COURSE MODULE

Course No. CE 26: Initial SE/JE-II

Duration: 26 Weeks **Effective Days: 150**

S. N.	CM No.	*Subjects*	Sessions /Periods	Page
1	26.1	Electrical & Electronics	74 / 148	1-166
2	26.2	Hydraulics, Pneumatics & Mechanical	74 / 148	167-248
3	26.3	I.C. Engine & Workshop Technology	80 / 160	249-374
4	26.4	Track Machines & Working Principles	74 / 148	375-501
5	26.5	P.Way, Establishment, Stores, Accounts & Rajbhasha	74 / 148	502-582
6	26.6	Group Inter Personal Skill Development (GIPSD)	7 / 14	588-593
7	26.7	Computer	24 / 48	594-617
8		Technical Film Show	10 / 20	
9		Library	10 / 20	
10		Visit to CPOH & Track Machines Working Sites	42 / 84	
11		Examination (Theory/Practical/Viva-voce) & Valediction	18 / 36	
		Total	487 / 974	617

Note: A.

1. **Eligibility: Directly Recruited SE/JE-II and such Promoted SE/JE-II, who has no exposure of track machines working.**
2. **Computer, Technical Film Show and Library periods shall be scheduled during the afternoon session.**
3. **M&C Training shall be covered under Module No. 26.3. Faculty for M&C Training may be drawn from M&C Directorate of RDSO.**
4. **Medical Awareness Programme shall be covered under Module No. 26.5 for which Faculty may be drawn from Medical Department.**
5. **Faculty for GIPSD may be drawn from CBWE, Min. of Labour & Employment or from Management Institutes.**
6. **To bridge the gap between theory and practical, every alternate week visit to CPOH & Track Machines Working Sites shall be arranged for demonstration and proper understanding of machine working.**
7. **Practical demonstration in Model rooms shall be given along with theoretical sessions as and when required besides Practical sessions specifically earmarked for Model Rooms.**

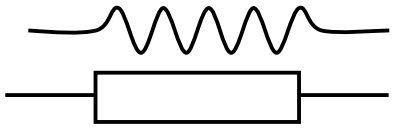
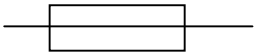
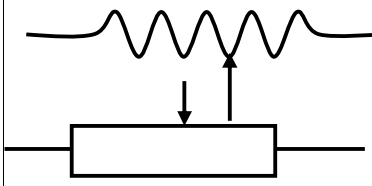
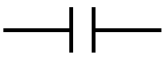
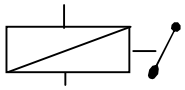
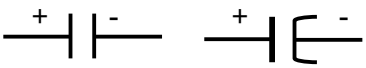
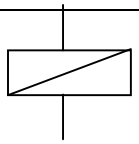
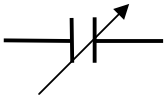
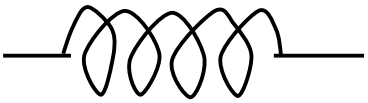
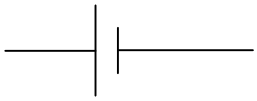
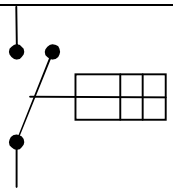
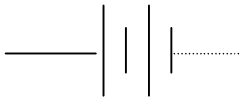
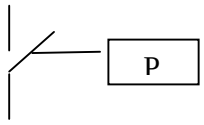
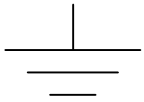
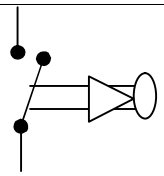
SUB: ELECTRICAL & ELECTRONICS SYSTEM

Duration: 74 Sessions = 148 Periods

Sub-discipline:- Electrical System(Lessons: 03 Sessions:15)

Lesson-I: Fundamentals of Electricity **Session-1:** Symbols**,** Basic Concept of voltage and current, Ohm's law, Power law

---

ELECTRIC SYMBOLS			
Name & Letter Notation	**Symbol**	**Name & Letter Notation**	**Symbol**
Resistor R or r		Fuse Si or e	
Variable resistor or Potentiometer P or f		Circuit Breaker e	
Capacitor(Non-Polarised) C or K		Relay Re	
Polarize Capacitor or Electrolyte Capacitor C or K		Solenoid or Shut down coil (s)	
Variable Capacitor C		Speaker	
Inductor **L**		Galvanometer (g)	
Cell		Ignition Switch (b)	
Battery		Pressure Switch (b)	
Earth OD(OA)		Limit Switch Ls	

GENERAL :

Electricity cannot be weighed on a scale or measured into a container. But, certain electrical "actions" can be measured.These actions or "terms" are used to describe electricity; **voltage, current, resistance,** and **power**.

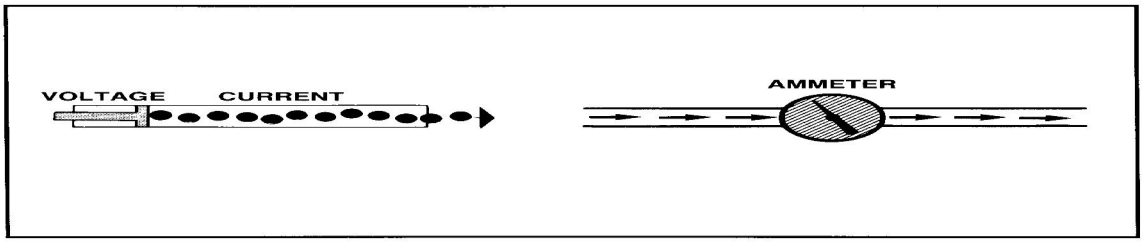
VOLTAGE:
Voltage is electrical pressure, a **potential force** or difference in electrical charge between two points. It can push electrical current through a wire, but not through its insulation.Voltage is measured in **volts**. One volt can push a certain amount of current, two volts twice as much, and so on. A **voltmeter** measures the difference in electrical pressure between two points in volts. A **voltmeter** is used in parallel.

Voltage is pressure

Voltage	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	V	μV	mV	kV	MV
Pronounced As	Volt	Micro-volt	Milli-volt	Kilo-volt	Mega-volt
Multiplier	1	0.000001	0.001	1,000	1,000,000

CURRENT :
Current is electrical flow moving through a wire. Current flows in a wire pushed by voltage. Current is measured in amperes, or amps, for short. An ammeter measures current flow in amps. It is inserted into the path of current flow, or in series, in a circuit.

Current is flow.



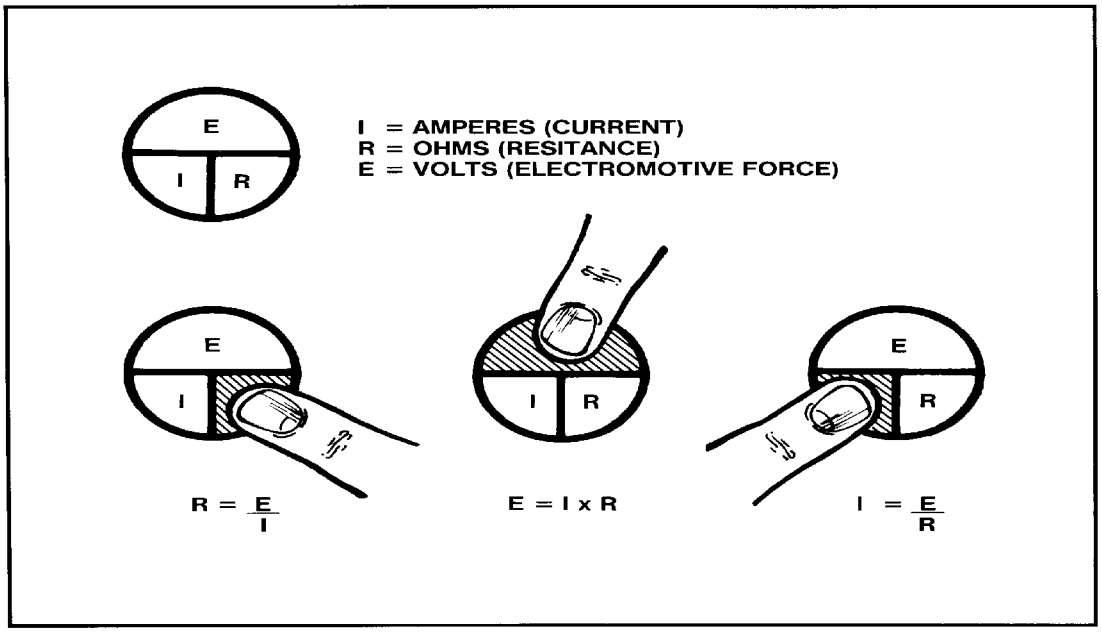
Current	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	A	μA	mA	kA	MA
Pronounced As	Ampere (Amp)	Micro-ampere	Milli-ampere	Kilo-ampere	Mega-ampere
Multiplier	1	0.000001	0.001	1,000	1,000,000

