a.



THE TRIANGLE OF COMBUSTION.

b.



THE FIRE TETRAHEDRON

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 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.
l. 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.

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_2 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^3 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_2 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.

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_2 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_2 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_2 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_2 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_2 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_2 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 45ºC (approx.) but fire fighters are expected to carry out work up to a temp. of 1000ºC. 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.

Personnel engaged in operations must always wash their hands thoroughly before eating and should not wear or bring, contaminated clothing into the accommodation.

In case of an accident ship captain's Medical Guide is to be consulted and medical advice is to be obtained as soon as possible.

Handling Hazardous Gases

Direct contact with cold liquid or vapour or uninsulated pipes and equipment can cause:

1. Cold burns or 'frostbite'.
2. Permanent damage to certain organs (e.g. lungs, eyes).

Personnel who are involved in cargo operation or handling equipment containing cargo must wear protective clothing to cover the whole body.

Personnel who are on tank deck but not engaged in operations must wear adequate clothing to cover the whole body.

If frostbite of the skin does occur accidentally,

1. Remove any clothing that may restrict the circulation to the frozen area.
2. Immediately immerse the affected area in a water bath with a temperature between 40^0 and 46^0C.

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.
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

ADULT ONE-RESCUER	ADULT TWO-RESCUER	CHILD	CHILD
"Are you okey?"	"Are you okey?"	"Are you okey?"	"Are you okey?"
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	CHILD	INFANT
1 BREATH EVERY 5 SECONDS	1 BREATH EVERY 4 SECONDS	1BREATH EVERY 3 SECONDS

OBSTRUCTED AIRWAY COMPARISON CHART

CONSCIOUS VICTIM

ADULT	CHILD	INFANT
HEIMLECH MANEUVER	HEIMLECH MANEUVER	4 BACK BLOWS, 4 CHEST THRUSTS

UNCONSCIOUS VICTIM

ADULT	CHILD	INFANT
6 TO 10 ABDOMINAL THRUSTS	6 TO 10 ABDOMINAL THRUSTS	4 BACK BLOWS 4 CHEST THRUSTS
FINGER SWEEP	FINGER SWEEP IF OBJECT IS VISIBLE	FINGER SWEEP IF OBJECT IS VISIBLE
Attempt to ventilate	Attempt to ventilate	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*

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, explosions, 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

1. *Temporal*
   Location : Directly in front of the ear.
   Control : Bleeding from the head.

2. *Facial*
   Location : About an inch from the angle of the lower jaw towards the chin.
   Control : Bleeding from the face.

3. *Carotid*
   Location : In the neck, beside the wind pipe.
   Control : Bleeding from the throat and the upper neck.

4. *Subclavian*
   Location : Behind the collarbone, near its inner end.
   Control : Bleeding from the shoulder, armpit and part of the upper arm.

5. *Brachial*
   Location : Inner aspect of the upper arm.
   Control : Bleeding from the arm.

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
c. Neck–forearm–leg bandaging
d. Elbow–knee bandaging
e: Crushed palm bandaging
f. Five overlap bandaging
g. Ankle bandaging

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

SURVIVAL AT SEA

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 life-boats, 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 inthe 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°C	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	Death (Hypothermia)

WATER TEMPERATURE	RESCUE TIME
0°C – (32°F)	Within one (1) hour
4°C – (40°F)	1/2 to 3 hours
10°C – (50°F)	1 to 6 hours
16°C – (60°F)	2 to 24 hours
21°C – (70°F)	3 to 40 hours
27°C – (80°F)	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 onthe 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.

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.

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.

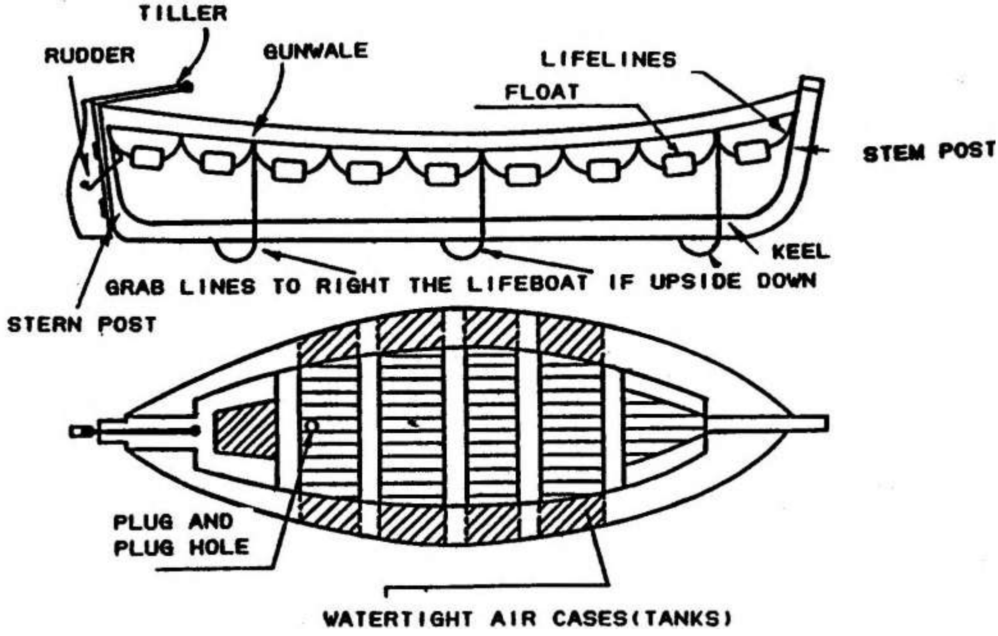
RUBBER – A rounded beading fore and aft.

WATER LINE – Marker between the gunwale and the keel.

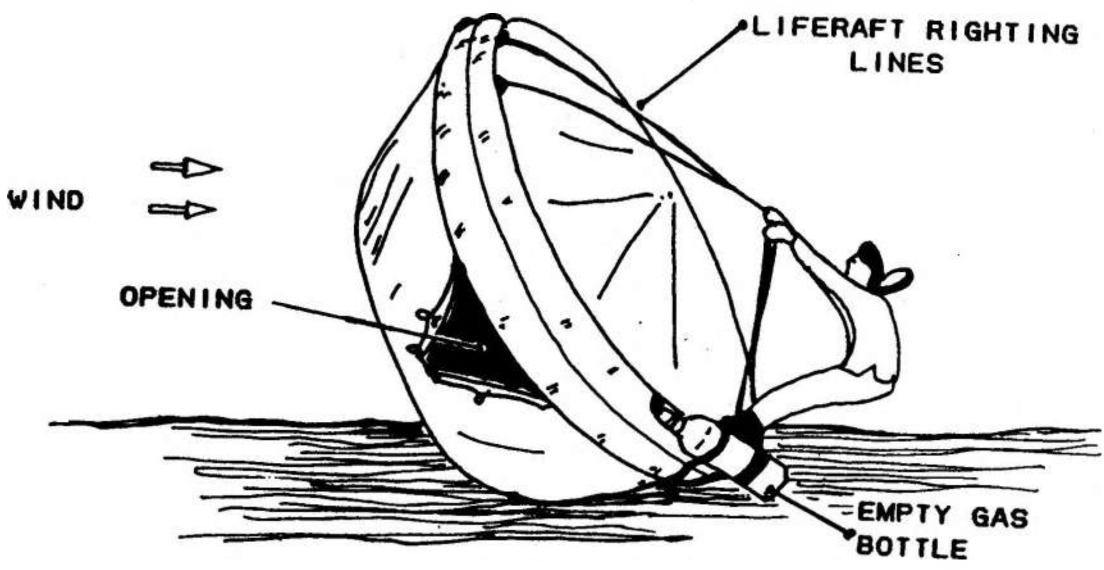
FREEBOARD – Distance between the gunwale and the waterline.

MAST CLAMP – Use to hold mast when it is shipped.

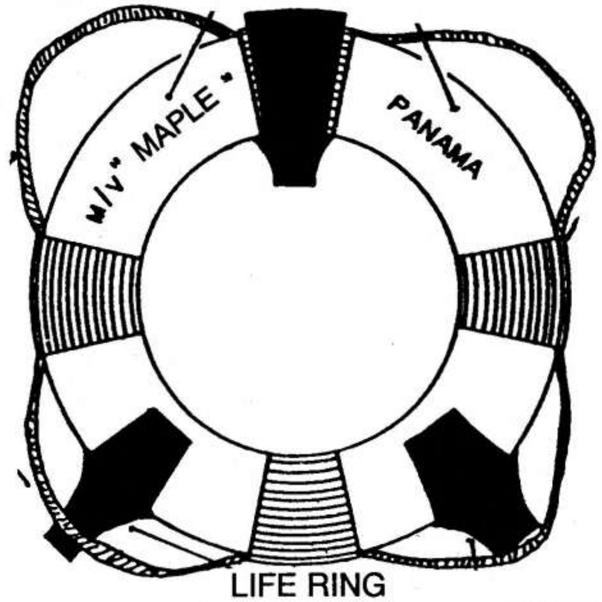
SAFETY EQUIPMENTS ON BOARDSHIP



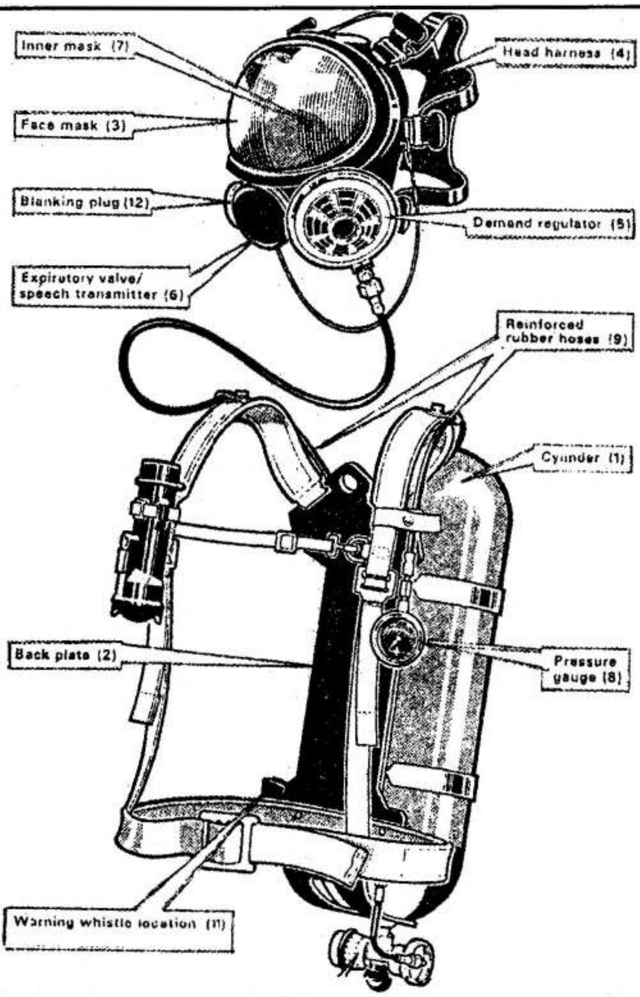
LIFEBOAT



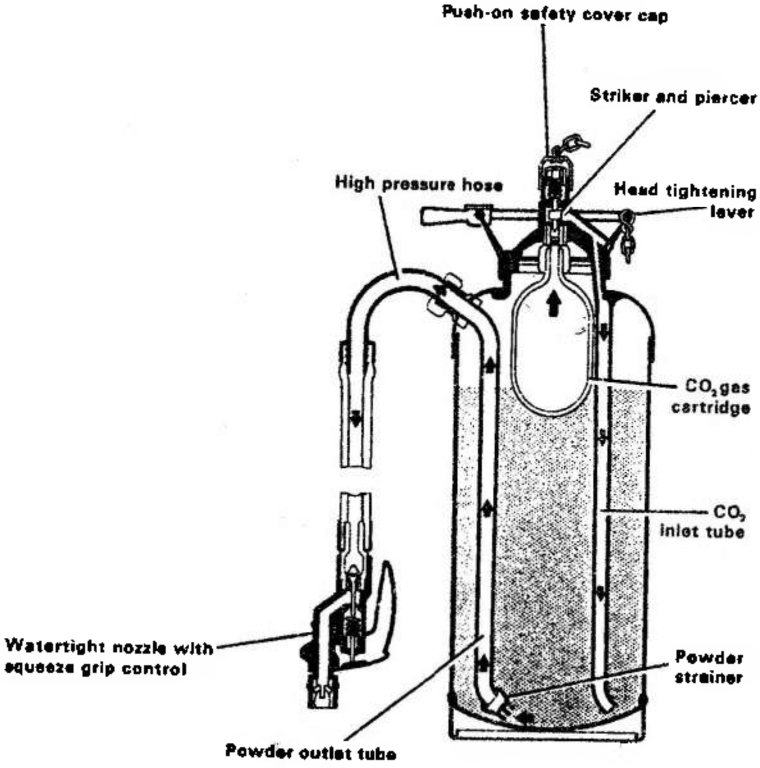
LIFE RAFT



LIFE RING



SELF CONTAINED COMPRESSED AIR BREATHING APPARATUS



FIRE EXTINGUISHER

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 valve 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.

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.
- 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_2 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:

   a. 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 CONCENTRATION MAY BE. An atmosphere containing less than 11% of oxygen is considered to be THEORETICALLY INERT.

Quantity and Rate of Supply of Inert Gas

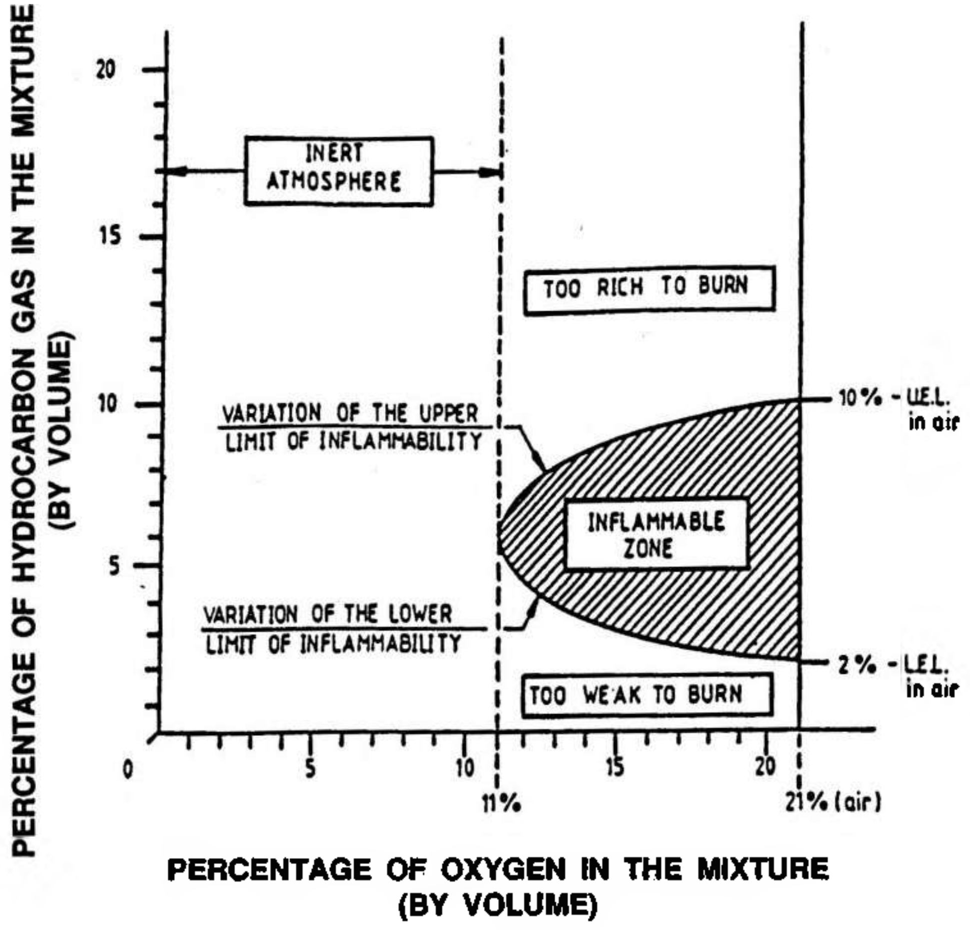
The most critical demand for Inert Gas is during cargo discharge, when the supply must at least equal the cargo discharge rate. Centrifugal cargo pumps have a rated capacity against a nominal head , but on some occasions it is possible to exceed the rated capacity when discharging against a lower head.

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.


INERT ATMOSPHERE
TOO RICH TO BURN
VARIATION OF THE UPPER LIMIT OF INFLAMMABILITY
INFLAMMABLE ZONE
VARIATION OF THE LOWER LIMIT OF INFLAMMABILITY
TOO WEAK TO BURN
10% - U.E.L. in air
2% - L.E.L. in air
0
5
10
15
20
11%
21% (air)
PERCENTAGE OF HYDROCARBON GAS IN THE MIXTURE (BY VOLUME)
PERCENTAGE OF OXYGEN IN THE MIXTURE (BY VOLUME)

Oxygen Levels:

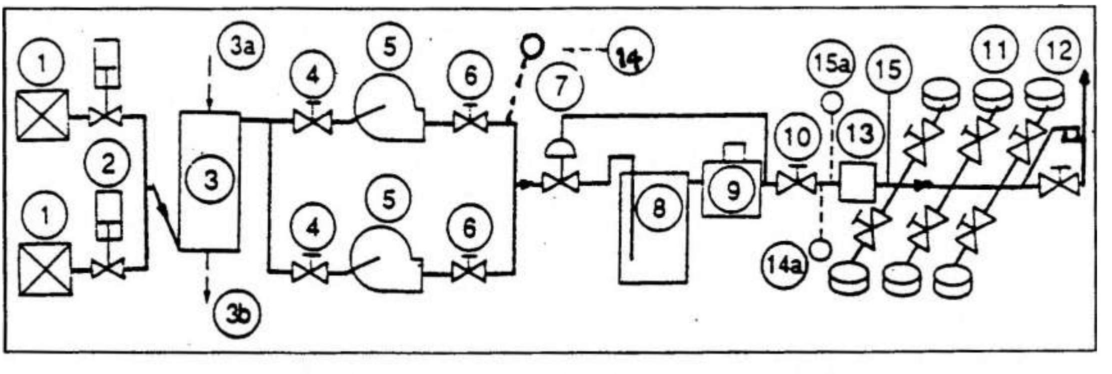
11% Oxygen:	MINIMUN OXYGEN LEVEL necessary to support combustion/ explosion, this level, however, is not considered safety, since there is no margin left for measurement errors.
8% Oxygen:	MINIMUN OXYGEN LEVEL ALLOWED during inert gas plant operations. However, all necessary steps must be taken to ensure 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

0_2	– content:	Approx. 3% by volume
CO_2	– content:	Approx. 13% by volume
SO_2	– content:	Approx. 3000 ppm
NO_2	– content:	Balance

This means that during normal operation of oil tankers the following operational modes frequently take place:

- Inerting of empty tanks
- Inerting 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:

1. Boiler gas uptake	4. Suction valve	9. Back flow valve	14. O_2 – analyser or gas generator
2. Gas uptake valve	5. Fan	10. Isolating valve	14a. O_2 – analyser and recorder
3. Scrubber	6. Supply valve	11. Tank Isolating valve	15. Pressure indicator
3a. Cooling water inlet	7. Pressure control	12. Ventilation (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 boilers/generators.
3.	Inert gas scrubber	Cooling of gas and removal Sulphur dioxide and solid particles.
3a.	Seawater inert	Cooling and washing water inlet to scubber.
3b.	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.	Mast ventilation	For ventilation or relieving of gas pressure from tanks.
11.	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.
12.	Gas analyser	Control of the inert gas with respect to high oxygen content.
12a.	Gas analyser	Oxygen content meter with recorder
13.	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 scrubber	Water flush	After use
	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 from flue gas scrubber	Flushing with scrubber water pump for about one hour	After use
	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 non–return 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/cm². 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/cm².
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_2 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 valve on deck through inspection opening. The valve 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.