A simple relationship exists between voltage, current, and resistance in electrical circuits.Which can be explain with the help of Ohm’s Law.

OHM'S LAW
The current in a circuit is directly proportional to the applied voltage and inversely proportional to the amount of resistance.

This means that if the voltage goes up, the current flow will go up, and vice versa. Also, as

the resistance goes up, the current goes down, and vice versa.



ELECTRIC POWER AND WORK:
Voltage and current are not measurements of electric power and work. Power, in watts, is a measure of electrical energy ... power (P) equals current in amps (1) times voltage in volts (E), P = I x E. Work, in watt seconds or watt-hours, is a measure of the energy used in a period of time ... work equals power in wafts (W) times time in seconds (s) or hours (h), W = P x time. Electrical energy performs work when it is changed into thermal (heat) energy, radiant (light) energy, audio(sound) energy, mechanical (motive) energy, and chemical energy. It can be measured with a waft- hour meter.

Power	Basic Unit	Units for Very Small Values	Units for Very Large Values	
Symbol	W	mW	kW	MW
Pronounced As	Watt	Milliwatt	Kilowatt	Megawatt
Multiplier	1	0.001	1,000	1,000,000

Power is the amount of work performed. It depends on the amount of pressure and the volume of flow.

Sub-discipline:- Electrical System(Lessons: 03 Sessions:15)

Lesson–II: Electrical Components Session-2: Resistor: Definition, Unit,Symbol, Types ,Power Rating, Tolerance,

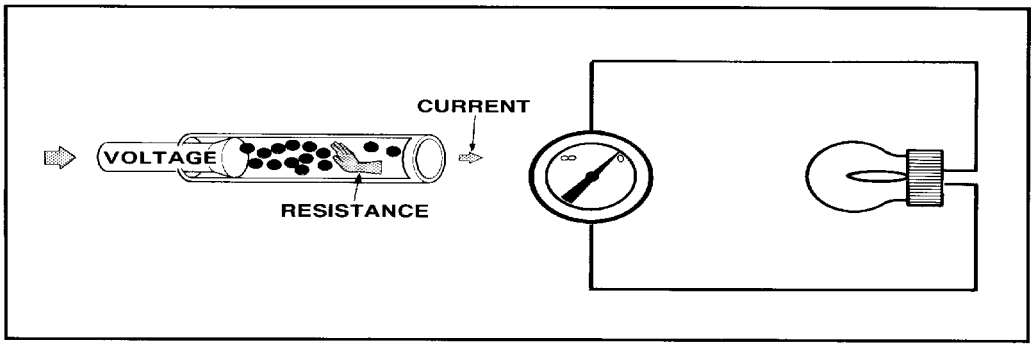
---

RESISTANCE:

Resistance opposes current flow. It is like electrical "friction." This resistance slows the flow of current. Every electrical component or circuit has resistance. And, this resistance changes electrical energy into another form of energy - heat, light, motion. This property of the component is called resistance, it's unit is "Ohm" Ω.

1 Kilo Ohms(KΩ) = 1000 Ohms
1 Mega. Ohms(MΩ) = 1,000,000 Ohms = 10^6 Ohms =1,000 KΩ

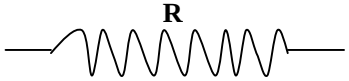
Resistance opposes flow.

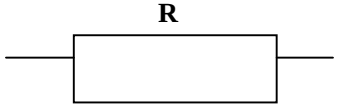


Resistance is measured in ohms. A special meter, called an **ohmmeter**, can measure the resistance of a device in ohms when no current is flowing.

Resistance	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	Ω	μΩ	mΩ	kΩ	MΩ
Pronounced As	Ohm	Micro-ohm	Milli-ohm	Kilo-ohm	Mega-ohm
Multiplier	1	0.000001	0.001	1,000	1,000,000

Symbol:

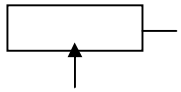




TYPES OF RESISTOR

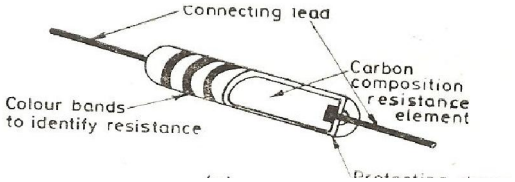
Fixed type resistor

Variable type resistor
(Potentiometer)
value of Resistance can be varied



Carbon composition Resistor

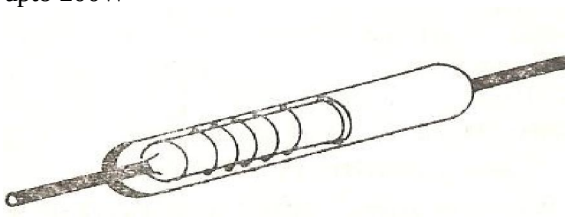
The resistive material is of carbon-clay composition. The leads are made of tinned copper. Resistors of this types are readily available in values ranging from few ohms to about 22MΩ



Wire wound resistor

In wire wound resistor a length of resistance wire such as nichrome is used, which is wound on to a round hollow porcelain core

The ends of winding are attached to there metal pieces inserted in the core. These resistors are available from 1Ω to 100 KΩ with wattage rating upto 200W



Properties of Resistor:

(1) Resistance is directly proportional to the length of conductor & inversely proportional to cross-sectional area of conductor.

$R \propto l/a$ or $R = \rho l/a$

Where l = Length of conductor
a = Cross sectional area.
ρ = Resistivity.

(2) Resistance depends upon nature of material & rises with rise in temp. in case of conductors & metals. In case of insulators, resistance decreases with the increase in temp.

(3) Resistance has no polarity. It can be used in any direction.

POWER RATING :

The power rating of a resistor is given by the maximum wattage it can dissipate without excessive heat. They are available in 1/8, 1/4 , 1/2, 1, 2, watt. The size of resistos varies with

wattage rating. The size of resistor increases as wattage rating increases.

$\mathbf{P = I^2 R}$ Where P = Power in Watt
I = Current in Amps
R = Resistance in Ohms

Resistor of appropriate wattage should be selected. Resistors of ¼ watt are widely used .

TOLERANCE:

The tolerance of resistor is a measure of the precision with which the resistor was made. It is the value in percentage, which may be less or more than the manufactured value of resistor. Resistors are available in following tolerances 0.1%, 1%, 2%, 5%, 10% and 20%. Generally resistors of 5% tolerance are used. Where accuracy is required, resistors of .1% to 1% are used.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

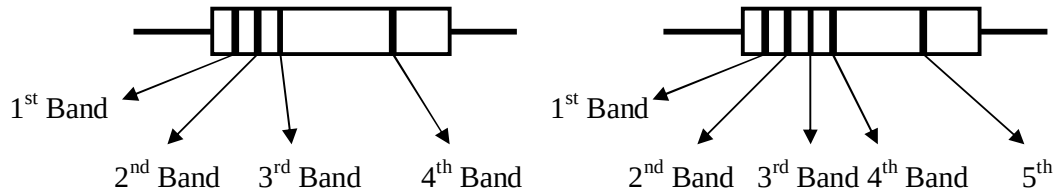
Lesson–II: Electrical Components **Session-3:** Resistor: Colour coding, Combination, Application, Faults & Troubleshooting

---

COLOUR CODING OF RESISTORS:

To indicate value of resistors colour coding technique is used instead of printing value directly on resistors which is followed by all manufacturers. In this technique bands of colours are printed on resistors generally 4-band and 5-band techniques are used to indicate value of resistors. 4-band colour coding is explain below.

4-band colour resistor **5-band colour resistor**



4-Band colour code Table

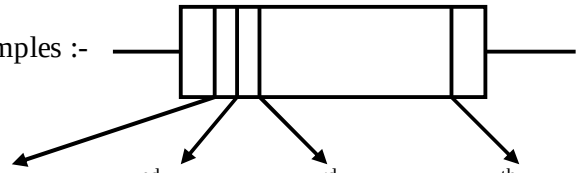
Colour	Ist & 2nd Band Digit	3rd Band Multiplier	4th Band Tolerance
Black	0	$10^0=1$	
Brown	1	$10^1=10$	1%
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	.1%
Gray	8	10^8	
White	9	10^9	
Gold	-	$0.1 = 10^{-1}$	± 5%
Silver	-	$0.01 = 10^{-2}$	± 10%
No colour	-	-	± 20%

Mnemonics: As an aid to memory in remembering the sequence of colour codes given above, the Trainees can remember the following sentence (all the capital letters stand for colours):

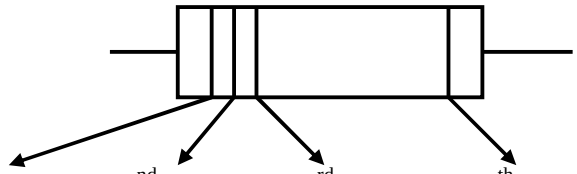
(a) B. B. R O Y in Grate Britain has a Very Good Wife.
0 1 2 3 4 5 6 7 8 9

(b) Bill Brown Realized Only Yesterday Good Boys Value Good Work.
© Bye Bye Rosie Off You Go Bristol Via Great Western.

Examples :-



1st band	2nd band	3rd band	4th band		
Yellow	Violet	Orange	Gold		
4	7	10^3	±5%	=	47 kΩ ± 5%



1st band	2nd band	3rd band	4th band		
Blue	Gray	Brown	Gold		
6	8	10^1	± 5%	=	680Ω ± 5%

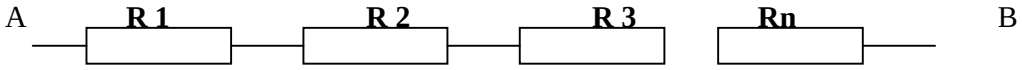
In practical electronic circuits, the values of the resistors required may lie within a very wide range (say, from few ohms to about 20 MΩ). In most of the circuits, it is not necessary to use resistors of exact values. Even if a resistor in a circuit has a value which differs from the desired (designed) value by as much as 20%, the circuit still works quite satisfactorily. Therefore, it is not necessary to manufacture resistors of all the possible values. A list of readily available standard values of resistors are given in Table .

Standard values of commercially available resistors:

Ohms (Ω)			**Kilohms (kΩ)**			**Megaohms(MΩ)**	
1.0	10	100	1.0	10	100	1.0	10
1.2	12	120	1.2	12	120	1.2	12
1.5	15	150	1.5	15	150	1.5	15
1.8	18	180	1.8	18	180	1.8	18
2.2	22	220	2.2	22	220	2.2	22
2.7	27	270	2.7	27	270	2.7	
3.3	33	330	3.3	33	330	3.3	
3.9	39	390	3.9	39	390	3.9	
4.7	47	470	4.7	47	470	4.7	
5.6	56	560	5.6	56	560	5.6	
6.8	68	680	6.8	68	680	6.8	
8.2	82	820	8.2	82	820	8.2	

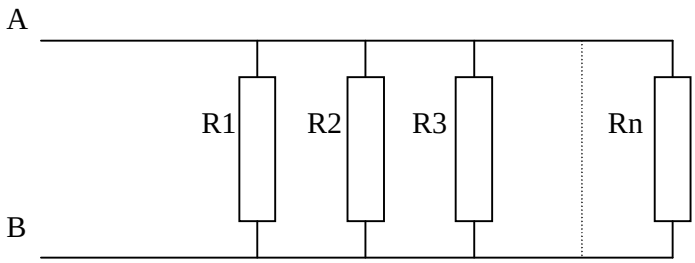
COMBINATION OF RESISTORS :

a) Series Connection :-



$R_{total} = R1 + R2 + R3 + \ldots\ldots\ldots\ldots\ldots + Rn$

b) Parallel Connection :-



$1/Rt = 1/R1 + 1/R2 + 1/R3 + \ldots\ldots\ldots + 1/Rn$

APPLICATION :

1. It apposes the current so it is used to reduce current in the circuit.
2. To drop the voltage (V = I.R.) and as potentiometer.
3. In timer circuit to set time (T=RC).
4. To set the gain of operational amplifiers.
5. In bulb and heaters.

TROUBLES:

General trouble in resistor is open circuit and it get short rarely.

How to check the Resistor in PCBs:

1. Select higher Ohmic(MΩ) range in Multi meter.
2. At least one terminal of the resistor should be taken out from PCB with the help of desoldering.
3. If Multi meter indicates open or short, it is faulty. If it indicates printed value then resistor is correct.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–II: Electrical Components **Session-4:** Capacitor: Definition, Unit, Symbol Types, Combinations, Application, Faults and Troubleshooting

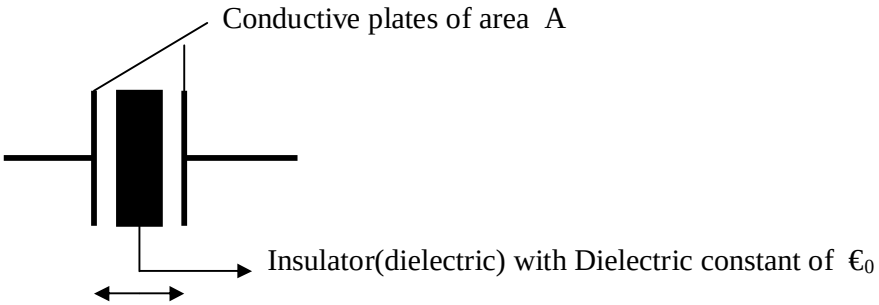
---

CAPACITOR:

Capacitor is a passive component, which can store electrical energy in the form of charge (Electrons) and release them whenever required .Capacitor's ability to store electrical charge is called **Capacitance** . It is represented by "C"and it's unit is Farad(F) but practically its small units are used like Micro farad(μF), Pico farad (pF) Nano Farad (nF).

1 Farad = 10^6 Micro farad(μF) 1 Micro farad(μF) = 10^{-6} Farad
1 Farad = 10^9 Nano farad(nF) 1 Nanofarad(nF = 10^{-9} Farad
1 Farad = 10^{12} Pico farad(pF) 1 Pico farad(pF) = 10^{-12} Farad

Construction :-Capacitor consists of two plates of conductive material separated by insulating material which is called **dielectric.**



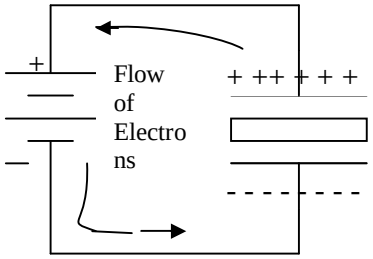
Material	Dielectric Constant €0
Air	1.0
Mica	4.2
Paper	4.7
Ceramic	80

Capacitance of capacitor $C \alpha \frac{A}{d}$

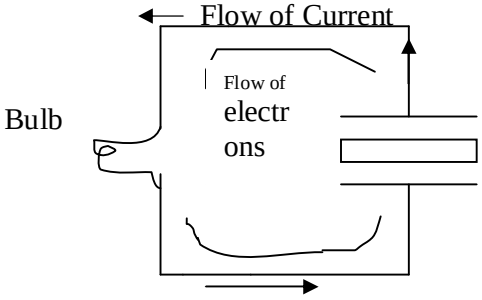
$C = \frac{€_0 . A}{d}$

Capicitance of capacitor can be increased by increasing area of plates, decreasing distance between plates.