THE SECOND WET FILTER AND ESPECIALLY ALONG THE SHELL SIDES SHOULD BE FLUSHED WITH FRESH WATER.

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_2 – analyser. Open lids or hatch covers on stand pipes or purge pipes on tanks to be inerted.

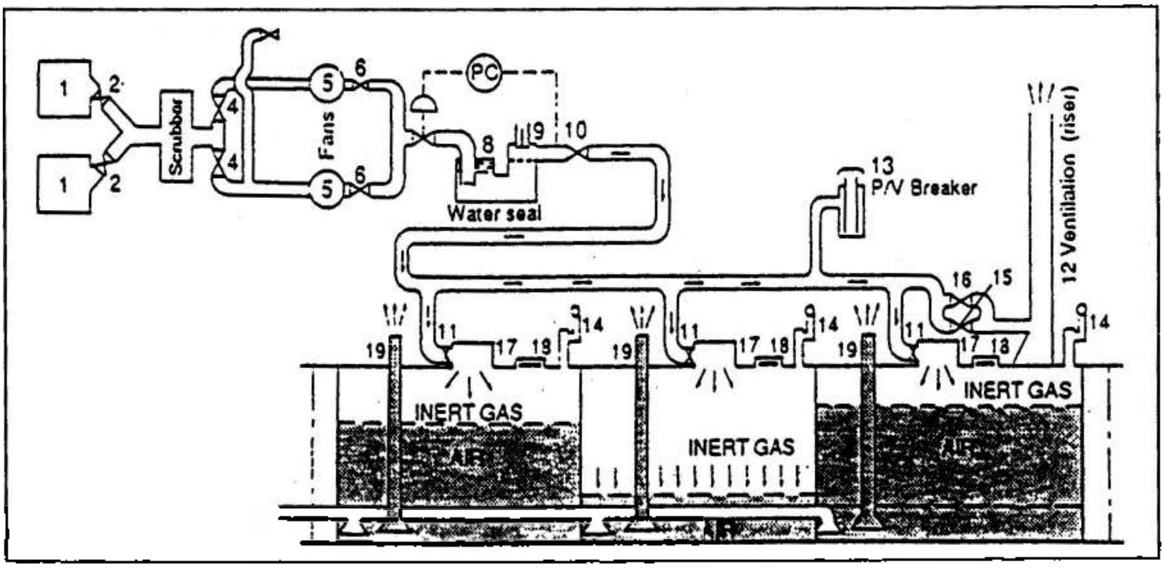
Open fan discharge valve (6) and main isolating valve (10) (see Fig. 1)

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



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 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)

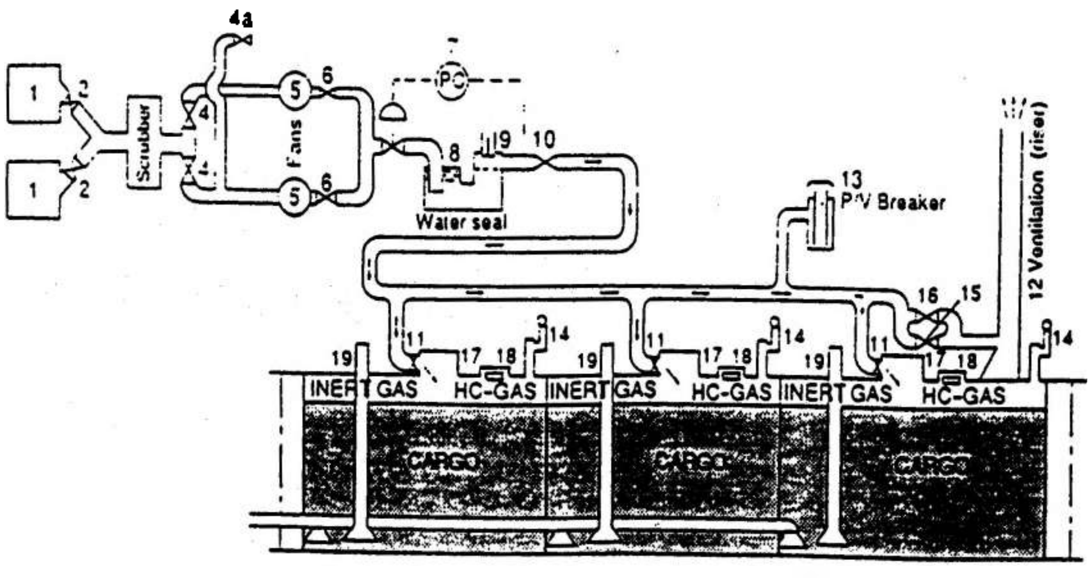
– rolling and heaving in rough sea.

The effect of the different conditions as mentioned above is partly a pressure drop inthe 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	6. Fan isolating valves pressure side	13. Pressure/vacuum breaker (common)
2. Gas uptake valves	7. Pressure control valve	14. P/V valves (individual)
3. Scrubber	8. Deck water seal	15. P/V valve in ventilation line
4. Fan isolating valves suction side	9. Non return valve	16. By–pass valve
	10. Deck line isolating valve	17. Tank hatch
4a. Fresh air intake valve	11. Tank isolating valves	18. Level indicator
5. Fans	12. Ventilation mast (riser)	19. Purge pipe

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.

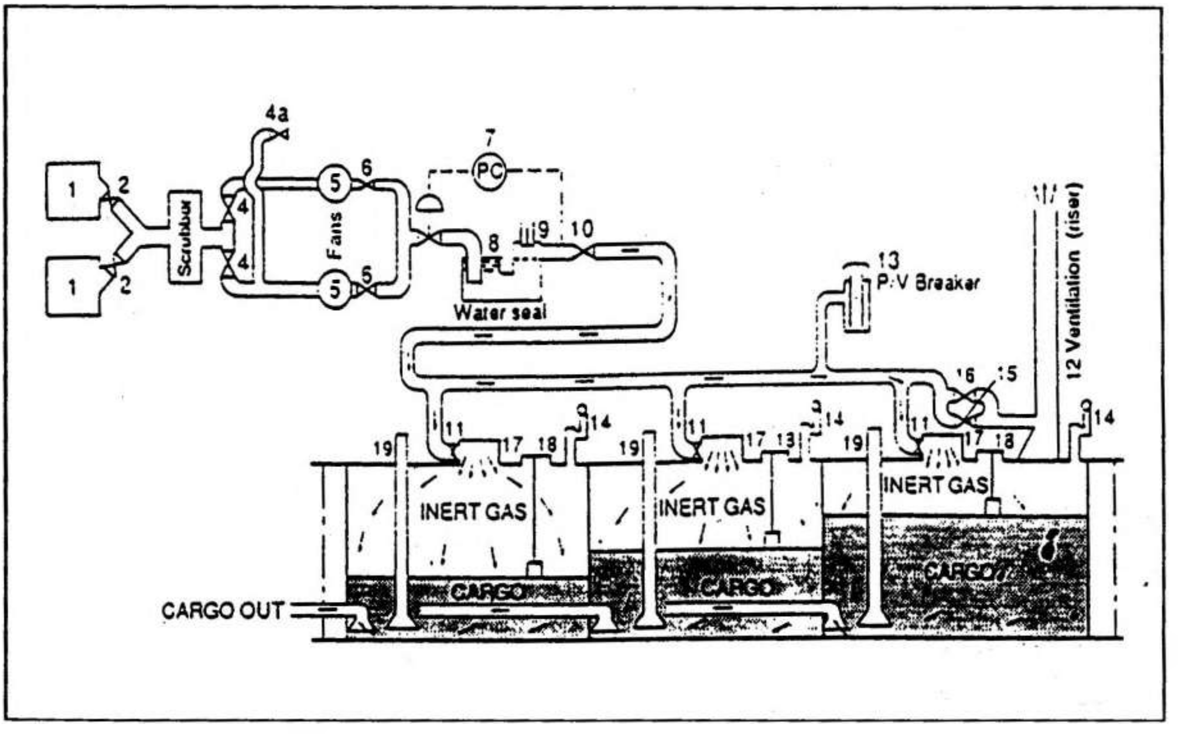
Before cargo oil pumping is started the inert gas system should be in operation and connected to the deck line, with the pressure control in the automatic position.

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 inthe 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.

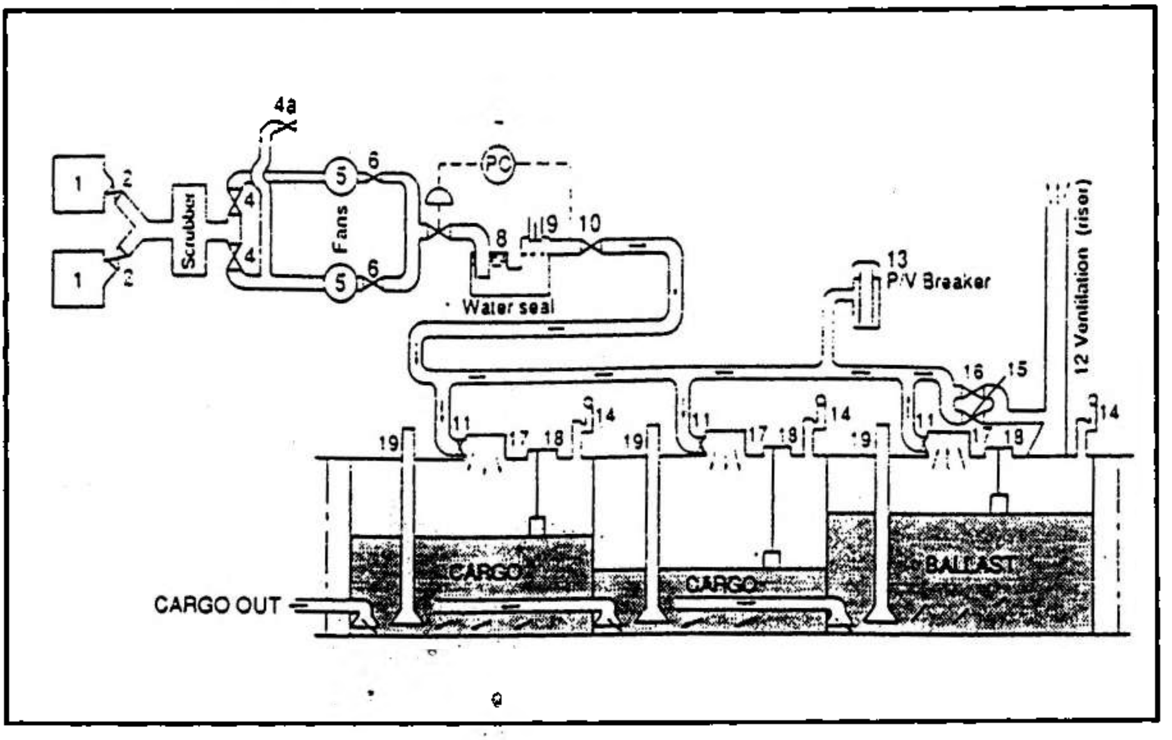
When discharge and stripping are finished, the tanks should be put under the desired positive pressure.

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.

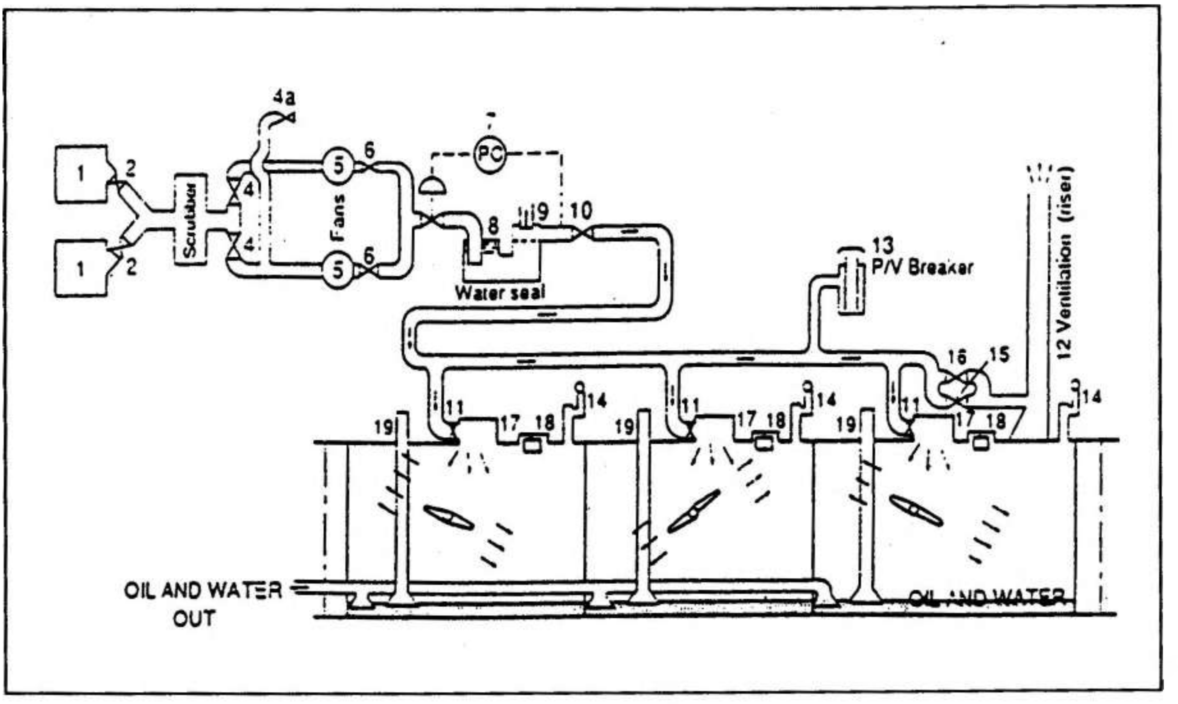
Before each tank is crude oil washed, the oxygen shall be determined at a point 1 metre from the deck and at the middle region of the ullage space and neither of these determinations shall exceed 8 per cent by volume. Where tanks have complete or partial wash bulkheads, the determinations should be taken 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.

Figure 7. Condition: Tank cleaning



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 in metal. In this machine, the work is securely held while a revolving cutting tool is fell into it.

Safety 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 abrasive 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.

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.

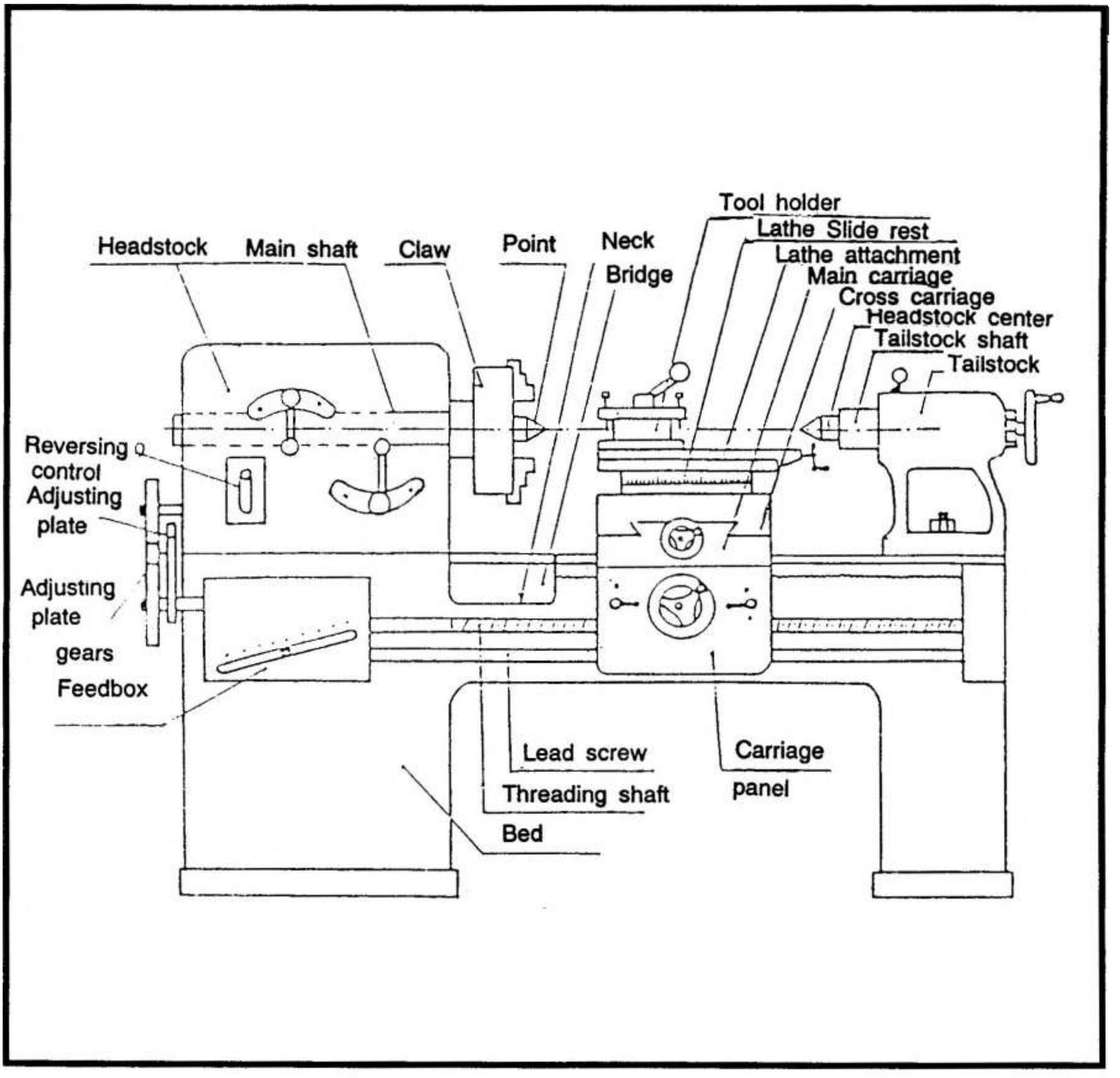
TACHOMETER – differs from speed indicator, it directly registered revolutions of the rotating shaft, no timing or computation being necessary.

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.

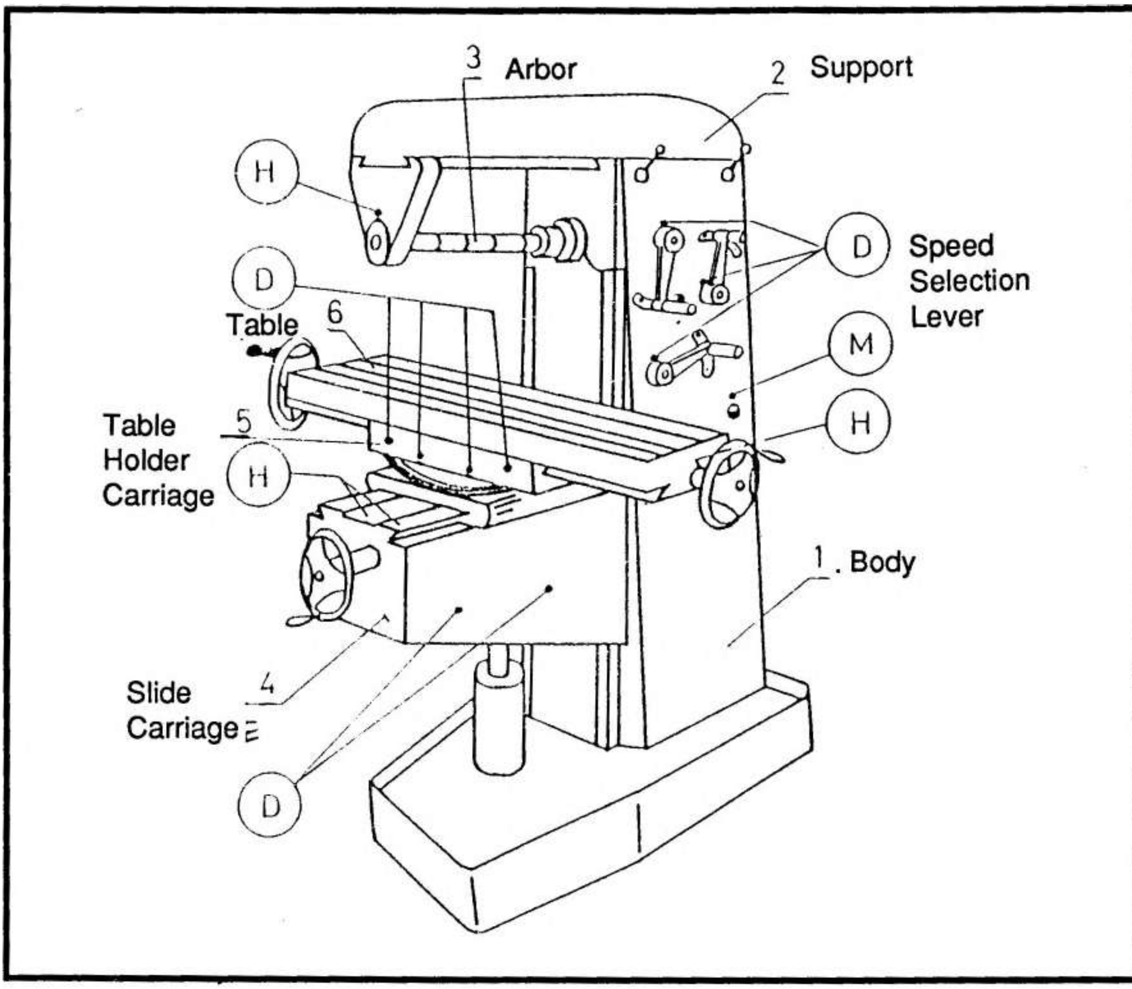
WIRE AND SHEET GAGE – used to measure cross sections of wire and sheet gage and to determine the thickness of metal sheets.

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.

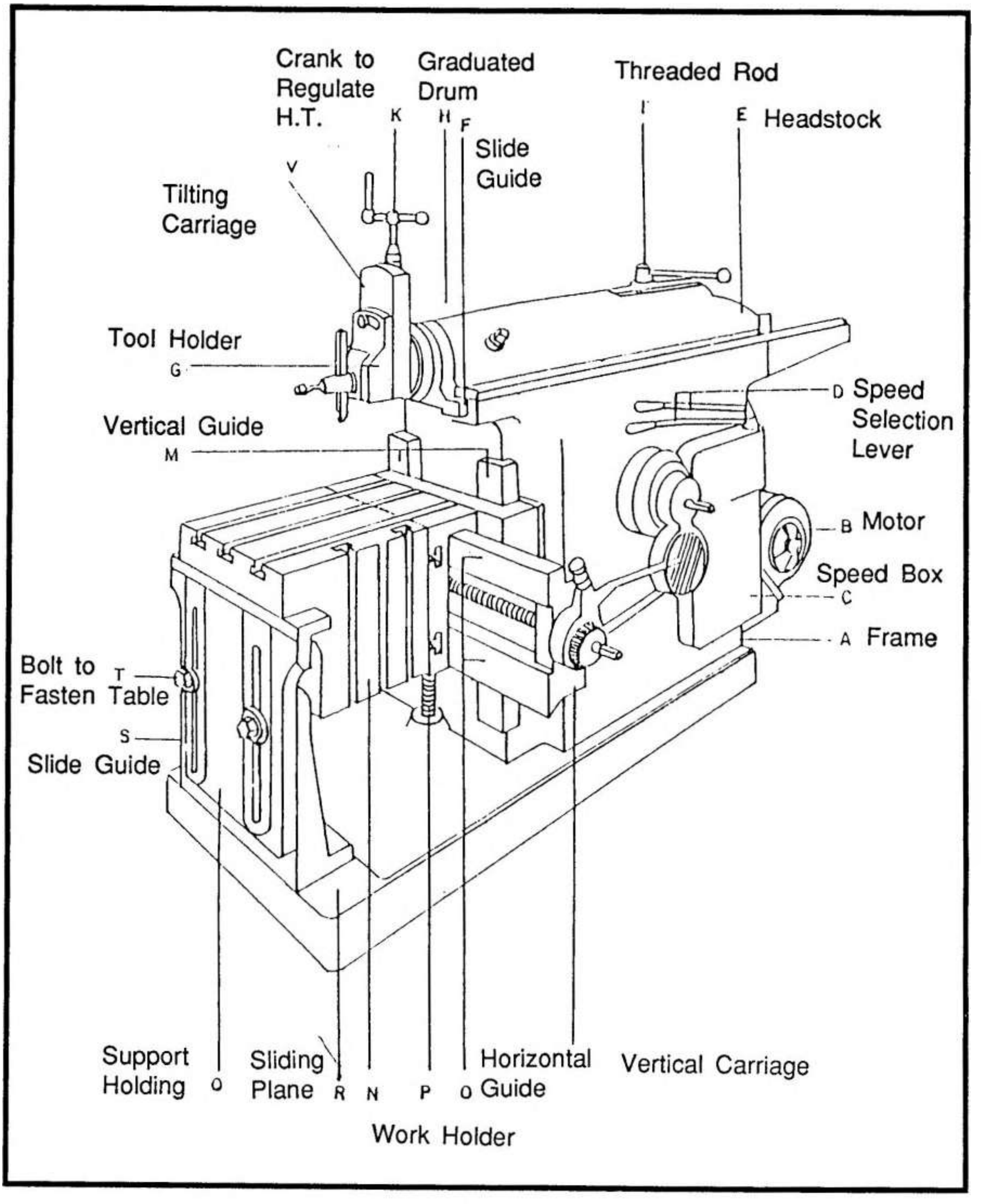


Tool holder
Lathe Slide rest
Lathe attachment
Main carriage
Cross carriage
Headstock center
Tailstock shaft
Tailstock
Headstock
Main shaft
Claw
Point
Neck
Bridge
Reversing control
Adjusting plate
Adjusting plate
gears
Feedbox
Lead screw
Threading shaft
Bed
Carriage
panel

LATHE



MILLING MACHINE



Crank to
Regulate
H.T.
K
Graduated
Drum
H
F
Slide
Guide
Threaded Rod
I
E
Headstock
V
Tilting
Carriage
Tool Holder
G
Vertical Guide
M
D
Speed
Selection
Lever
B
Motor
Speed Box
C
A
Frame
Bolt to
Fasten Table
T
S
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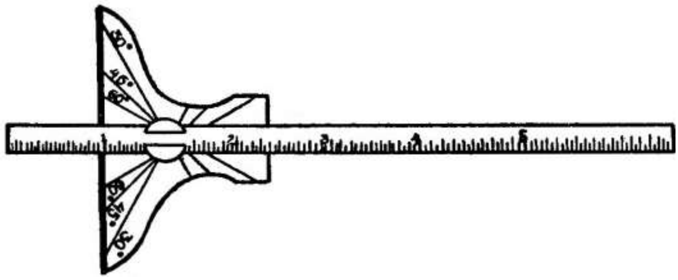
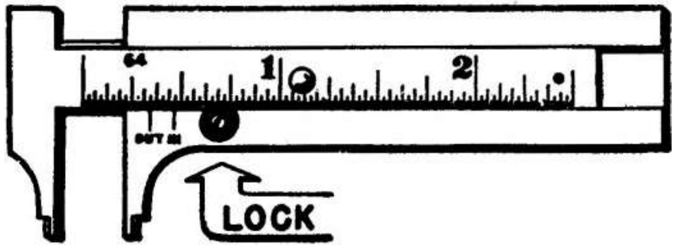
Support
Holding
O
Sliding
Plane
R
N
P
O
Horizontal
Guide
Vertical Carriage
Work Holder

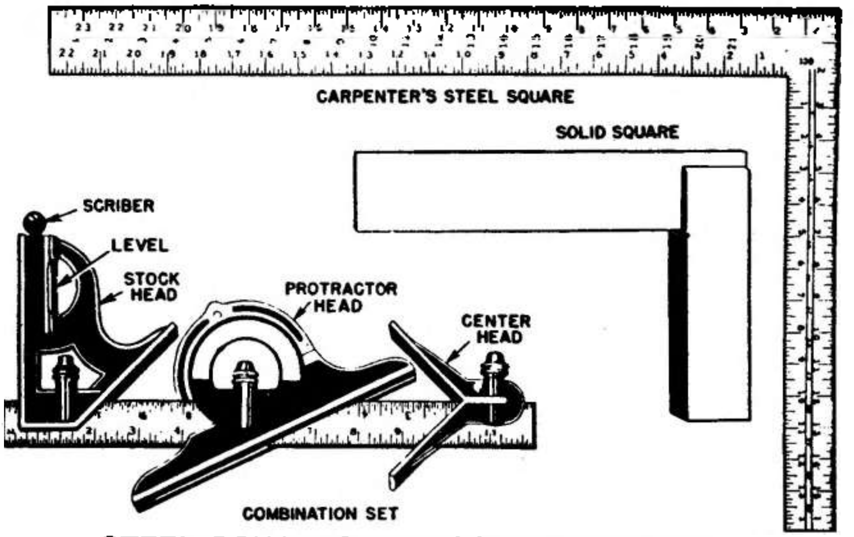
SHAPER



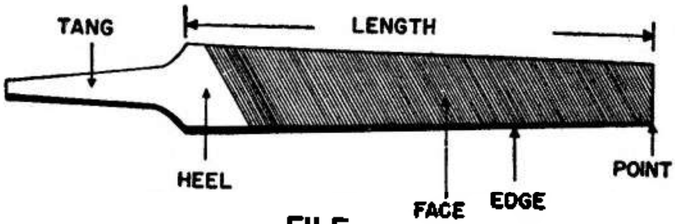
DEPTH RULE.



COMBINATION CALIPER RULE.

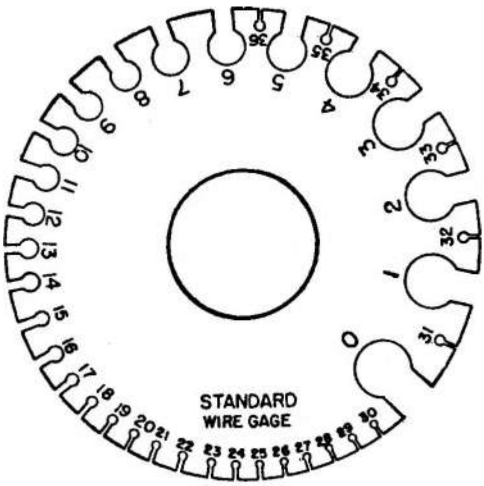


STEEL SQUARES AND COMBINATION SET.

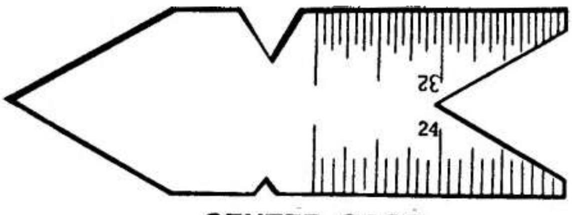


FILE

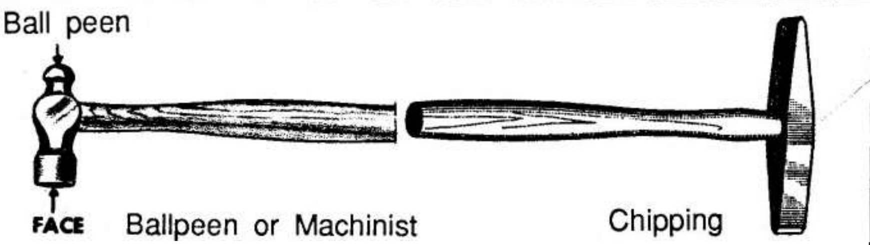
SHAPES OF FILES.



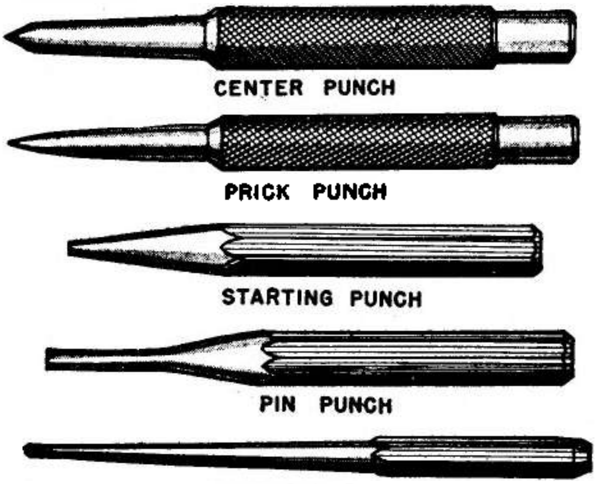
WIRE AND SHEET GAUGE



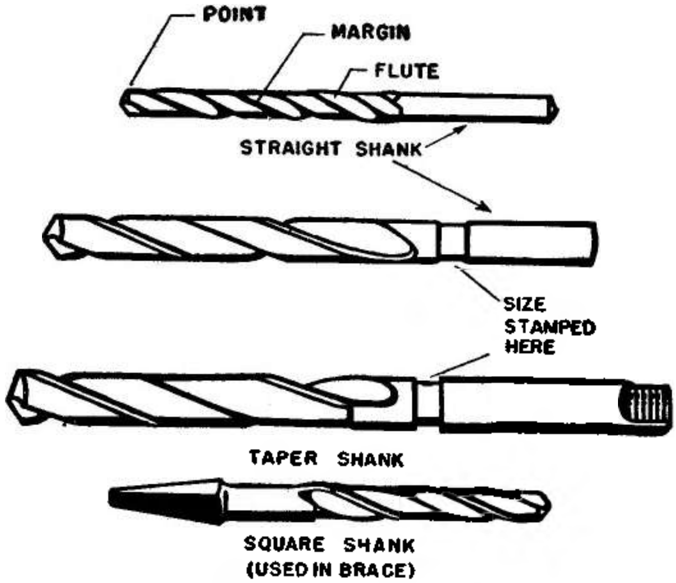
CENTER GAGE.