Charging and discharging of capacitor :-**The process of storing electrical charge(electrons) is called charging of capacitor. When capacitor release stored energy it is called discharging of capacitor.**



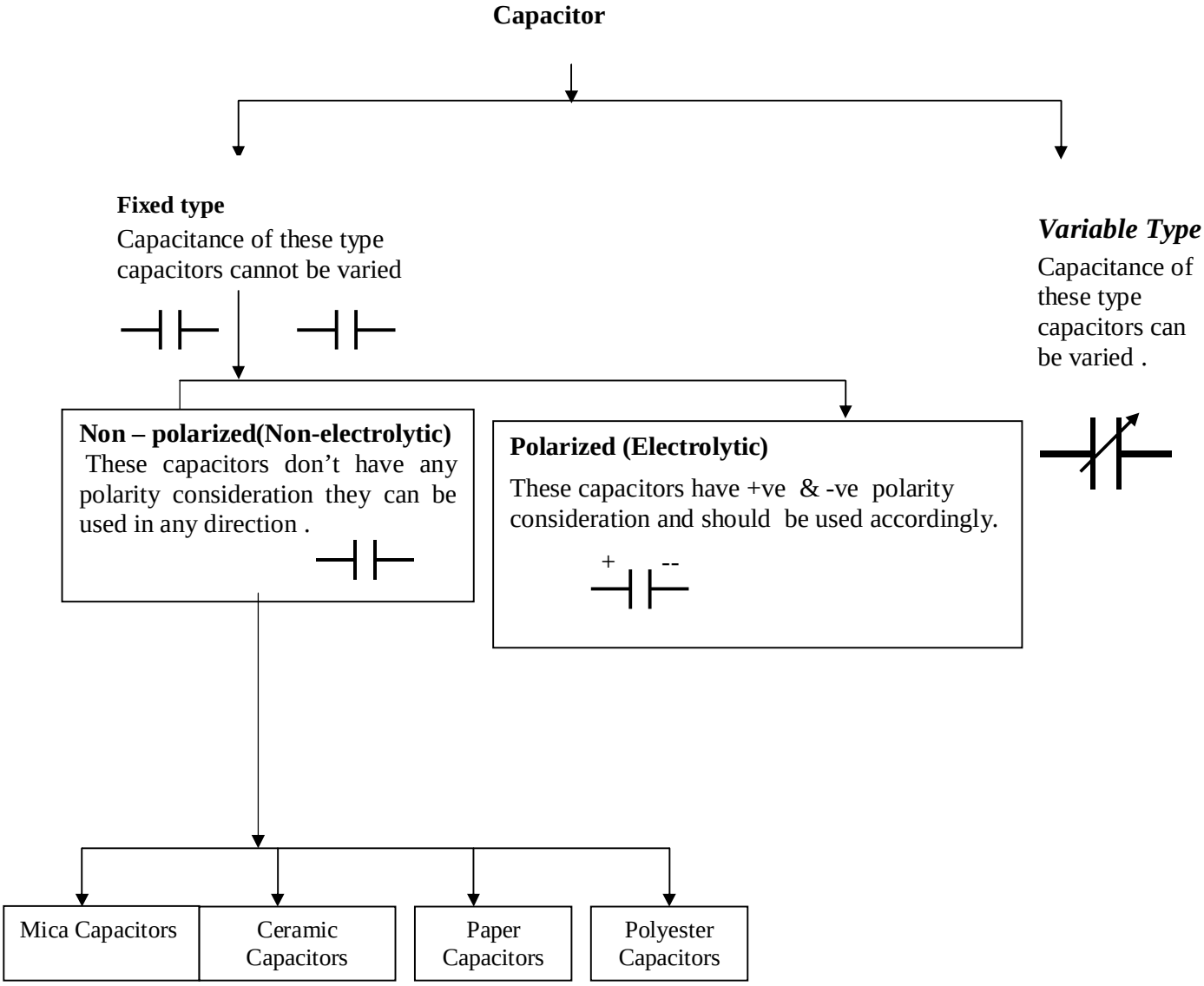
Charging of Capacitor



Discharging of Capacitor

TYPES:

Like resistors, capacitors are also fixed type and variable type. Fixed type capacitors are again of two types, non – polarized(Non electrolytic) and polarized (Electrolytic) . Some of the most commonly used non – polarized capacitors are mica, ceramic , paper capacitors . Polarized capacitors are electrolytic and tantalum capacitors . Variable capacitors are air-gang and trimmer capacitors .



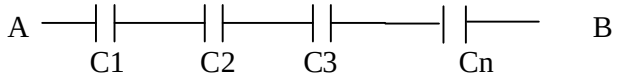
APPLICATIONS:

1. To store charge and discharge when required.
2. To pass A.C. signal and block D.C. signals.
3. To pass UN wanted signals.
4. In time delay circuits.
5. In tuned circuits.

COMBINATION OF CAPACITOR:

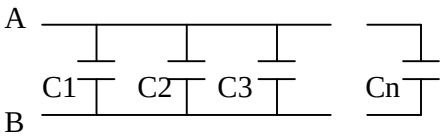
1.Series Combination :

Suppose C_1, C_2, C_3, C_n capacitors connected in series, then effective capacitance across the combination will be-



1/C total = 1/C1 + 1/C2 + 1/C3 + ….. + 1/Cn

*2.*Parallel Combination :



C total = C1 + C2 + C3 + …….. + Cn

APPLICATION:

(i) It is used in filter circuit.
(ii) It is used in timer circuit.
(iii) It is used as a memory.

TROUBLES IN CAPACITORS:

(1) Short circuiting
(2) Open circuiting
(3) Leakage

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–II: Electrical Components **Session-5:** Inductor: Definition, Unit, Symbol Types, Combinations, Application, Faults and Troubleshooting

---

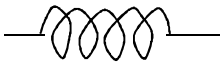
INDUCTOR :

When current flows through a coil of conductor wire then it generates a magnetic field. The magnetic field reacts so as to oppose the change in current. This reaction of magnetic field is called inductance, and the force it develops is called induced emf, and component producing inductance is called inductor. It is a fine length of wire wound on a core, frame or air core. Unit of inductance is Henry .

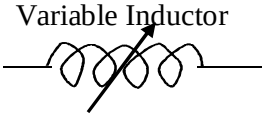
Mili Henry mH = 10^{-3} Henry
Micro Henry µH = 10^{-6} Henry

Types of Inductor

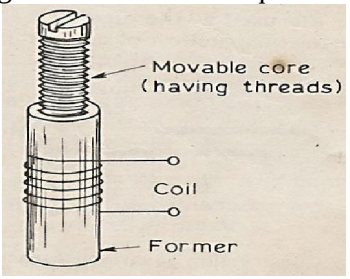
Fixed type Inductor



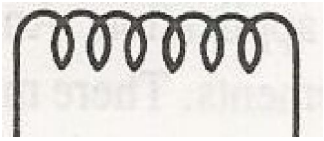
Variable Inductor



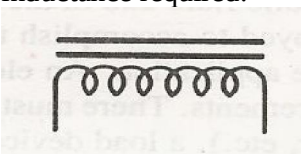
Variable inductors are used in tuning circuits of radio frequencies.