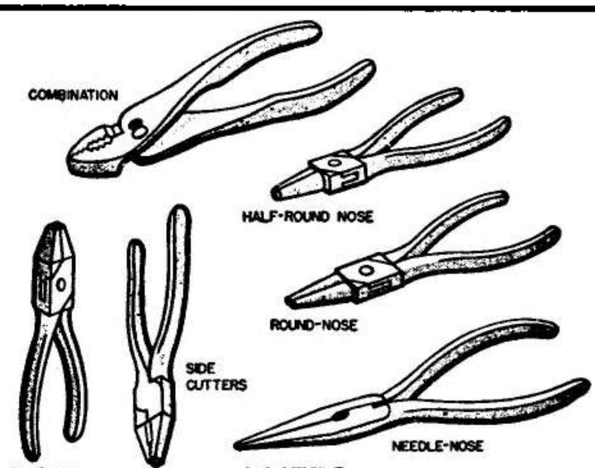
HAMMER



PUNCHES

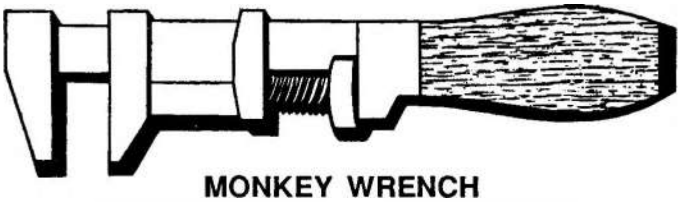


TWIST DRILL SHANKS



PLIERS

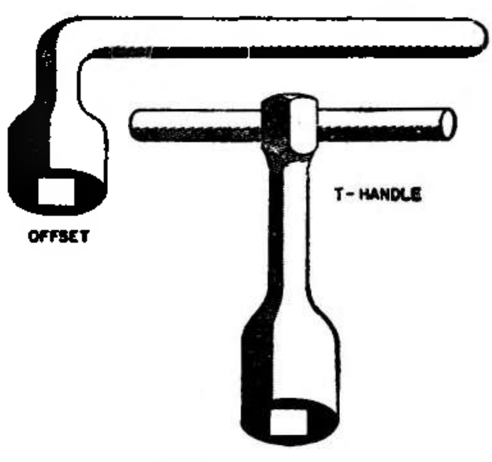
ADJUSTABLE WRENCH



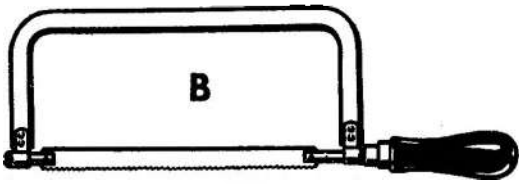
MONKEY WRENCH

STILLSON WRENCH

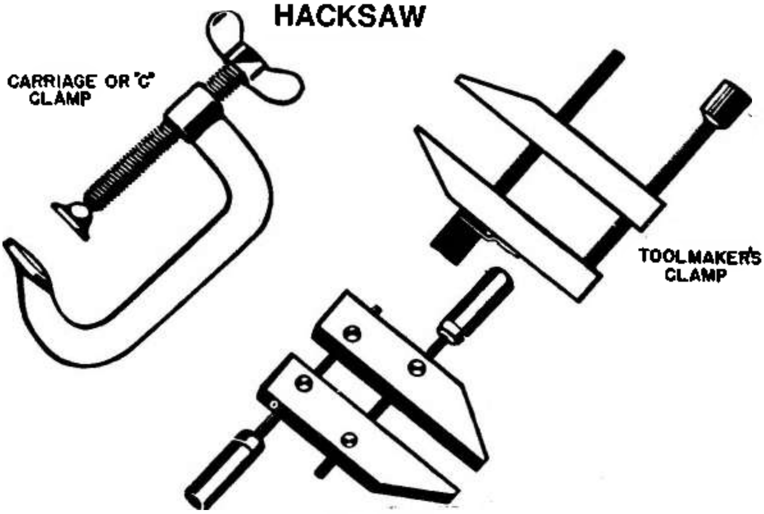
BOX WRENCH



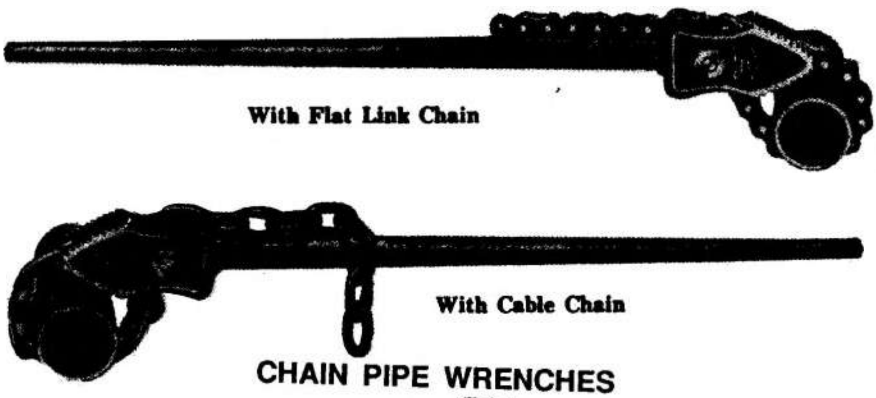
SOCKET WRENCHES



HACKSAW

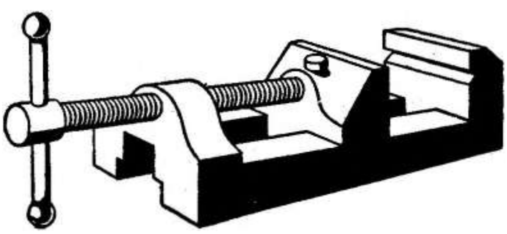


CLAMPS

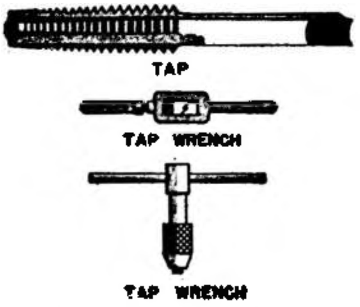


CHAIN PIPE WRENCHES

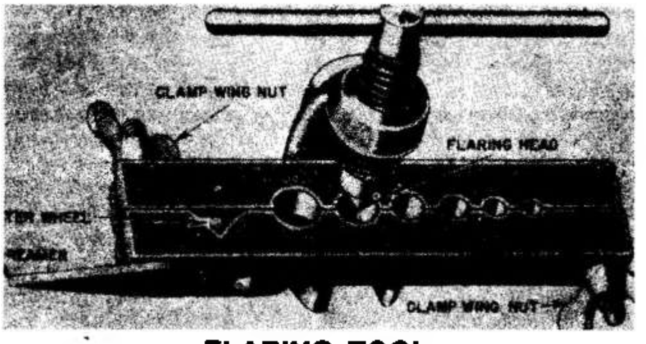
BOLT (HOLE) PUNCH



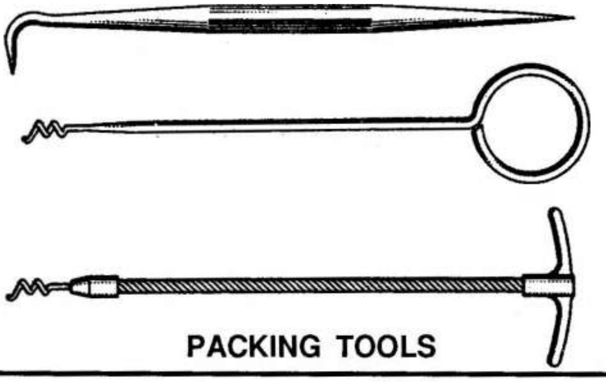
DRILL VISE



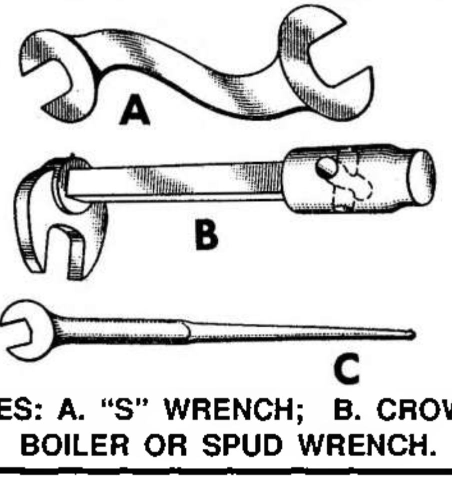
TAPER TAP AND TAP WRENCHES



FLARING TOOL

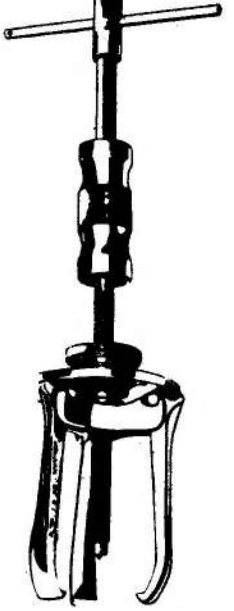


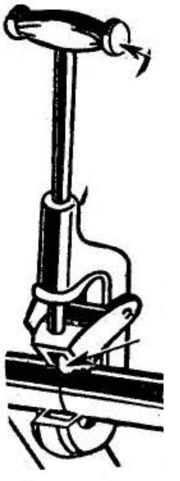
PACKING TOOLS



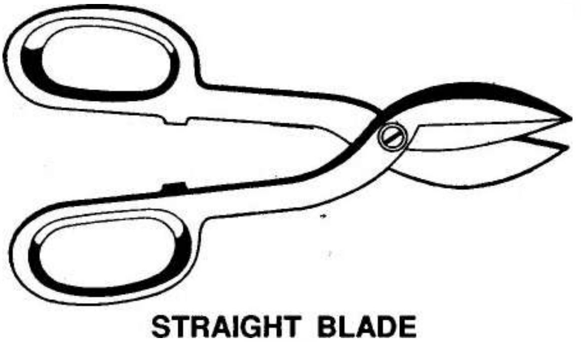
OPEN-END WRENCHES: A. "S" WRENCH; B. CROWFOOT WRENCH; C. BOILER OR SPUD WRENCH.

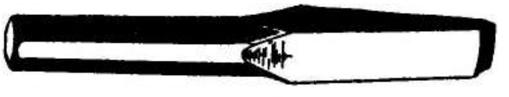

SCREW-GEARED CHAIN HOIST

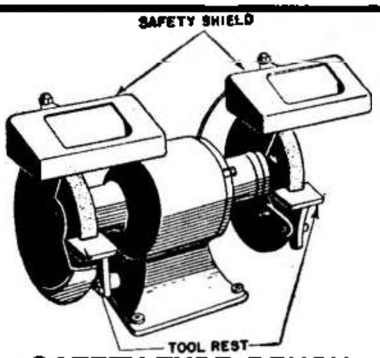

GEAR PULLER


TUBE CUTTER


FUSE PULLER


STRAIGHT BLADE SNIPS


CHISEL



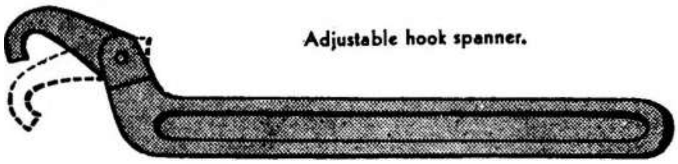
SAFETY-TYPE BENCH GRINDER

HAND DRILL

STOCK AND ADJUSTABLE DIE

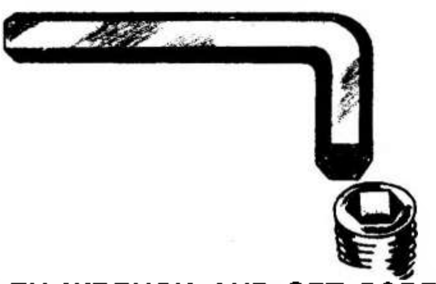
SPLIT OR ADJUSTABLE DIE

Hook spanner.

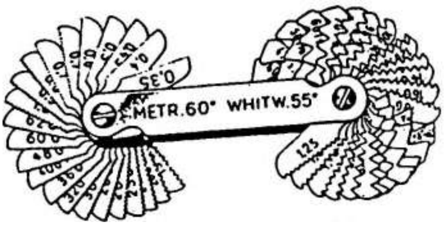


Adjustable hook spanner.

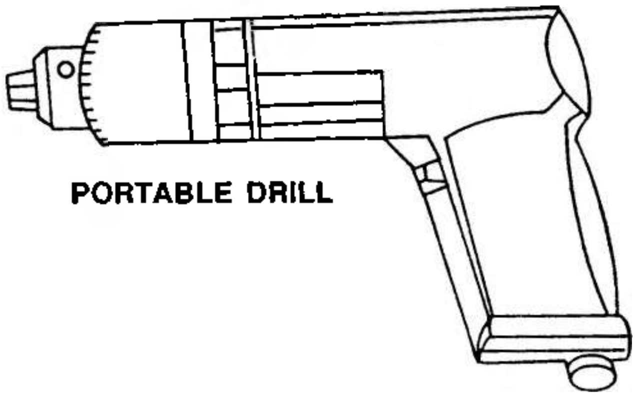
SPANNER WRENCHES



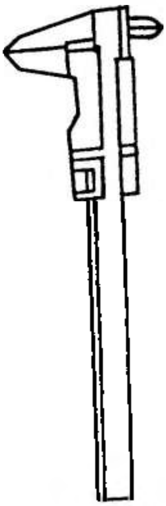
ALLEN WRENCH AND SET SCREW



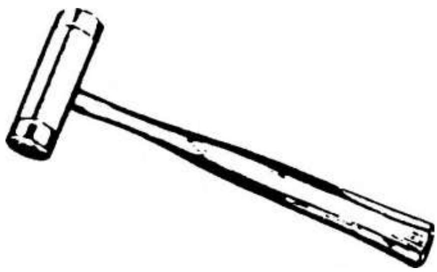
THREAD COUNTER



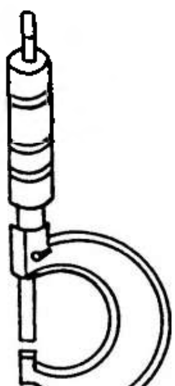
PORTABLE DRILL



VERNIER CALIPERS



PLASTIC HAMMER

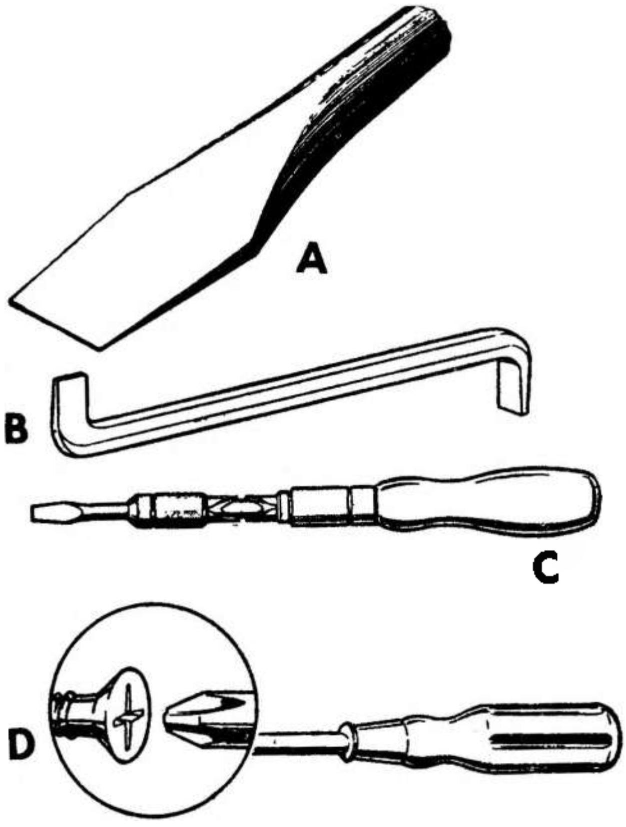


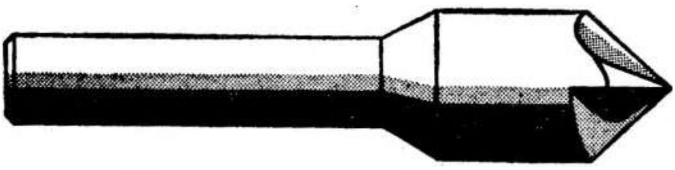
MICROMETER FOR
EXTERIOR MEASUREMENTS

SLEDGE
HAMMER OR MACE

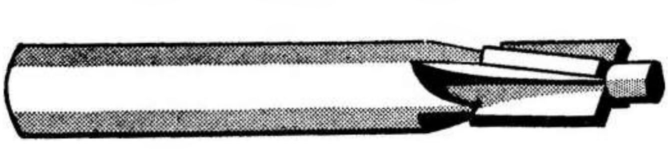
REAMER

SCREW DRIVERS: A. REGULAR DRIVER; B. OFFSET DRIVER; C. RATCHER DRIVER; D. PHILLIPS HEAD DRIVER

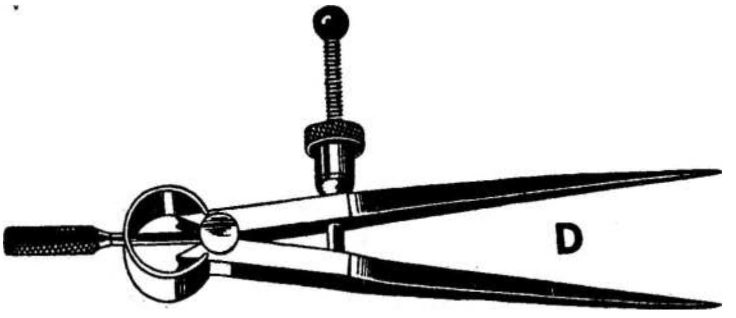




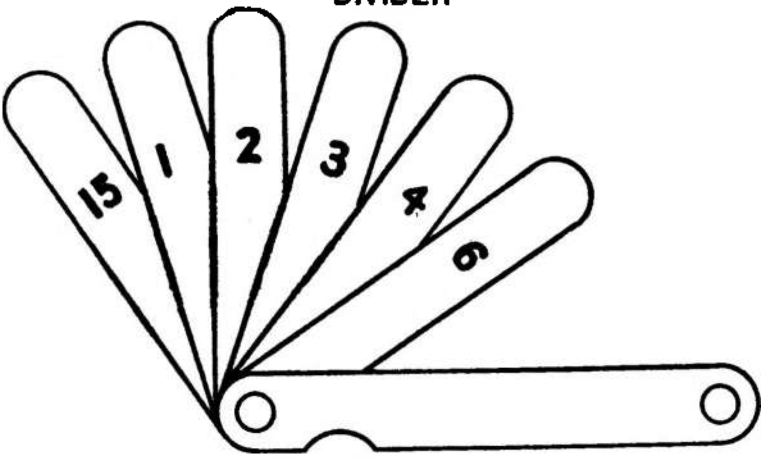
RECENTERING A DRILL CUT



COUNTER BORE

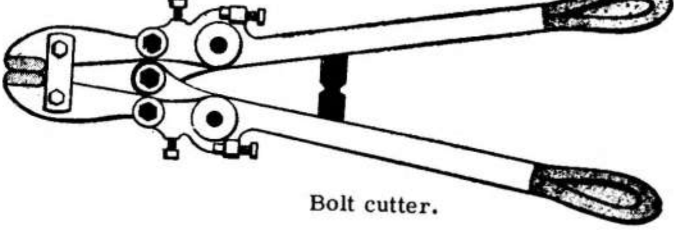


DIVIDER



THICKNESS GAGE

SCRIBER WITH DOUBLE ENDS

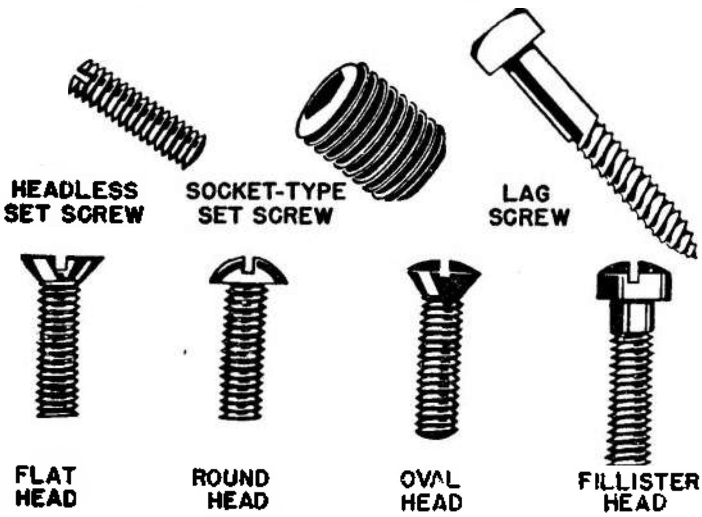


Bolt cutter.