AirCore Inductor: When a coil is wound on a hollow insulting tube, this is called air core inductor. These are used where small inductance required .



IronCoreInductor: When Coil is wound on iron base, it is called iron core inductor.These are used where large inductance required.



APPLICATIONS: -

1.It is used as solenoid in hydraulic and pneumatic valves to shift spools.

2.In electromagnetic relay to change positions of contacts.

3.It is used as shut down coil in engines.

4.In filter circuits.

5.In oscillator circuits.

6.In tuning circuits.

7.In transformers to step down or step the A.C. voltage.

8.It is used as choke in florescent tubes.

9.It is used in motors and generators.

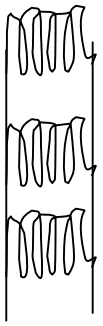
COMBINATION OF INDUCTORS:

a) Series Combination :

$L_t = L_1 + L_2 + L_3 + \ldots\ldots + L_n$

b) Parallel Combination :

$1/L_t = 1/L_1 + 1/L_2 + 1/L_3 + \ldots\ldots + 1/L_n$



TROUBLES OF INDUCTOR :-

(1) Short circuit.
(2) Open circuit.

Session-6: Electronics Model Room for demonstration, checking of Resistor, Capacitor and Inductor

---

In Electronic model room these components are shown and checked with the help of Multimeters

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical **Session-7 :** Battery: Definition of Cell & Battery, Types, Construction, Specific Gravity, Rating

---

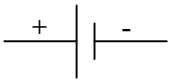
BATTERY :

The battery is the primary "source" of electrical energy on Automotives. It stores chemicals, not electricity. Two different types of lead in an acid mixture react to produce an electrical pressure. This **electrochemical reaction** changes chemical energy to electrical energy. Battery is the Combination of cells .

CELL:

It converts chemical energy to electrical energy. In cell electrical energy is store in the form of chemical energy. When battery is connected to any circuit then chemical energy is converted to electrical energy current flows from +ve to –ve terminal.

Symbol Cell:



Battery

TYPES :

1. **PRIMARY CELL:** Non rechargeable cell is called Primary Cell.The chemical reaction totally destroys one of the metals after a period of time. Small batteries for Torch and radios are primary cells.

2. **SECONDARY CELL:** Rechargeable cell is called Secondary Cell .The metals and acid mixture change as the battery supplies voltage. The metals become similar, the acid strength weakens. This is called **discharging**. By applying current to the battery in the opposite direction, the battery materials can be restored. This is called **charging** . Automotive lead-acid batteries are secondary cells

CONSTRUCTION :

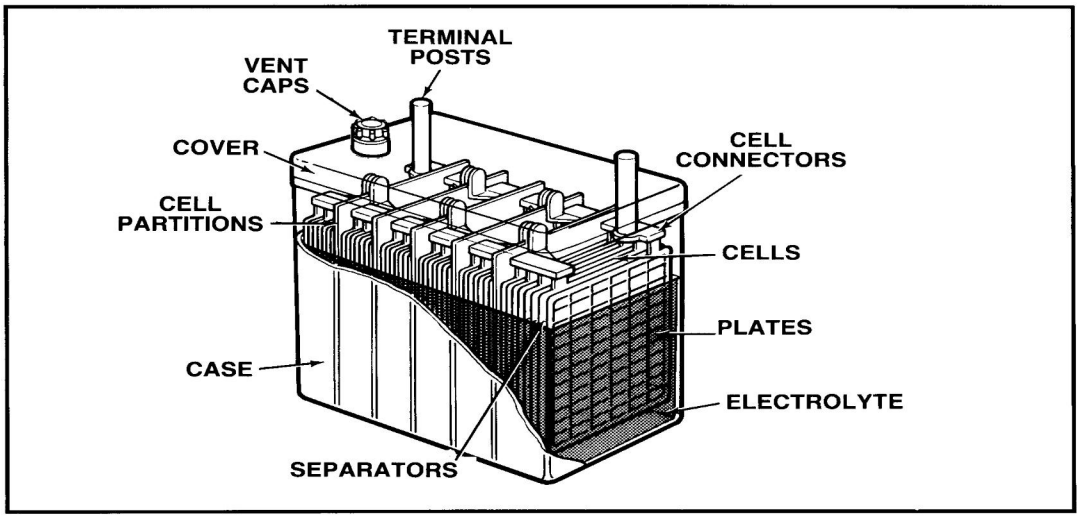
1.Case: Container which holds and protects all battery components and electrolyte, separates cells, and provides space at the bottom for sediment (active materials washed off plates) Translucent plastic cases allow checking .

2.Cover: Permanently sealed to the top of the case; provides outlets for terminal posts, vent holes for venting of gases and for battery maintenance (checking electrolyte, adding water).

3.Plates: Positive and negative plates have a grid framework of antimony and lead alloy. Active material is pasted to the grid ... brown-colored lead dioxide (Pb02) on positive plates, gray- colored sponge lead (Pb) on negative plates. The number and size of the plates determine current capability ... batteries with large plates or many plates produce more current than batteries with small plates or few plates.

4. Separators: Thin, porous insulators (woven glass or plastic envelopes) are placed between positive and negative plates. They allow passage of electrolyte, yet prevent the plates from touching and shorting out.

5.Cells: An assembly of connected positive and negative plates with separators in between is called a cell or element. When immersed in electrolyte, a cell produces about 2.1 volts (regardless of the number or size of plates). Battery cells are connected in series, so the number of cells determines the battery voltage. A"1 2 - volt" battery has six cells.



6. Cell Connectors: Heavy, cast alloy metal straps are welded to the negative terminal of one cell and the positive terminal of the adjoining cell until all six cells are connected in series.

7. Cell Partitions: Part of the case, the partitions separate each cell.

8. Terminal Posts: Positive and negative posts(terminals) on the case top have thick, heavy cables connected to them. These cables connect the battery to the vehicle's electrical system (positive) and to ground (negative).

9. Vent Caps: Types include individual filler plugs, strip-type, or box-type. They allow controlled release of hydrogen gas during charging (vehicle operation). Removed, they permit checking electrolyte and, if necessary, adding water.

10. Electrolyte: A mixture of sulfuric acid (H2SO4) and water (H2O). It reacts chemically with the active materials in the plates to create an electrical pressure (voltage). And, it conducts the electrical current produced by that pressure from plate to plate. A fully charged battery will have about 36% acid and 64% water.

SPECIFIC GRAVITY:-

Specific gravity means exact weight. The hydrometer compares the exact weight of electrolyte with that of water. **Strong electrolyte in a charged battery is heavier than weak electrolyte in a discharged battery.**

By weight, the electrolyte in a fully charged battery is about 36% acid and 64% water. The specific gravity of water is 1.000. The acid is 1.835 times heavier than water, so its specific gravity is 1.835. The electrolyte mixture of water and acid has a specific gravity of 1.270 is usually stated as "twelve and seventy."By measuring the specific gravity of the electrolyte, you can tell if the battery is fully charged, requires charging, or must be replaced. It can tell you if the battery is charged enough for the capacity, or heavy- load test.

CAPACITY RATINGS:

The battery must be capable of cranking the engine and providing adequate reserve capacity. Its capacity is the amount of electrical energy the battery can deliver when fully charged. Capacity is determined by the size and number of plates, the number of cells, and the strength and volume of electrolyte.

AMP-HOURS (AH) RATING :

The battery must maintain active materials on its plates and adequate lasting power under light-load conditions. This method of rating batteries is also called the 20-hour discharge rating. Original equipment batteries are rated in amp-hours. The ratings of these batteries are listed in the parts microfiche. The **Amp-Hour Rating** specifies, in amp-hours, the current the battery can provide for 20 hours at 80˚F (26.7˚C) while maintaining a voltage of at least 1.75 volts per cell (10.5 volts total for a 12- volt battery). For example, a battery that can deliver 4 amps for 20 hours is rated at 80 amp-hours (4 x 20 =80A).