BOLT CUTTER

CAP SCREW

SQUARE HEAD SET SREWS



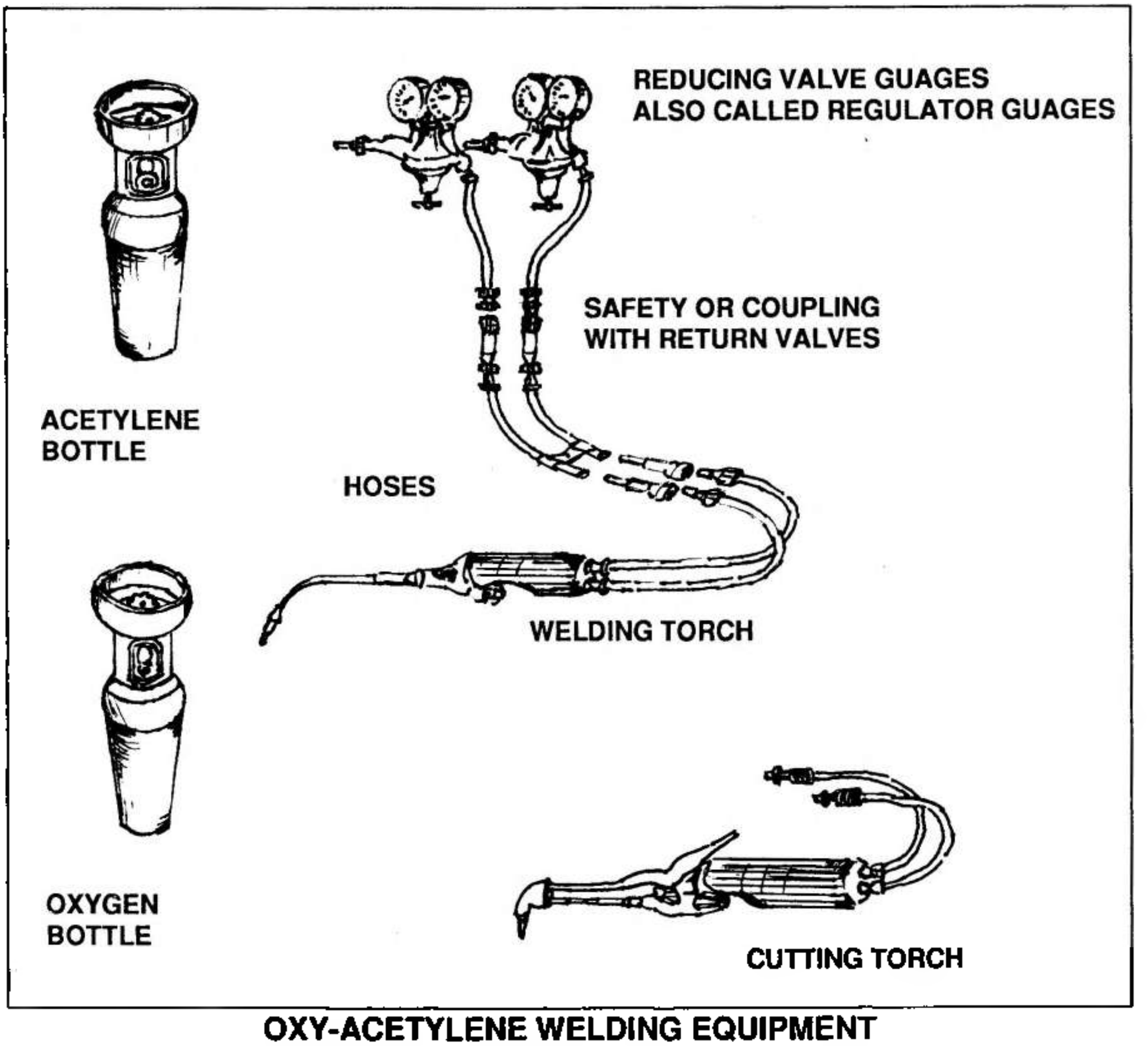
MACHINE SCREWS

SHEET-METAL SCREWS.

A. WELDING EQUIPMENT:

I. Nowadays, ships must depend on their own resources to make repairs, one of the most important pieces of equipment for such tasks is the welding equipment. Depending on the job to be performed it can be either oxy-acetylene or arc welding and is used in addition to ordinary soldering, which is effected at low heat.

The oxy-acetylene welding equipment consists of two gas bottles, one for oxygen the other for acetylene, two flexible tubes, pressure regulating valves, non-return safety valves and a blow torch.



OXY-ACETYLENE WELDING EQUIPMENT

SAFETY AND OPERATION INSTRUCTION FOR GAS AND ELECTRIC WELDING

SETTING UP EQUIPMENT:

A. ***Hoses*** – should be examined for cuts, burn and other defect before fitted and never used steel or copper tubes for temporary repair. It must fitted with protector like non-return valve. Oxygen hoses should be blue and right hand threads while acetylene must be red and left hand threads.

B. ***Regulators:***

Check the oxygen and acetylene regulator are enough to deliver required pressure and see to it that it does not shows the following signs:

1. broken gauge
2. damage cylinder nuts
3. bent pressure adjusting screw
4. cone setting on outlet
5. damage safety values

C. ***Hand Equipment:***

1. Check equipment in used before turning on the gas supply like the following: damage or bent valves spindles, loose handwheel, cone seat thread on inlet connection, sealing, orifice, nozzles.
2. Before starting to work check the following points:
   Both regulator pressure are correct pressure setting fitting tight, correct size and type of nozzle, spark igniter, goggles, gloves are available. Also no flammable materials in working area.

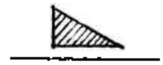
D. ***Flame Adjustment and Stability:***

1. In welding operation safest method by setting the required pressure on the regulator of oxygen and acetylene.
2. Light first acetylene, with oxygen valve closed, until flame becomes bright and free of sooty smuts.
3. Then open oxygen valve to desire flame condition.
4. On cutting procedure, oxygen control valve must be fully open at all times to allow full supply to avoid oxygen starvation while cutting.
5. Use correct nozzle for the job to be done, change damage regulators for oxygen-acetylene, orifice always free from dirt.
6. Adjust proper distance between flame and cutting, and avoid intermittent back fire and action should be done by closing first the oxygen valve, then acetylene valve, and shut off cylinders.

E. ***Closing Down***

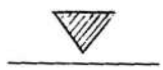
When shutting off the flame, it is a safer practice to turn the oxygen off first, to avoid accident. And after job finished the worker should secure and close all equipments for safety procedures.

II. BASIC WELDING SYMBOLS

 Fillet Weld

 Plug or Slot Welding

 Square Groove Welding

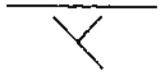
 Single Vee Welding

 Double Vee Welding

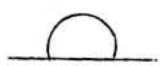
 Bevel Groove Welding

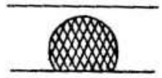
 "U" Groove Welding

 "N" Groove Welding

 Flare Bevel Groove Welding

 Flare Use Bevel Groove Welding

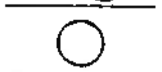
 Baking Weld or Back

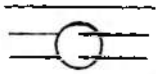
 Nelt Through Weld (One Side)

 Surfacing Weld

 Flange Edge Weld

 Flange Corner Weld

 Spot Weld

 Seam Weld

 Flash or Upset Weld

III. GAS/ELECTRIC WELDING

RECOMMENDED METHOD OF PROCEDURE:

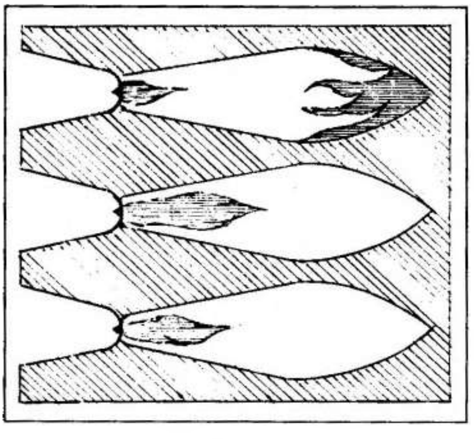
TABLE FOR CUTTING:

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/cm²	0.2	0.2	0.2	0.2	0.2	0.2
Oxygen press kg/cm²	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/cm²			BOTH 0.3 kg/cm²		

IV. FLAME TORCH CHARACTERISTICS:

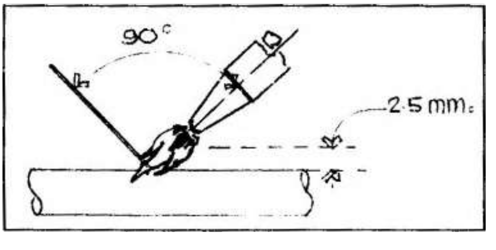


OXYGEN SURPLUS –
deposit brittle & burnt

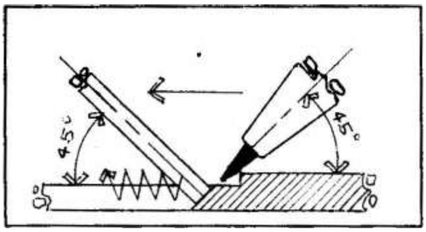
ACETYLENE SURPLUS –
deposit brittle & hard

NEUTRAL FLAME –
deposit normal

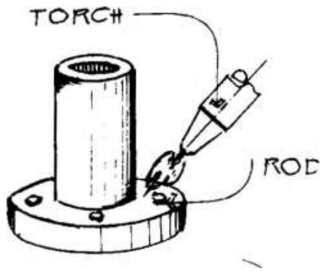
V. DISTANCE OF FLAME AND MATERIAL

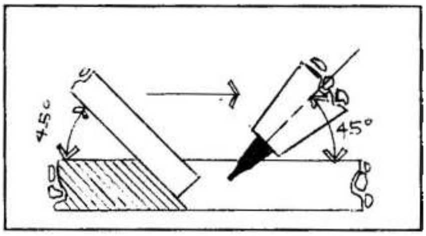


VI. METHOD OF WELDING:



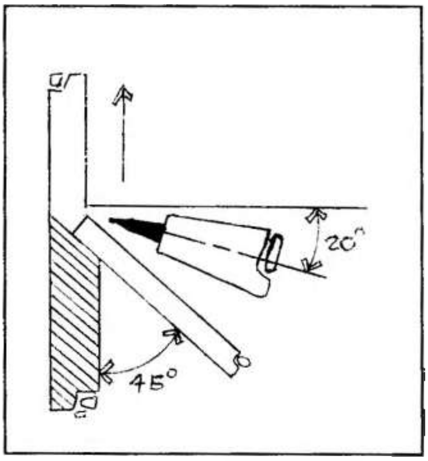
LEFTWARD WELDING:
use on material up to 4 mm.
The welding rod precedes
the torch in the welding direction.



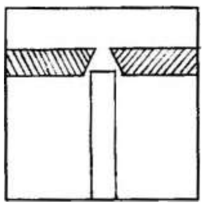


RIGHTWARD WELDING:
use on material thicker than
4 mm. The welding rod
follows the torch in the welding
direction.

During pre-heating the
torch should be removed
in such away time use
correct temperature.

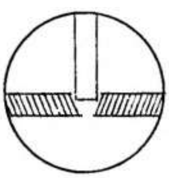


VERTICAL-UP WELDING:
Also used for material thicker
4 mm.

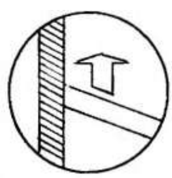


**OVERHEAD BUTT
or FILLET WELD**

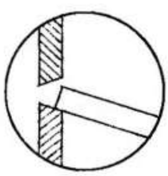
VII. POSITION ELECTRIC WELDING



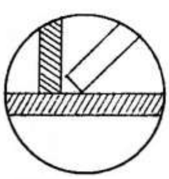
**DOWNHAND BUTT OR
FILLET WELD**



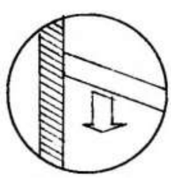
VERTICAL-UP



**HORIZONTAL-VERTICAL
BUTT WELD**



**HORIZONTAL-VERTICAL
FILLET WELD**



VERTICAL-DOWN

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. Gear	3. Screw
2. Vane	4. Lobe

C. Rotary – Reciprocating pumps.

Types:

1. Radial Piston Pumps – Heleshaw pumps
2. Axial Piston Pumps – Swash plate pumps

Rotodynamic Pumps and Their Classification:

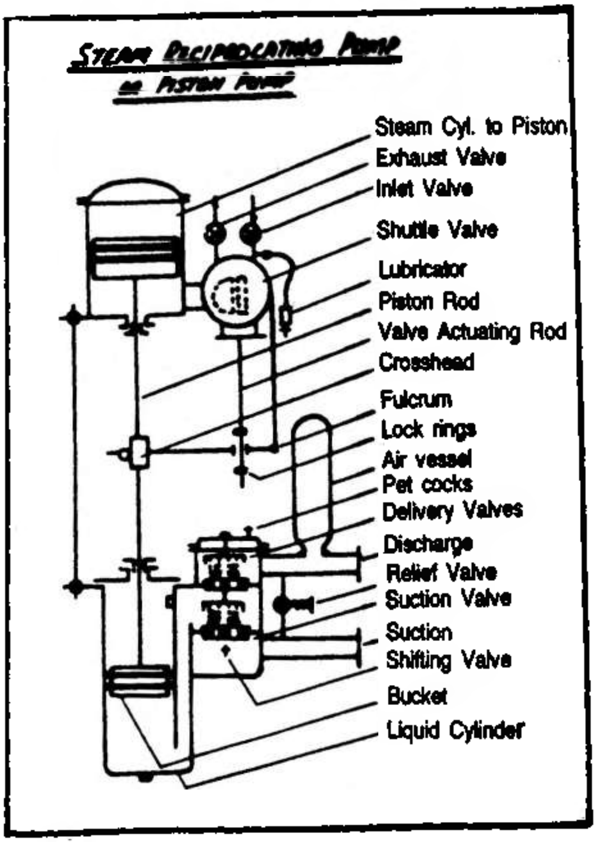
A. Centrifugal pumps – volute and diffuses types.
Dynamo pumps with radial, axial and mixed flow

B. Regenerative turbine pumps – all turbine pumps.

C. Special Effect pumps – ejector, eductor, gas lift, jet pumps

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:

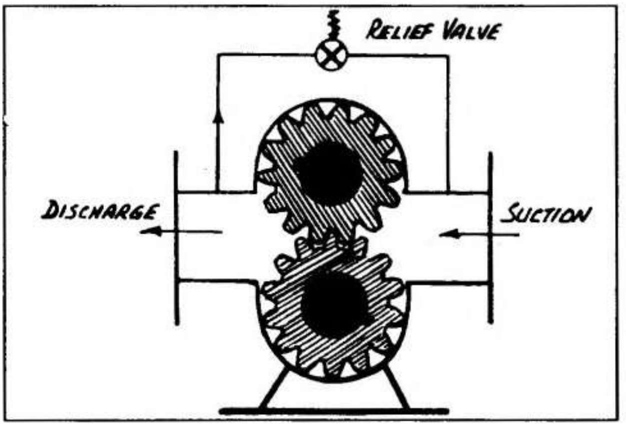
1. Gear
2. Screw
3. Vane
4. Lobe
5. Other Geometric form pumps.

General Characteristics:

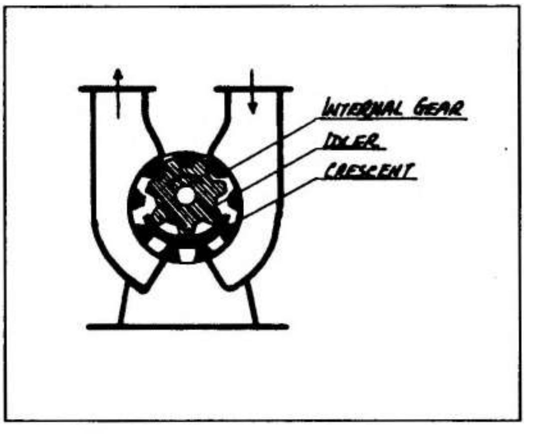
1. Suitable and efficient for handling, intermediate range of pressure, volumes and viscosities – like fuel, lube oil, diesel, and other commercial liquids.
2. Due to rotation and close clearances a time–continuous liquid seal is maintained. Hence, these pumps do not require suction/delivery valve chest arrangements like reciprocating pumps.

GEAR PUMPS : Types

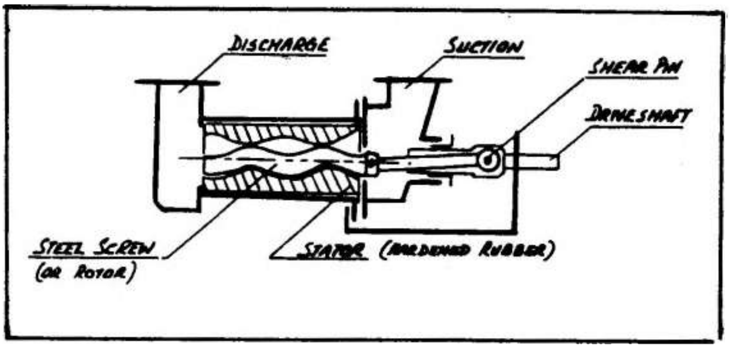
EXTERNAL GEAR PUMP



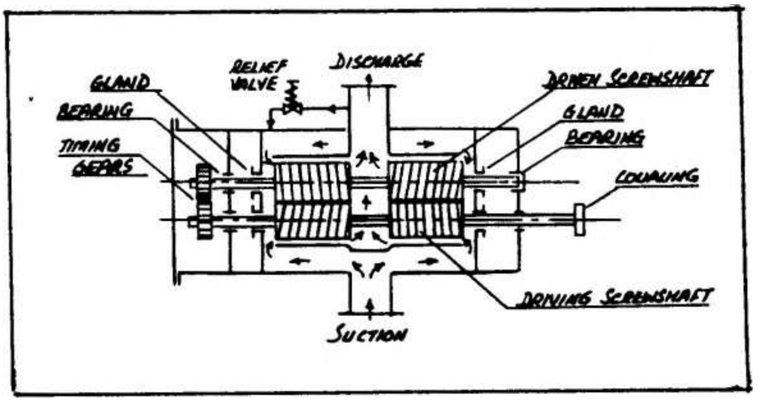
INTERNAL GEAR PUMP



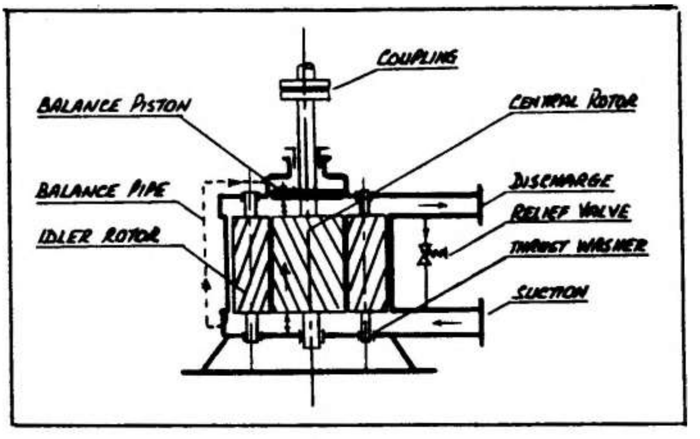
SCREW PUMPS: Types



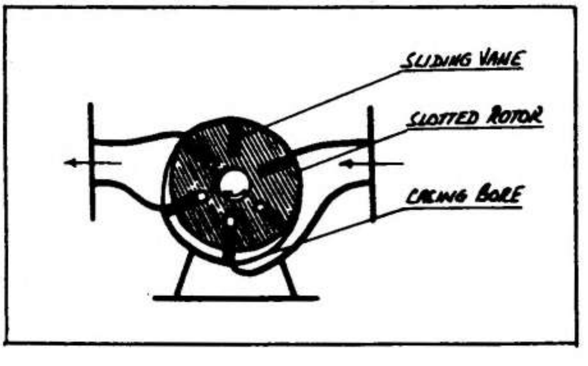
SINGLE SCREW PUMP



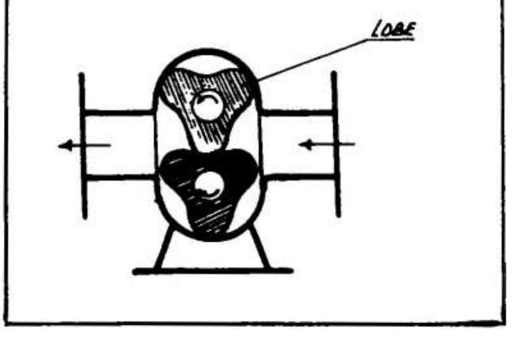
DOUBLE SCREW PUMP



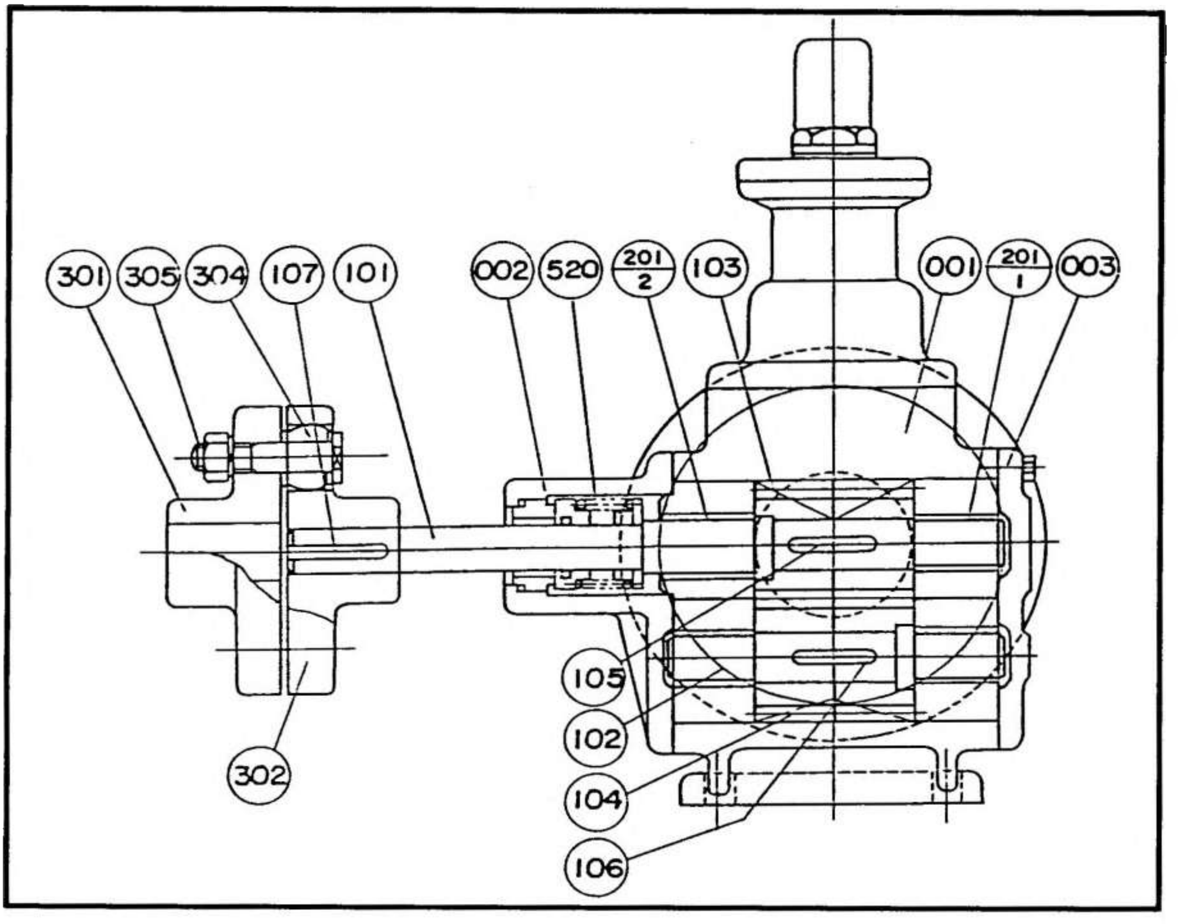
TRIPLE SCREW PUMP



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:

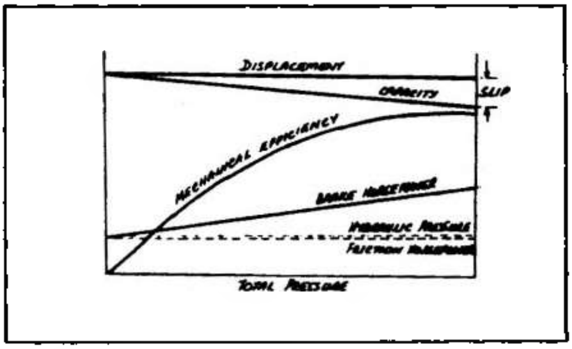
1. Centrifugal Pumps,
2. Turbine Pumps,
3. Special Effect Pumps.

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

$$\text{Volumetric Efficiency} = \frac{\text{Capacity}}{\text{Displacement}} \times 100$$

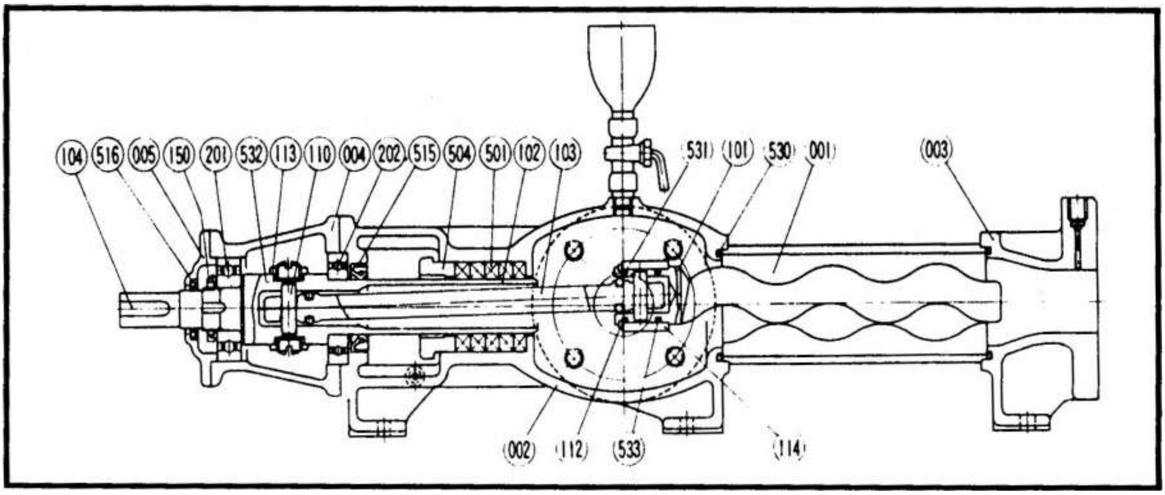
Brake Horse Power = Frictional HP + Hydraulic HP

$$\text{Mechanical Efficiency} = \frac{\text{Hydraulic HP}}{\text{Brake HP}}$$

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

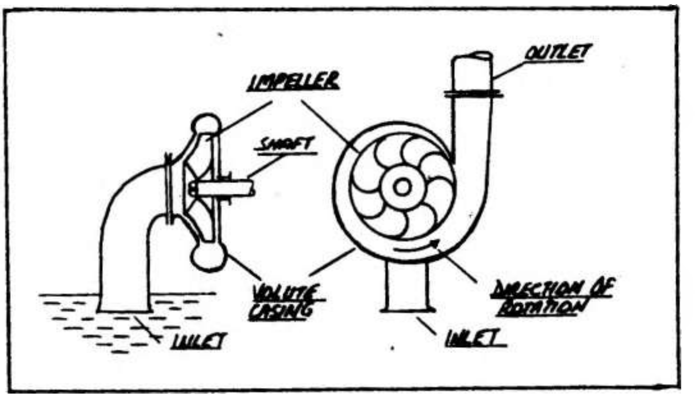


Parts list:

001	Stator	104	Key	501	Gland Packing
002	Pump Stand	110	Pin	504	Gland
003	End Piece	112	Snap Ring	515	Oil Seal
004	Bearing Case	113	Sleeve (A)	516	Oil Seal
005	Bearing Cover	114	Sleeve (B)	530	"O" Ring
101	Rotor	150	Bearing Nut	531	"O" Ring
102	Shaft	201	Bearing	532	Seat Packing
103	Connecting Rod	202	Bearing	533	"O" Ring

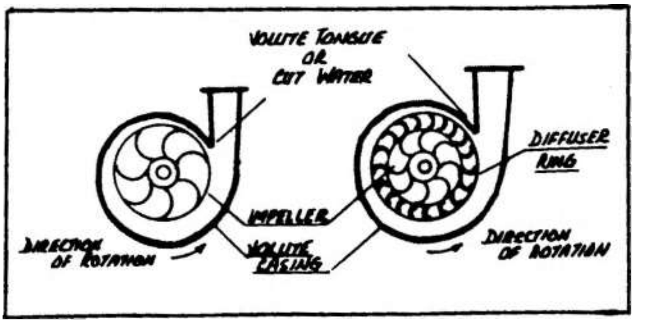
IV CENTRIFUGAL PUMPS

Construction:

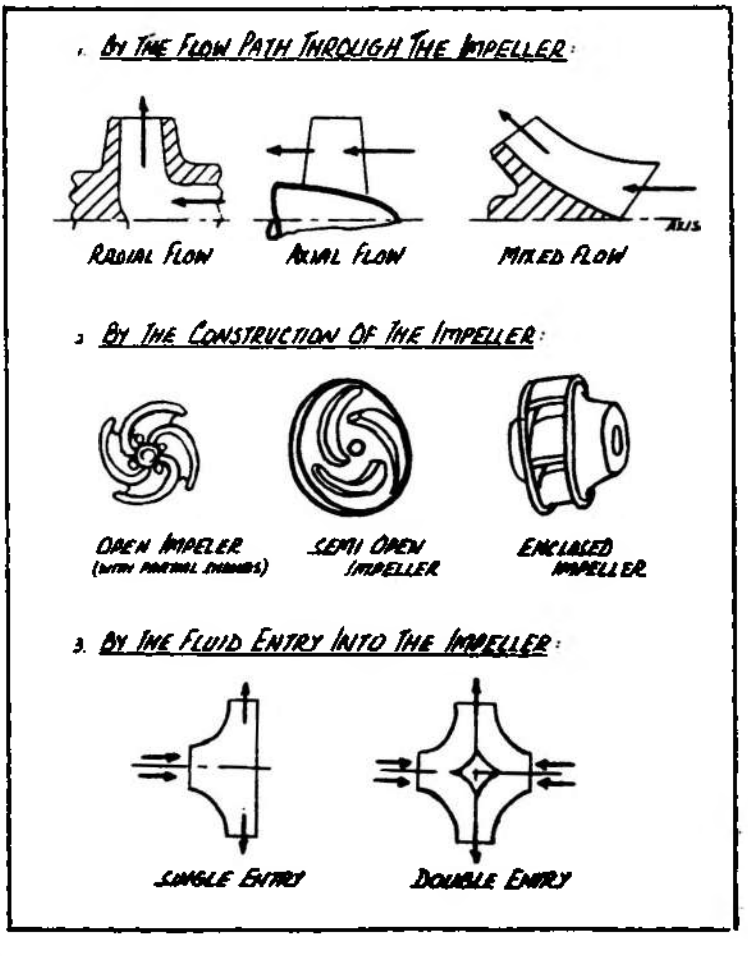


Two Main Classes:

1. Volute Pumps,
2. Diffuser Pumps,

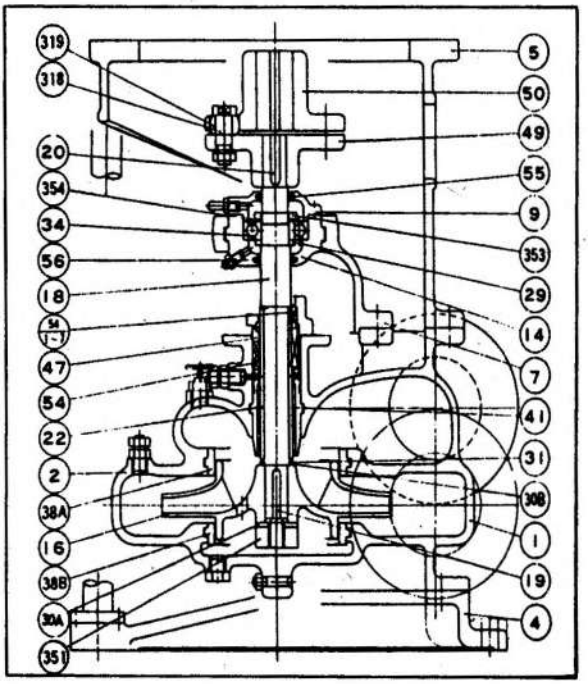


Impeller Classification:



I 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:

1	Volute Casing	34	Ball Bearing
2	Volute Cover	38A	Mouth Ring
4	Pump Bed	38B	Mouth Ring
5	Motor Bed	41	Line Bearing
7	Bearing Housing	47	Gland
9	Bearing Cover	49	Coupling
14	Bearing Inner Case	50	Coupling
16	Impeller	54	Gland Packing
18	Impeller Shaft	55	Packing Ring
19	Impeller Key	56	Packing Ring
20	Coupling Key	318	Coupling Bolt Nut & Washer
22	Sleeve	319	Coupling Ring
29	Washer	351	Impeller Nut
30A	Washer	353	Bearing Nut
30B	Washer	354	Bearing Washer
31	Packing		

SECTIONAL VIEW OF CENTRIFUGAL PUMP

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.

Alignment 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

Checking 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

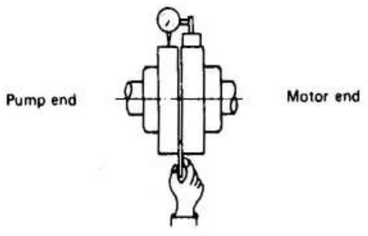


Fig.1. Check with dial indicator and thickness gauge

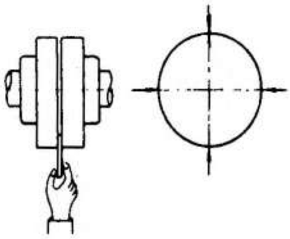


Fig. 2. Check straight edge and thickness gauge

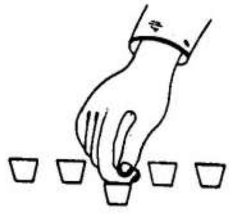


Fig. 3 Check Tension V-belt

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

Maintenance and check for the following can extend a life of the pump.

Item	Inspection Procedure	Remedy in case of trouble
Suction pressure	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. Renew oil every 3000 hours.	Supply oil if level is low. 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 abnormal noise every three days.	Stop the pump immediately and remove cause
Line bearing	Check for heating in the pertinent 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 passing and if the line bearing clearance 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 temperature is not abnormal in every two days.	Stop the pump and check the cooling water pipe line.

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. Impeller 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.
7. 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.

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.

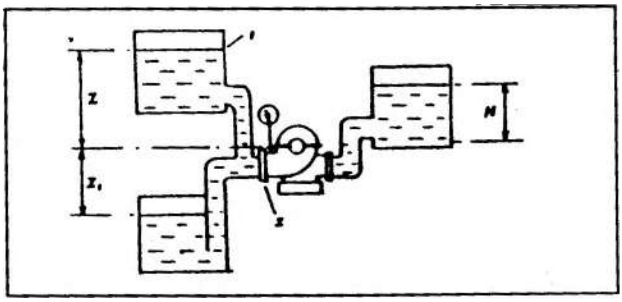
NET POSITIVE SUCTION HEAD. (NPSH) It is the amount of energy in the liquid at the pump datum. To have any meaning it must be defined as either available or required NPSH.

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.