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical Maintenance, Session-8 : Working of Lead-acid Cell & Battery. Testing by Hydrometer and Load tester

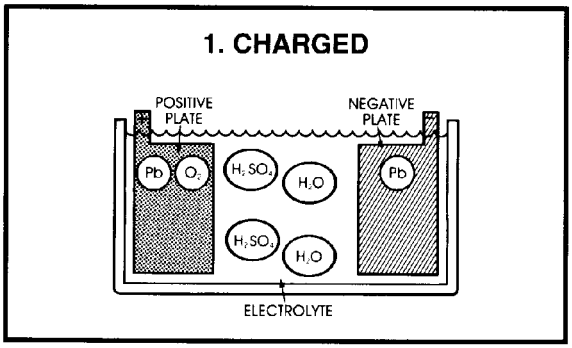
WORKING OF LEAD-ACID CELL & BATTERY :

A lead-acid cell works by a simple principle: when two different metals are immersed in an acid solution, a chemical reaction creates an electrical pressure.One metal is brown-colored lead dioxide (Pb02). It has a positive electrical charge. The other metal is gray colored sponge lead (Pb). It has a negative electrical charge. The acid solution is a mixture of sulfuric acid (H2SO4) and water (H20). It is called electrolyte.If a conductor and a load are connected between the two metals, current will flow. This **discharging** will continue until the metals become alike and the acid is used up. The action can be reversed by sending current into the cell in the opposite direction. This **charging** will continue until the cell materials are restored to their original condition.

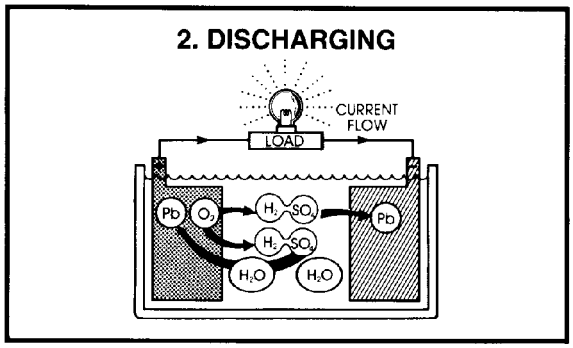
ELECTROCHEMICAL REACTION:

A lead-acid storage battery can be partially discharged and recharged many times. There are four stages in this discharging/charging cycle.

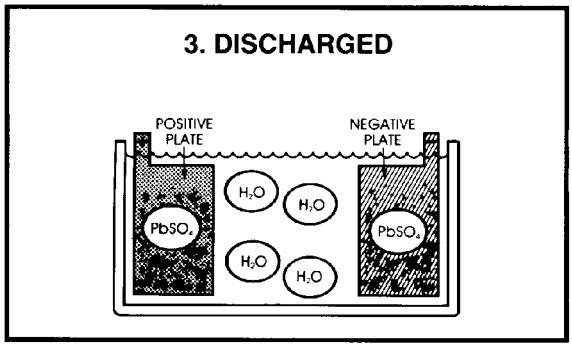
1. Charged: A fully charged battery contains a negative plate of sponge lead (Pb), a positive plate of lead dioxide (Pb02), and electrolyte of sulfuric acid(H2SO4) and water (H20).



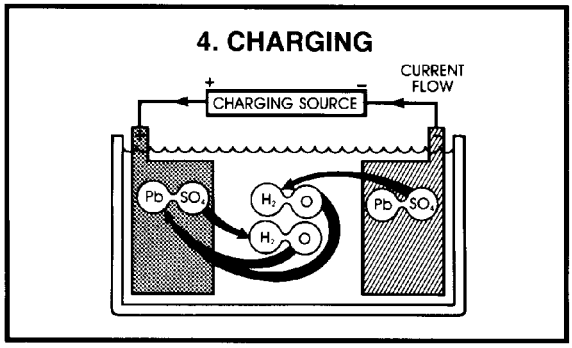
2. Discharging: As the battery is discharging, the electrolyte becomes diluted and the plates become sulfated. The electrolyte divides into hydrogen (H2) and sulfate(S04) . The hydrogen (H2) combines with oxygen (0) from the positive plate to form more water(H20). The sulfate combines with the lead (Pb) in both plates to form lead sulfate (PbS04)



3. Discharged: In a fully discharged battery, both plates are covered with lead sulfate (PbSO4) and the electrolyte is diluted to mostly water (H2O).



4. Charging: During charging, the chemical action is reversed. Sulfate (S04) leaves the plates and combines with hydrogen (H2) to become sulfuric acid (H2SO4). Free oxygen (02) combines with lead (Pb) on the positive plate to form lead dioxide (Pb02). Gassing occurs as the battery nears full charge, and hydrogen bubbles out at the negative plates, oxygen at the positive.



TEST PROCEDURE BY HYDROMETER:

The following steps outline a typical procedure for performing a state-of-charge test:

1 . Remove vent caps or covers from the battery cells.

2. Squeeze the hydrometer bulb and insert the pickup tube into the cell closest to the battery's positive (+) terminal.

3. Slowly release the bulb to draw in only enough electrolyte to cause the float to rise. Do not remove the tube from the cell.

4. Read the specific gravity indicated on the float. Be sure the float is drifting free, not in contact with the sides of top of the barrel. Bend down to read the hydrometer a eye level. Disregard the slight curvature of liquid on the float.

5. Read the reading of the electrolyte.

6. Record your readings and repeat the procedure for the remaining cells.

LOAD TESTING :

While an open circuit voltage test determines the battery's state of charge, it does not measure the battery's ability to deliver adequate cranking power.A **capacity**, or **heavy-load**, test does. A Sun VAT-40 tester is used. If another type of tester is used, follow the manufacturer's recommended procedure.

The following steps outline a typical procedure for load testing a battery:

1. Test the open circuit voltage. The battery must be at least half charged. If the open circuit voltage is less than 12.4v, charge the battery.
2. Disconnect the battery cables, **ground cable first**
3. Prepare the tester:
   - Rotate the Load Increase control to OFF.
   - Check each meter's mechanical zero. Adjust, if necessary.
   - Connect the tester Load Leads to the battery terminals; RED to positive, BLACK to negative.
   - Set Volt Selector to INT 18V. Tester voltmeter should indicate battery open-circuit voltage.
   - Set Test Selector to #2 CHARGING.
   - Adjust ammeter to read ZERO using the electrical Zero Adjust control.
4. Connect the clamp-on Amps Pickup around either tester load cable (disregard polarity).
5. Set the Test Selector Switch to #1 STARTING.
6. Load the battery by turning the Load Increase control until the ammeter reads **3 times the amp- hour (AH) rating or one-half the cold-cranking ampere (CCA) rating.**
7. Maintain the load for **no more than 15 seconds** and note the voltmeter reading.
8. Immediately turn the Load Increase control OFF.
9. If the voltmeter reading was 10.0 volts or more, the battery is good. If the reading is 9.6 to 9.9 volts, the battery is serviceable, but requires further testing. Charge and re-test. If the reading was **below 9.6 volts, the battery is either discharged or defective.**

NOTE: Test results will vary with temperature. Low temperatures will reduce the reading. The battery should be at operating temperature.

MAINTENANCE OF BATTERY:

Maintenance of battery of battery is done in 50-hour schedule. Which is as under.

1. Check the electrolyte level in each cell of the battery (daily). The level should be 10-15 mm above the plates. If not then top up with distilled water.
2. Check the specific gravity of each cell. It should be 1.180-1.280.
3. The connection should be tight and clean.
4. Put petroleum jelly on the terminal.
5. The vent hole should be cleaned.
6. The Voltage of battery should be checked by multi meter. It should be 2.1 volt in full charge condition.
7. Clean the battery with water.
8. Check the rubber pad , if found damaged then replace it.

PRECAUTIONS:-

1. While removing the connections of battery remove the negative terminal first and then the positive terminal.
2. Use proper tools.
3. Don’t take any lighted articles near to the battery.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical Working, **Session-9 :** Alternator, Regulator, Construction, Maintenance and Trouble-shooting

---

ALTERNATOR :

The Alternator converts mechanical energy into electrical energy when the engine is running. This energy is needed to operate the loads in the vehicle's electrical system as well as charging the Batteries., it sends current into the battery to maintain the battery's state of charge. Mechanical energy is transferred from the engine to the alternator by a grooved drive belt on a pulley arrangement. Through electromagnetic induction, the alternator changes this mechanical energy into electrical energy. The alternating current generated is converted into direct current by the rectifier, a set of diodes which allow current to pass in only one direction.

AC5R ALTERNATOR: AC5R alternators with inbuilt 440 Regulators are designed and matched as battery charging systems for Road Vehicles, Marine and Stationary engines. All models are basically the same but with minor variations to provide different voltages, cutting-in-speeds, methods of mounting etc. to suit individual requirements. Special finish is given to machines for Marine application.

General: The Alternator is a 3 phase machine of the revolving field and stationary armature type. Its output from the stator windings is rectified by means of built-in-silicon diodes in heat sinks mounted within the slip ring end shield. Output control is effected by varying the rotor excitation. The machine is self limiting in terms of output current. Cooling is provided by a radial fan mounted on the drive end of the rotor shaft. The standard machine is insulated return version. The Regulator is housed in the Alternator itself.

Terminal Arrangement: The alternator has three terminals i.e. positive terminal, negative terminal and warning lamp terminal 'WL'.

Rectifier: The rectifier pack comprises of nine silicon diodes, six main out put diodes and three field diodes mounted on suitable heat-sinks.

Rotor: Forged claw or pressed claw rotors are used. A pair of four fingered claws envelope the field coil and when finally assembled to the main shaft from the 8 pole imbricated rotor. The ends of the windings are brought out and connected to two slip rings at the end of the rotor assembly. The rotor is supported by ball bearings housed on the two end brackets.

Stator: The stator assembly comprises of a pack of laminations housing a three phase winding in the slots. The stator is held in position by the drive end (D.E.) and slip ring end (SRE) shields.

In-built Regulator:This is a fully transistorized device with no moving parts, requiring no service attention. The transistors, diodes and resistors are fixed on a printed circuit base and then encapsulated. No cutout relay is necessary as the diodes in the alternator prevent reverse currents from the battery flowing through the stator when the machine is stationary or when generating less than the battery voltage. As the alternator is self limiting in current output the regulator has only to control voltage which it does by regulating the alternator field current.The regulator is housed in the Alternator in between SRE shield and cowl by means of three studs.

OPERATION OF THE ALTERNATOR:

Initial excitation: When the ignition switch (or equivalent control switch for diesel engines) is switched 'ON' a small current flows from the battery through the warning lamp to the rotor field winding. At this stage the warning light is illuminated and the rotor is partially

magnetized.When the engine is started and the partially magnetized rotor rotates within the stator windings 3 phase alternating current (a.c.) and rapidly rising voltage is generated.

Self excitation:A portion of generated alternating current (A.C.) is rectified to direct current (D.C.) by the three field diodes incorporated in the rectifier pack. Output current from the field (auxiliary) diodes supplement the initial current flowing through the rotor field winding from the battery, causing an increase in the magnetic influence of the rotor and resulting in self excitation of the alternator. As the rotor speeds and generated until the Alternator becomes fully excited.

Charge indication: During the rise in generated output voltage (reflected at WL terminal) the warning lamp is extinguished as the generated voltage applied to one side of the warning lamp rises above the battery voltage applied to the other side of warning lamp. This normally indicates that the alternator is the developing its main battery-charging current.

Output Control: The main battery charging current is rectified from a.c. to d.c. by the six main output diodes in the rectifier pack which function as a full-wave bridge rectifier circuit.The Alternator output is controlled by the in-built 440 regulator. The regulator functions as an electronic control switch of the rotor field winding circuit switching the circuit 'OFF' and 'ON' at a very high frequency to maintain the alternator output voltage (and so the current) at a predetermined and safe working limit.

MAINTENANCE:

i) **General:** Keep the alternator reasonably clean and ensure that ventilation slots or air spaces are clear are unobstructed. Check mounting bolts for tightness.

ii) Belt: Ensure that the driving belt on the alternator is in good condition and is neither too slack nor too tight. If necessary the fan belt tension should be adjusted to obtain approximately 1|2"-3|4" deflection of the belt when pressed at midway of the longest point between pulleys.

NOTE: A slack belt will rapidly wear and because of slip may not drive the alternator at the required speed. Too tight a belt will impose severed side thrust on the bearings and seriously shorten their life.

iii) **Battery:** Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells to ensure that the battery is in good condition. Check for the tightness of its terminals. The specific gravity of the electrolyte should be uniform in all the cells. If the battery is found to be discharged it should be independently recharged or substituted before proceeding to further checks.

iv) **Brush Gear:** Check brushes once in 20000 kms. Renew the brush and spring assemblies if the overall length of the brushes are worn to or less than 7.9 mm (0.312"). If brushes are satisfactory but require cleaning use a petrol moistened cloth.

v) **Rotor slip rings:** The slip ring surfaces should be clean and smooth. If the rings are burnt or unclean and require refinishing the surfaces may be cleaned with a piece of very fine emery paper.

vi) **Bearings:** Check bearing for every 20,000 kms. And renew if worn.

PRECAUTIONS:

i) Ensure all connections are secure and clean.

ii) Ensure that no connection in the charging circuit, including battery, is broken while the engine is running.

iii) Observe correct polarity when refitting the vehicle battery or when using a slave battery to start the engine.

iv) Do not flash the alternator output leads to check its working

v) Disconnect all alternator terminals while carrying out any welding on the vehicle.

vi) Ensure that the alternator is not mounted close to the exhaust manifold without any protection.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical **Session-10 :** Self starter: Construction, Working, Maintenance and Troubleshooting

---

SELF STARTER :

Starting the engine is possibly the most important function of the Machine's electrical system. The starting system performs this function by changing electrical energy from the battery to mechanical energy in the starting motor. This motor then transfers the mechanical energy, through gears, to the flywheel on the engine's crankshaft. During cranking, the flywheel rotates and the air-fuel mixture is drawn into the cylinders, compressed, and ignited to start the engine. Most engines require a cranking speed of about 200 rpm.

Self starter are designed for use on the larger types of engine, where because of the high inertia of flywheel and crankshaft, it is necessary for the starter pinion to engage the engine flywheel before the starter develops full torque, thus avoiding heavy engagement shock and excessive wear on gear teeth. Engagement between starter and engine is effected by an axial movement of the complete armature assembly and it is from this movement that the term 'Axial' starter is derived.

Construction :

The field windings of the machines consist of a main series winding, an auxiliary series winding and shunt winding. A solenoid operated two stage switch forms an integral part of the starter and is used to control the starting cycle, so that only a small switch to handle the solenoid current is required externally.

Working:

When starter switch is operated, the first stage contacts on the solenoid switch close and a small current passes through the auxiliary field windings, causing the armature rotate slowly. Simultaneously the complete armature assembly is drawn towards the driving end of the machine by the magnetic field set up in the winding and the pinion is brought into mesh with the engine flywheel gear. As the armature nears the end of its axial travel, a tripping disc operates the trigger on the solenoid switch, causing the second stage contacts to close and complete the circuit to the main series winding. The starter then exerts its full torque on the engine. When the starter button is released, the armature is return to its disengaged position by the coiled spring on the armature plunger.

The auxiliary shunt windings are arranged so as to hold the pinion in mesh until the starter push button is released; this reduces the number of engagements used to start heavy engines as the pinion will remain in mesh despite irregular engine firing. The starter is fitted with an overload clutch interposed in the drive between armature and pinion. The clutch has a slipping torque of about twice the lock torque of the starter but below the shearing strength of the pinion teeth and is thus an effective safeguard against the teeth of the pinion being sheared due to excessive load.Where required oil sealing precautions are taken comprising an oil seal in the driving end shield and a rubber sealing ring inside the pinion.