How to calculate NPSHa:



NPSH = Pot. hd. energy + Static Pr. hd. energy + Vel. hd. energy.

$$= Z_1 + P_2 + \frac{V_1^2}{2g}$$

Since area of liquid surface compared to suction pipe area is very large:

$$\text{NPSH} = Z_1 + P_1$$

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_v).

$$\text{NPSH} = Z_1 + \frac{(P_1 - P_v)}{\text{Sp. gr.}} \times 2.31$$

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:

$$\text{NPSH} = Z_1 + \frac{(P_1 - P_v)}{\text{Sp. gr.}} \times 2.31 - h_f$$

PRIMING OF CENTRIFUGAL PUMPS:

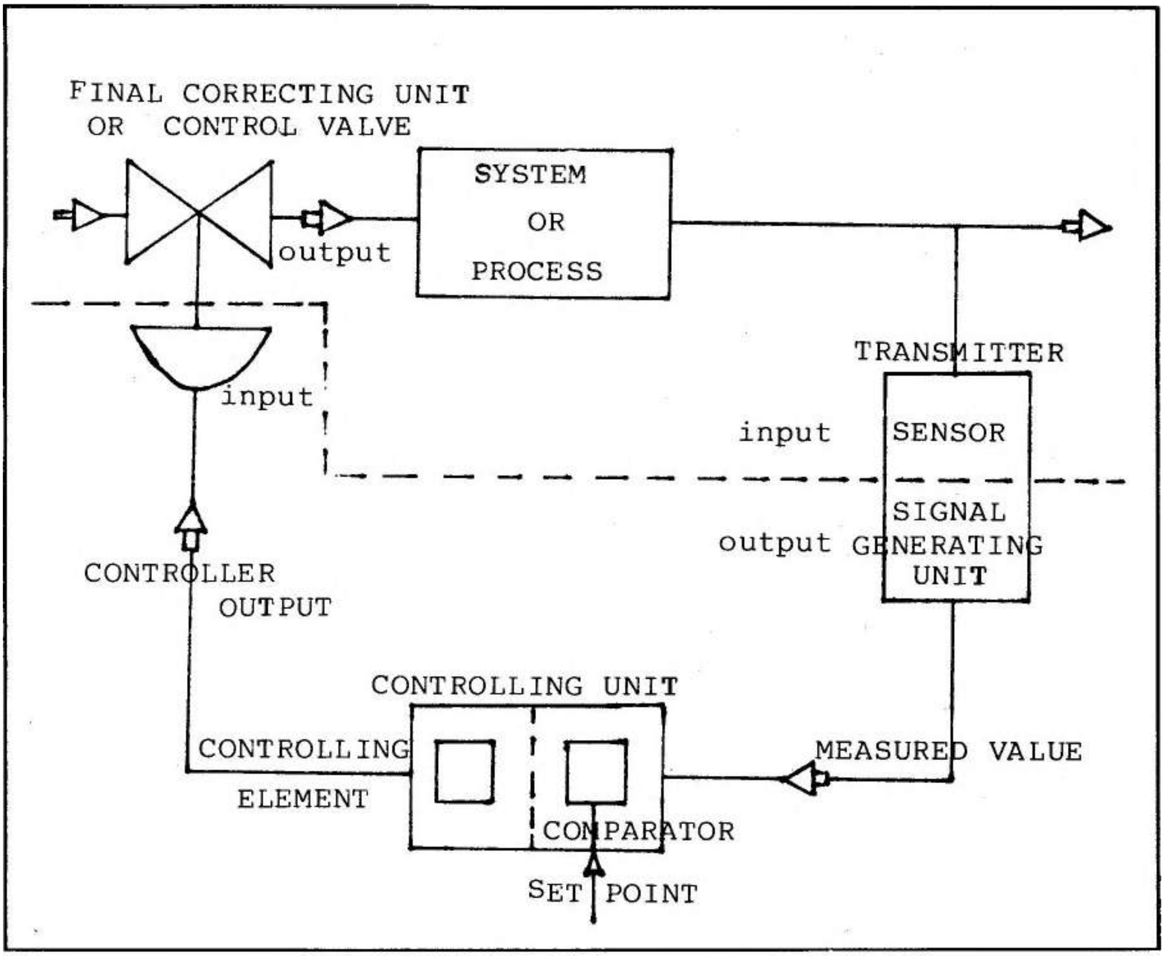
Since centrifugal pump are NOT self–priming pumps, they need to be primed to function satisfactorily. They could either be provided with a positive suction or be fitted with a priming device.

Priming devices used:

1. Ejectors
2. Dry Vacuum Pumps,
3. Wet Vacuum Pumps,
4. Central Priming System.

Section III

CONTROL AUTOMATION



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)

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.

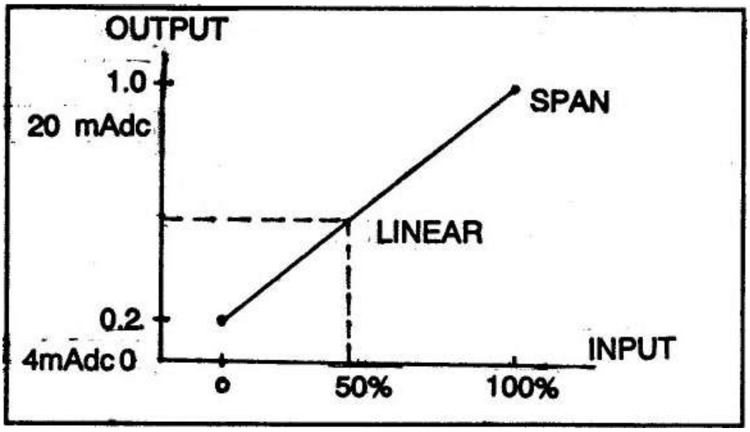
B. CALIBRATION OF AN INSTRUMENT:

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:

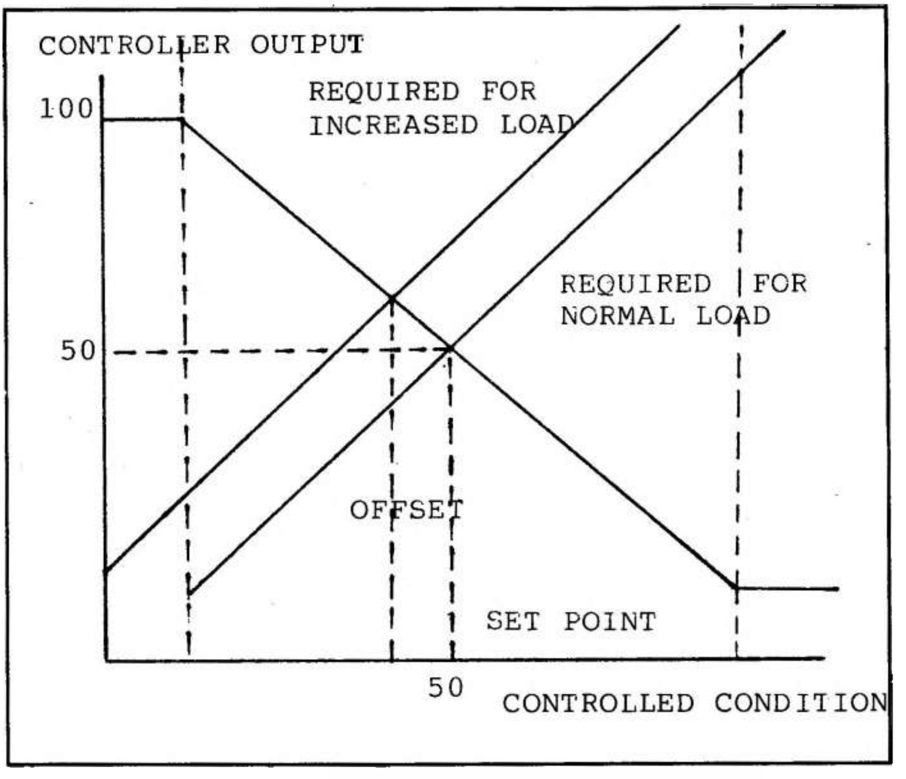
Gain of a component is defined as the ratio between the change in output to change in input.

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 $= \dfrac{100}{PB}$

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 désigned 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.



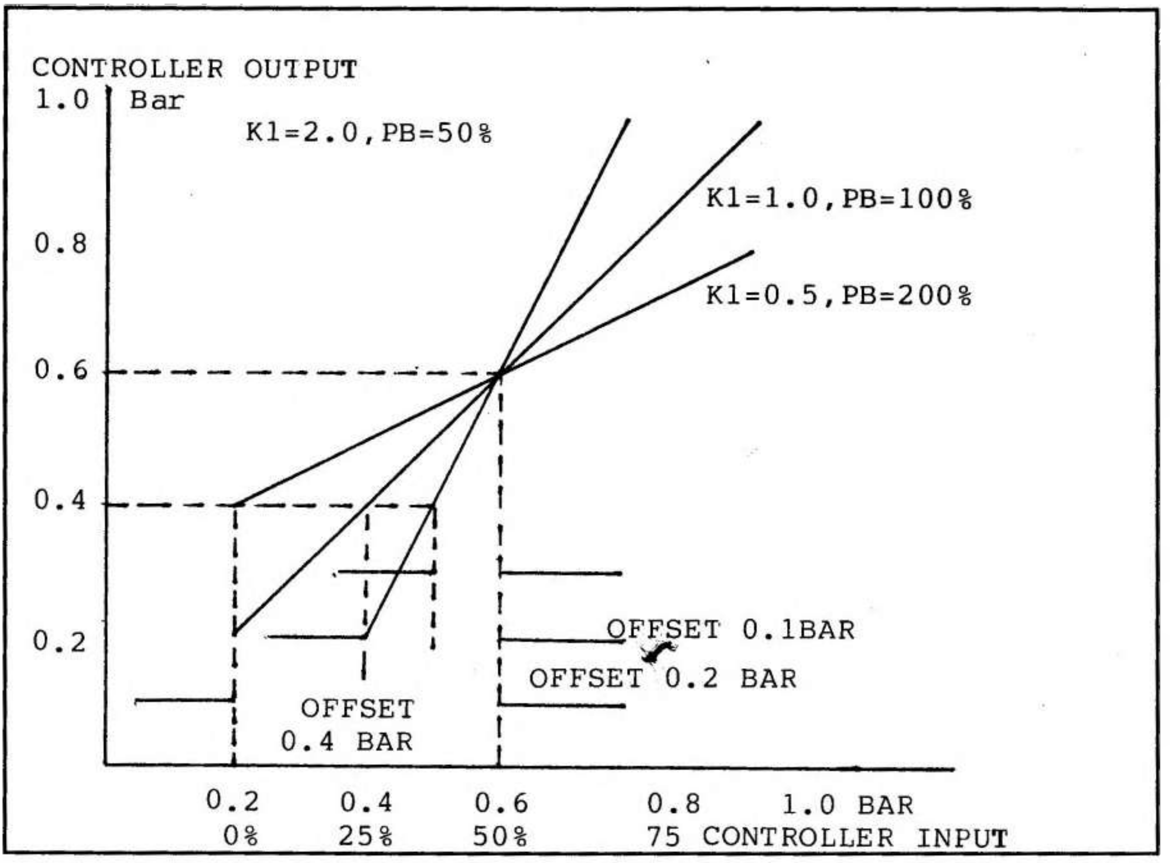
Proportional only mode of control is suitable for only those applications where the process load is fairly constant and the requirement for accuracy is not stringent. It is so because of the inability of proportioanl control to accommodate load changes without sustained deviation.

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

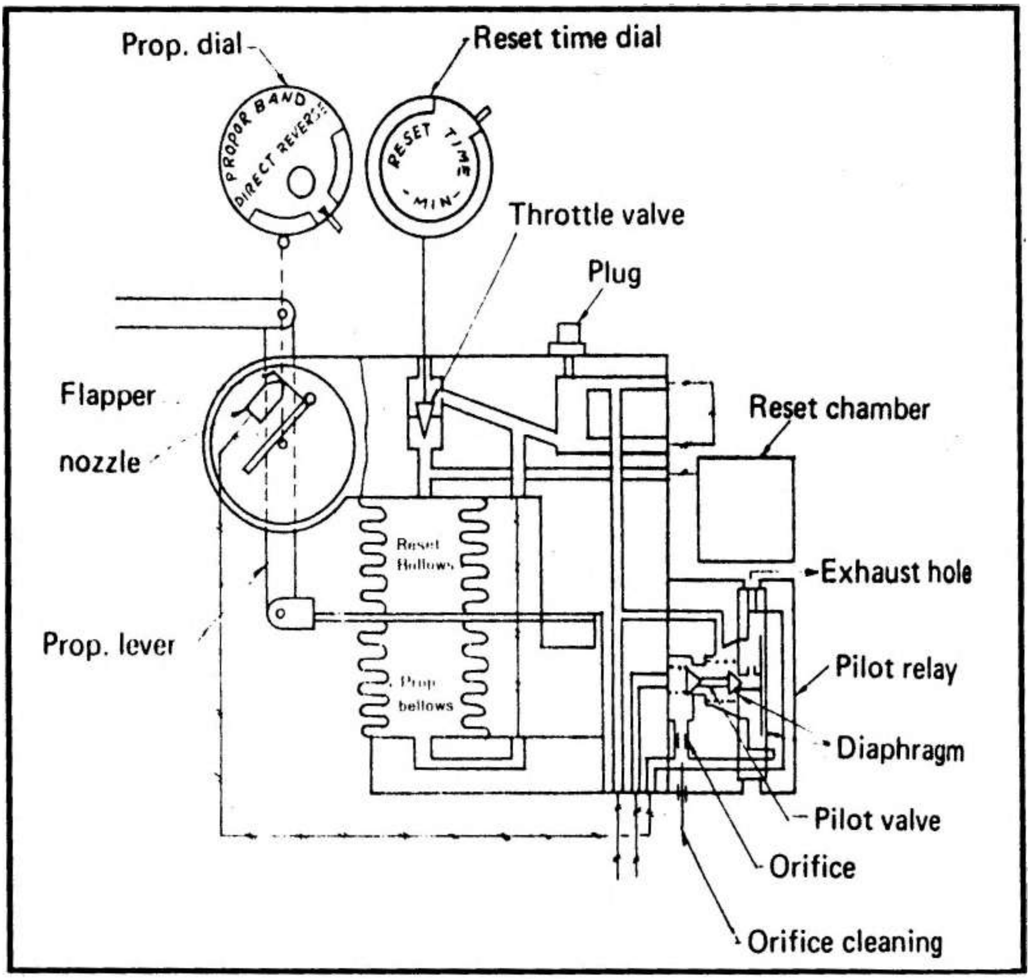
$$\text{Controller Gain (Loop)} = \frac{\text{output}}{\text{input}} = \frac{100}{\text{PB (50\%)}} = 2$$

$$\text{Proportional Band} = \frac{\text{input}}{\text{output}}$$

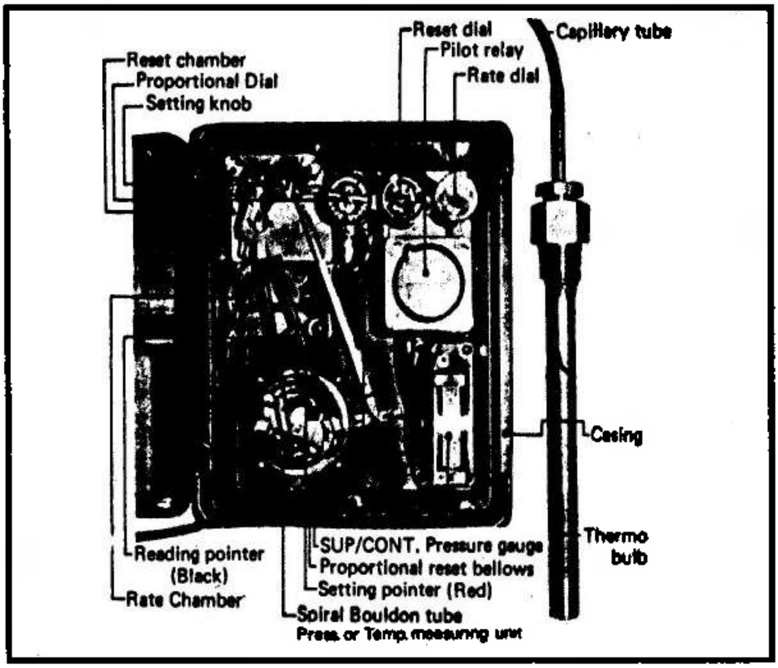
D. PERFORMANCE

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 realy 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/cm² (intermediate point of 0.2 - 1.0 kg/cm²)



PROPORTIONAL - ACTION



FRONT VIEW OF CONTROLLER

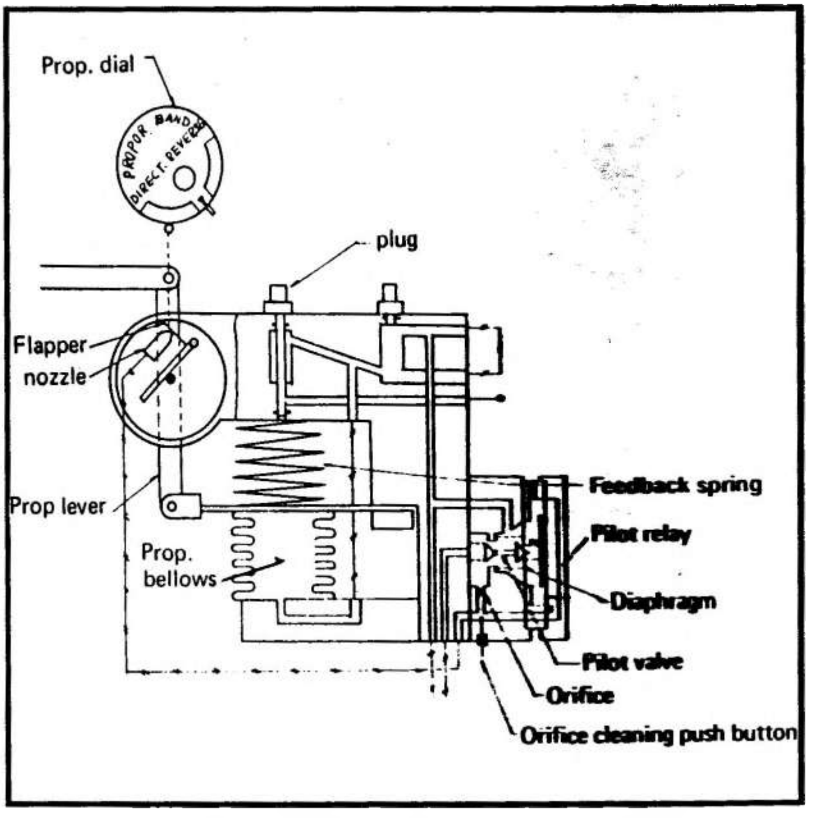
Controller can be applied to all possible fields of process control such as pressure, differential pressure, temperature, liquid level, flow rate, viscosity etc. when used in combination with diaphragm control valves at the operating end. It is a pneumatic controller which can automatically regulate 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.



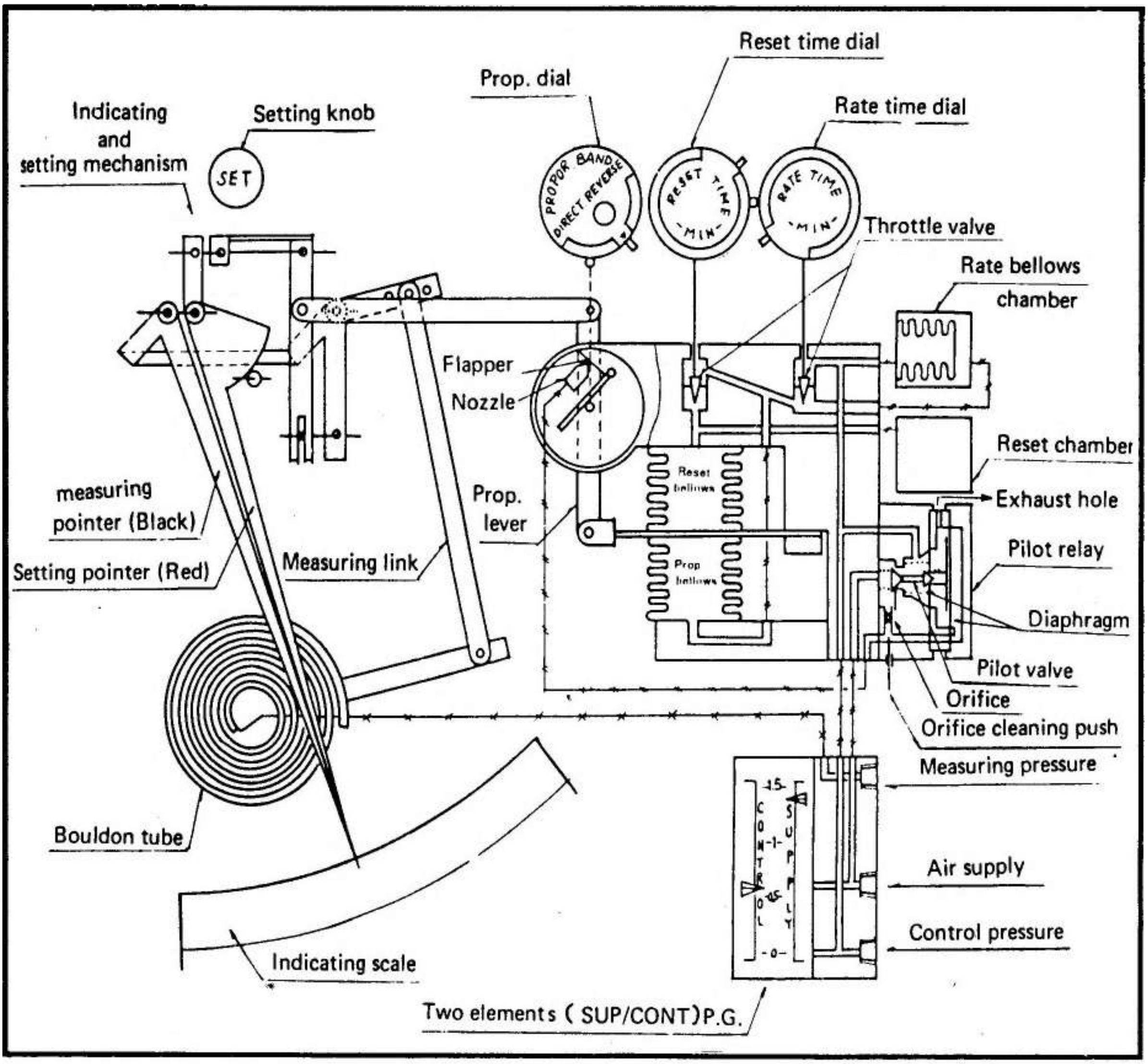
PROPORTIONAL–INTEGRAL ACTION

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

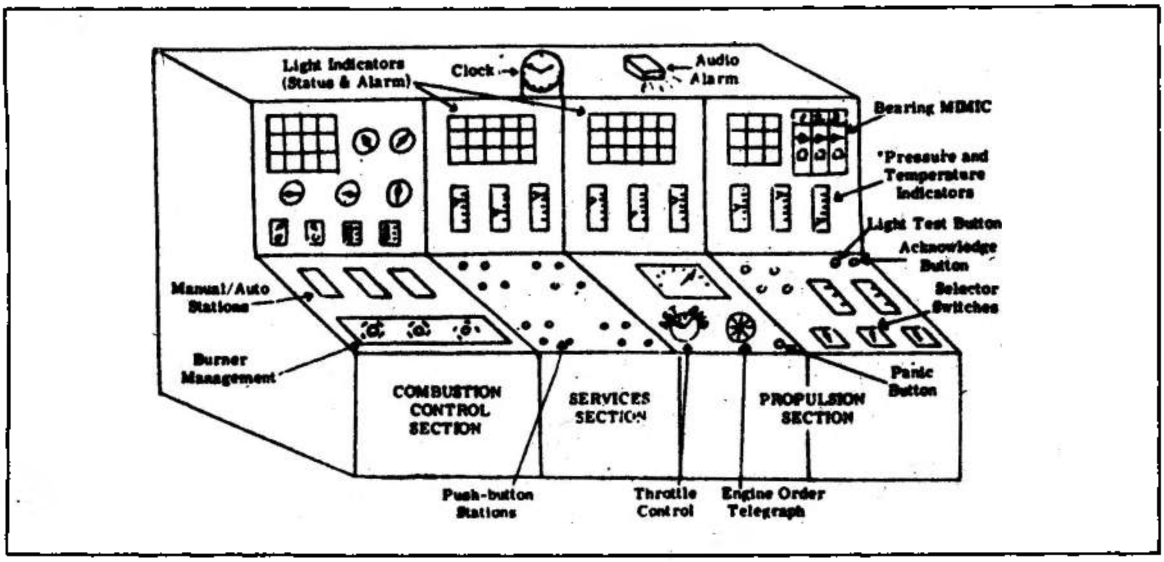
ENGINE ROOM AUTOMATION : THE CENTRAL OPERATION SYSTEM-

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.

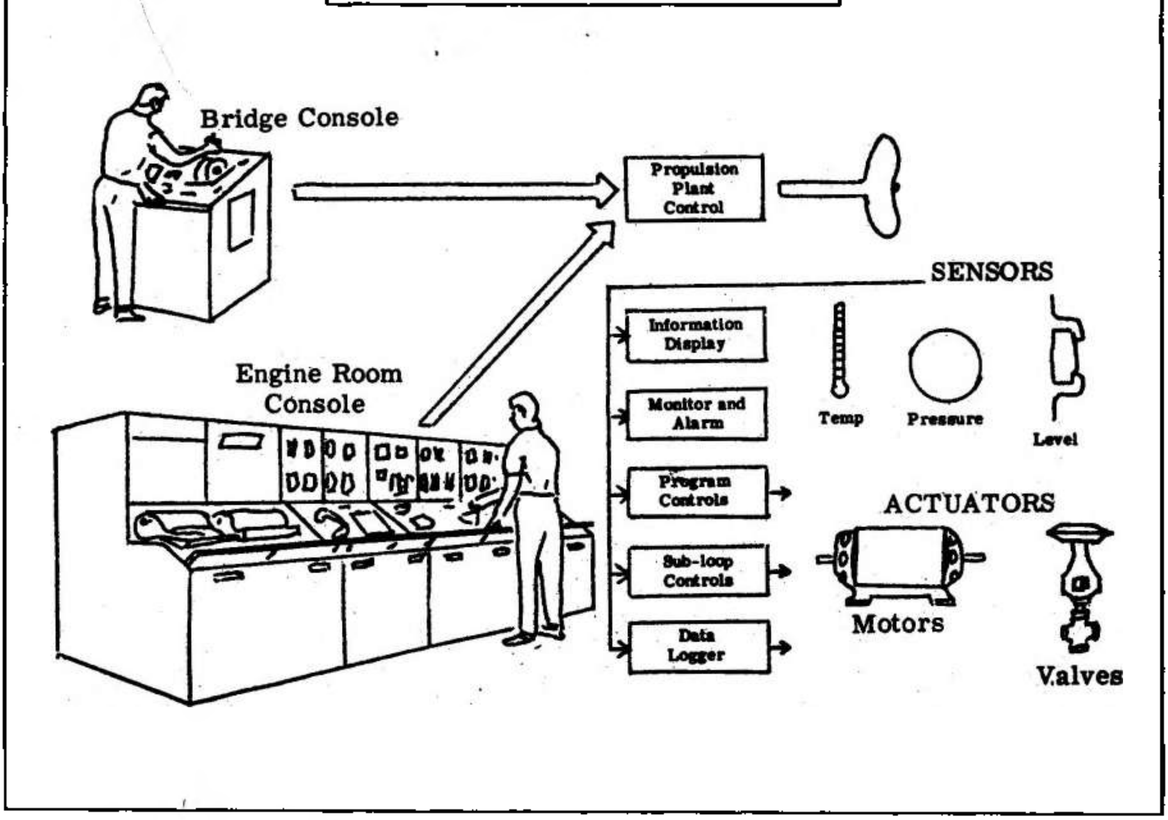
Program controls provide automatic sequential operations by a single operating command such as a push–button operation by the engineer. For example, a single push–button control can provide automatic synchronization and paralleling of a turbine generator. Also start up and shut down boiler feed pumps 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.

Block Diagram of COS

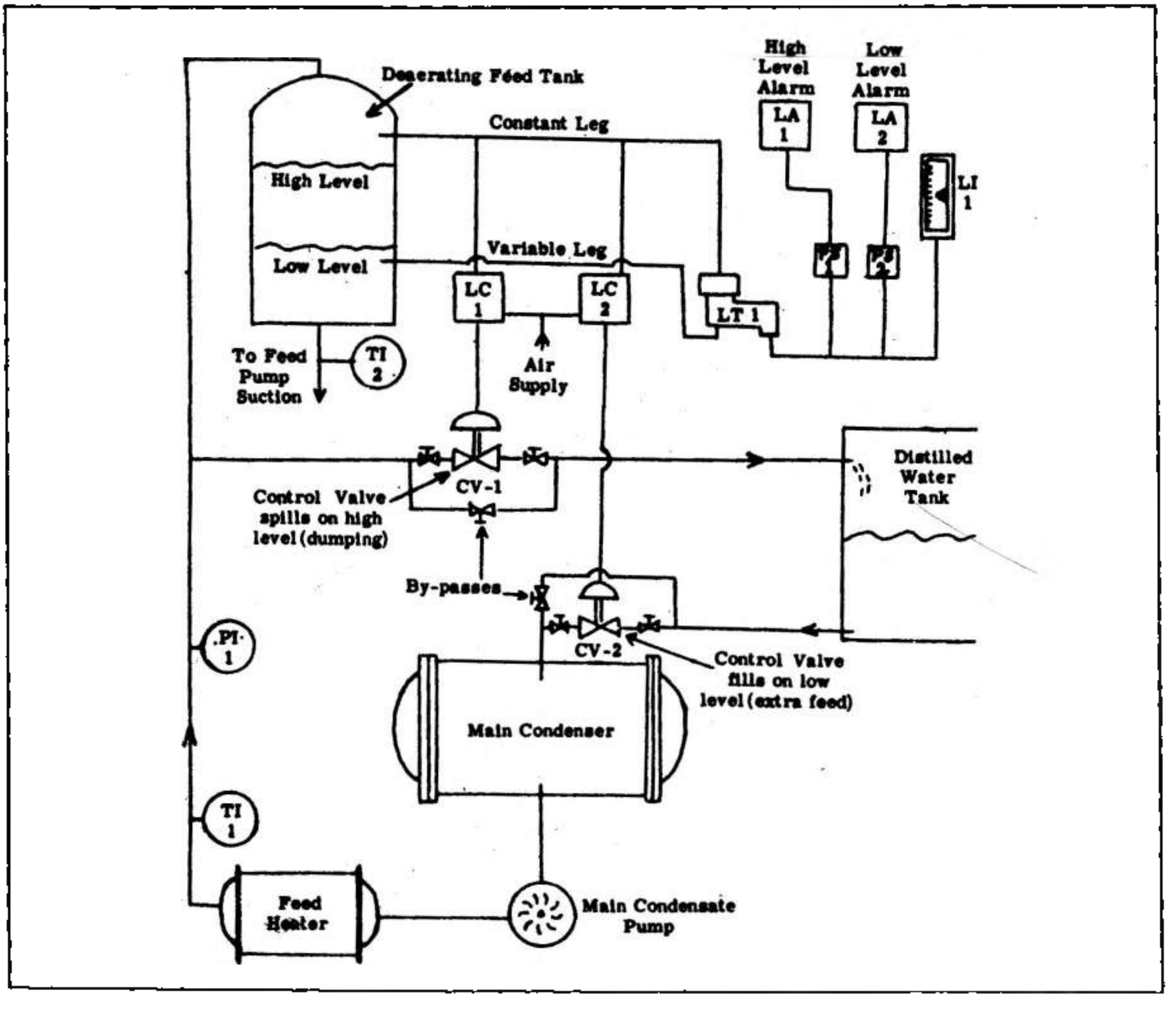


CONSOLE DEVICES

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

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

Position		Duties
Chief Engineer	–	In charge of Department
	–	Organization of watches
	–	Planning of trip requirements
First Assistant	–	Organization of Maintenance
Engineer:	–	Spare parts control
	–	Organization of off–watch work
	–	Control of overtime
	–	Fuel reception
Watch Officers:	–	Keeping of watch
Second, Third		
Asst. Engineer	–	1/3 of shifts
Electrician	–	Maintenance of electrical plant
	–	Electrical material, storeroom
Refrigeration	–	Maintenance of refrigeration plant
Technician		Maintaning cargo in air–conditioned hold
Boilermaker	–	Engine storerooms
	–	Cleanup personnel
	–	Tools control
	–	Tank probes
Greaser–Oiler	–	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 amd 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, ROUTINE 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.

Summary of MARPOL Annex V At Sea Garbage Disposal Limitations

Outside the Mediterranean Sea, Baltic Sea. Black Sea, Red Sea, and Gulf Area

Distance from Shore	Type of Dunnage Permitted to be Dumped at Sea
25 nautical miles or more	Floating, Lining and Packing Material
12 nautical miles or more	Food Waste-Not Ground or Comminuted All Other Garbage-Not Ground or Comminuted
3 nautical miles or more	Food Waste-Ground or Comminuted All Other Waste-Ground or Comminuted

Type of Garbage	At Sea Dumping Restrictions Apply
Plastics	Always (Dumping Prohibited)
Floating Dunnage, Lining, and Packing Materials	Less than 25 nautical miles from shore
Food Waste Ground or Comminuted	Less than 3 nautical miles from shore
No Ground or Comminuted	Less than 12 nautical miles from shore
All Other Garbage Ground or Comminuted	Less than 3 nautical miles from shore
Not Ground or Comminuted	Less than 12 nautical from shore
Mixed Garbage Types	Most Stringent Requirements Apply

Inside the Mediterranean Sea, Baltic Sea. Black Sea, Red Sea, and Gulf Area

Distance from Shore	Type of Garbage Permitted to be Dumped at Sea
12 nautical miles or more	Food Waste-Not Ground or Comminuted Food-Waste-Ground or Comminuted

Type of Garbage	At Sea Dumping Restrictions Apply
Plastics	Always (Dumping Prohibited)
Floating Dunnage, Lining, and Packing Materials	Always (Dumping Prohibited)
Food Waste Ground or Comminuted	Less than 12 nautical miles from shore
Not Ground or Comminuted	Less than 12 nautical miles from shore
All Other Garbage Ground or Comminuted	Always (Dumping Prohibited)
Not Ground or Comminuted	Allways (Dumping Prohibited)
Mixed Garbage Types	Most Stringent Requirements Apply

Plastics - including, but not limited to, synthetic ropes, synthetic fishing net, and plastic garbage bags

Ground or comminuted garbage must be able to pass through a screen with openings no greater than 25 millimiters

All Other Garbage - including paper products, rage, glass, metal, bottls, crockery, and similar refuse

Offshore Platforms and Asspciated Ships

Distance from Shore	Type of Garbage Permitted to be Dumped at Sea
12 nautical miles or more	Food Waste-Not Ground or Comminuted

Type of Garbage	At Sea Dumping Restrictions Apply
Plastics	Always (Dumping Prohibited)
Floating Dunnage, Lining, and Packing Materials	Always (Dumping Prohibited)
Food Waste Ground or Comminuted	Less than 12 nautical miles from shore
Not Ground or Comminuted	Always (Dumpiing Prohibited)
All Other Garbage Ground or Comminuted	Always (Dumping Prohibited)
Not Ground or Comminuted	Allways (Dumping Prohibited)
Mixed Garbage Types	Most Stringent Requirements Apply

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.

HELP STOP MARINE POLLUTION

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.

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 valve 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

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	SUBJECTS	WEIGHT
First Day of Examination		
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 A.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, First–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.

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 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

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 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.

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.

SEAFARERS PRAYERS

O GOD, I ASK YOU TO TAKE ME INTO YOUR CARE AND PROTECTION ALONG WITH ALL THOSE WHO SAILS IN SHIPS, MAKE ME ALERT AND WISE IN MY DUTIES, MAKE ME FAITHFUL IN THE TIME OF ROUTINE AND PROMPT TO DECIDES AND COURAGEOUS TO ACT IN ANY TIME OF CRISIS, PROTECT ME IN THE DANGERS AND THE PERILS OF THE SEA, AND EVEN IN THE STORM GRANT THAT THERE MAY BE PEACE AND CALM WITHIN MY HEART.

WHEN I'M FAR FROM HOME AND FAR FROM MY LOVED ONES AND FAR FROM THE COUNTRY WHICH I KNOW, HELP ME TO QUITE SURE THAT WHEREVER I AM I CAN NEVER DRIFT BEYOND YOUR LOVE AND CARE.

TAKE CARE OF MY LOVED ONES IN THE DAYS AND WEEKS AND MONTHS WHEN I'M SEPARATED FROM THEM, SOMETIMES WITH HALF THE WORLD BETWEEN THEM AND ME, KEEP ME TRUE TO THEM AND KEEP THEM SURE TO ME, AND EVERY TIME THAT WE HAVE TO PART, BRING US TOGETHER IN SAFETY AND IN LOYALTY AGAIN, THIS I ASK FOR YOUR LOVE'S SAKE, AMEN...

LORD, RULER OVER WAVES AND SEA, KEEP YOUR BLESSED HAND OVER ALL SEAFARER, GIVE ME THE STRENGTH TO LEAD A CHRISTIAN LIFE ABOARD OUR SHIP, I DO NOT WANT TO DISAPPOINT ANYONE WHO MAY EXPECT HELP FROM ME ABOARD, KEEP MY FAMILY AT HOME IN YOUR CARE, EVEN WHEN FAR AWAY FROM THEM FOR LONG, LET ME ALWAYS BE ATTACHED TO THEM, HELP ME AND ALL SEAFARERS TO KEEP ON THE RIGHT COURSE ALWAYS, AND TO REACH THE SAFE PORT OF HEAVEN.

BEFORE GOING TO WORK TO WATCH

LOVING FATHER, I THANK YOU FOR TAKING CARE OF ME DURING THESE PAST HOURS AND FOR THE GIFT OF REFRESHING SLEEP, HELP ME DURING THE COMING WATCH OR WORK TO LOVE AND SERVE YOU IN YOUR WELL DONE, SHOW ME WHAT IS RIGHT AND WHAT I OUGHT TO DO IT,, I COMMEND TO YOUR FATHERLY CARE ALL MY FAMILY, RELATIVES AND FRIENDS, KEEP US IN SAFETY, THOUGH WE ARE FAR APART, UNITE US IN LOYALTY AND LOVE TO ONE ANOTHER AND TO YOU, THROUGH JESUS CHRIST OUR LORD, AMEN.

ON LEAVING PORT

BE WITH US, O LORD, ON THIS VOYAGE, TO CHEER US AND KEEP US SAFE IN ALL DANGERS, LET NOTHING AFLOAT OR ON SHORE CUT US OFF FROM YOU, MAY WE PLEASE YOU IN EVERYTHING WE DO, BLESS ALL ON BOARD, HELP US TO BE GOOD SHIPMATES AND BRING US BACK AGAIN IN SAFETY TO OUR HOMES, AND THOSE WHO LONG FOR OUR RETURN, THROUGH JESUS CHRIST, OUR LORD, AMEN.