Maintenance :

Examine starter to ensure that the mounting bolts are securely fastened and all electrical connections are clean and tight. The cable should be examined for fractures particularly at the point where the cables enter the terminal lugs. The cable insulations must be free from signs of chafing and deterioration due to oil, etc.

Brush Gear- Check that the brush leads are clear of any obstruction likely to impede movement and see that the brushes are free in their holders by first lifting brush spring and gently pulling on the brush leads. If a brush is inclined to 'stick' clean the inside of the brush holder with a clean cloth moistened in petrol. Be sure to replace the brush in its original position so that the curvature of its contact surface conforms accurately with commutator periphery.Always ensure that a minimum of .045" clearance is there between the brush holder throughout. If necessary this can be achieved by rubbing down the brushes using 400 grade emery and a sheet of glass. However, it is emphasized that no attempt should be made to file the brush boxes to obtain the recommended clearance.

The brush should be well bedded i.e. worn to the commutator periphery over at least 80 percent of their contact area. If not, lift each brush from commutator and wedge in position with spring. Wrap a strip of very fine glass paper (do not use emery cloth) or caborundum paper around the commutator with abrasive side outwards. Lower the brush (or brushes) in one brush gear arm on to the glass paper and bed to the correct shape by drawing the glass paper backwards and forwards over the commutator. Raise the finished brushes and repeat the bedding procedure for the brushes on the other brush gear arms in turn. After bedding, each brush must be removed from its holder and all traces of dust and abrasive cleared away, preferably using compressed air or some form of hand bellows. Examine the brushes to ensure that no particles of abrasive are embedded in their contact surfaces.The brushes must be renewed if they are worn to approximately 13 m which is half of the original length or to a point where springs no longer provide effective pressure. It is essential that brushes are fitted in complete sets and under no circumstances should brushes of different grade be used together. To be sure of obtaining the correct grade brush, always specify Lucas-TVS Spares (Brush Part No. 9030-698A). This can be bought from any authorized Lucas-TVS Agent. Replacement brushes must be always bedded before use as described earlier.

Commutator

The commutator surface should be clean and entirely free from oil any trace of which should be removed by pressing a dry clean fluff less cloth against the commutator while the armature is hand rotated. On starters fitted to engines with wet flywheel an excessive amount of oil may indicate a defective oil seal, in which case the starter must be removed from the engine and completely overhauled.If the commutator is dirty or badly discoloured, lift the brushes and wedge in position with their springs. Wrap a strip of very fine glass paper around the commutator with the abrasive side inwards and draw the glass paper backwards and forwards over the commutator while slowly rotating ar4mature until surface is clean. Remove all traces of dust and abrasive using compressed air or hand bellows.Finally, lower the brushes on the commutator and carefully replace the commutator cover.

Lubrication

The drive end bearing is lubricated by oil (Telluse 33) from a large reservoir contained in the drive end shield. Refilling can be done when the starter is dismantled during overhaul periods. Lubrication of starter components which can be done at overhaul period is as follows.

LOCATION	LUBRICATION	INSTRUCTION
DE Bearing	Shell Tellus 33	Wick and felt pad saturate before assy. Top up with 8 ccs. Oil. Light oil.
Pinion Sleeve & Helix	Shell Telluse 33	Light oil.
Mating inner race	Shell Telluse 33	Saturate before assy.
Felt seal in trip plate	Shell Telluse 33	Grease both sides of plates before assy.
Clutch plate	Caltex Marfax 3HD or Shell Nerita 3 Grease	Strongly grease the spring and smear the plunger shaft.
Return spring on armature plunger assy		Smear with grease.
Inner race fiber thrust washer	Shell Retinax or Shell Alvania 3 grease	Lightly grease the surface.
DE shaft & pinion bore		Smear with grease.
CE Brg. Bush, Pin and thrust washer		

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical Operation, **Session-11 :** Relay: Definition, Construction & Types, Pindiagrams, Testing

---

RELAY : - Relay is an electromagnetic device which operation is controlled by electrical signal when relay operates it provides switching of other electrical & and electro-hydraulic components i.e relay & solenoids. It works on electromagnetic induction principle ie when current flows in a conductor in the form of coil it becomes magnet and when current stops it demagnetizes .

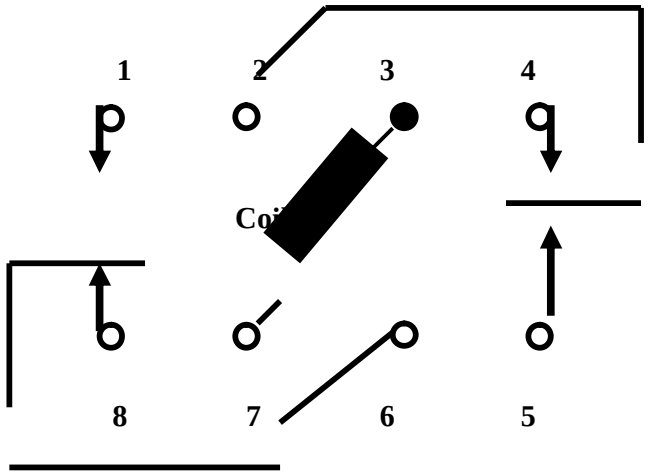
Generally relay have multi contacts. Which are of two types NC (Normally close) and NO (Normally Open) when relay is "OFF" some contacts are close which are called normally closed**(NC).** Open contacts are called normally open **(NO).** When relay operates NC contacts become open and NO contacts become close.

Different Types of Relays & their Pin Diagrams used in Machines :-

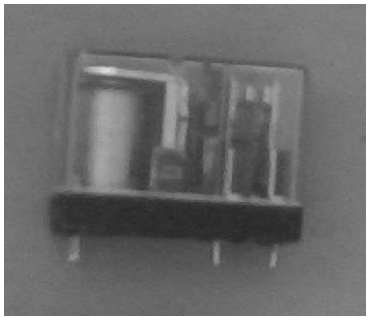
ELT - 663:

This relay is 8-Pin relay operated by 24V. This relay has two NC and two NO contacts. This relay is used in Lining PCB, lifting PCB, Tamping Unit control PCB etc of CSM, Duomatic & Unimat.

Pin Diagram

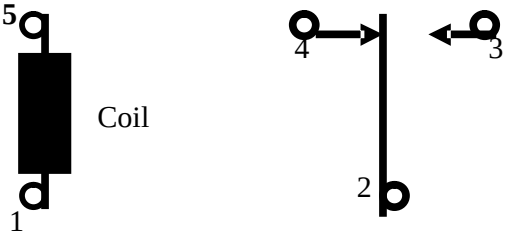


ELT - 1218:



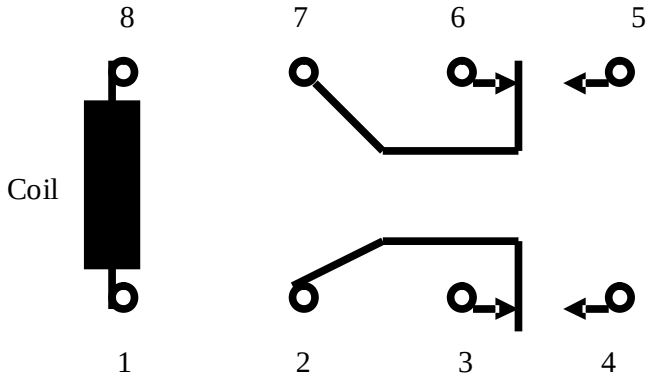
This relay is 5-Pin relay operated by 24V. This relay has one NC and one NO contact. This relay is used in Lighting and horn circuit of CSM, Duomatic & Unimat.

Pin Diagram

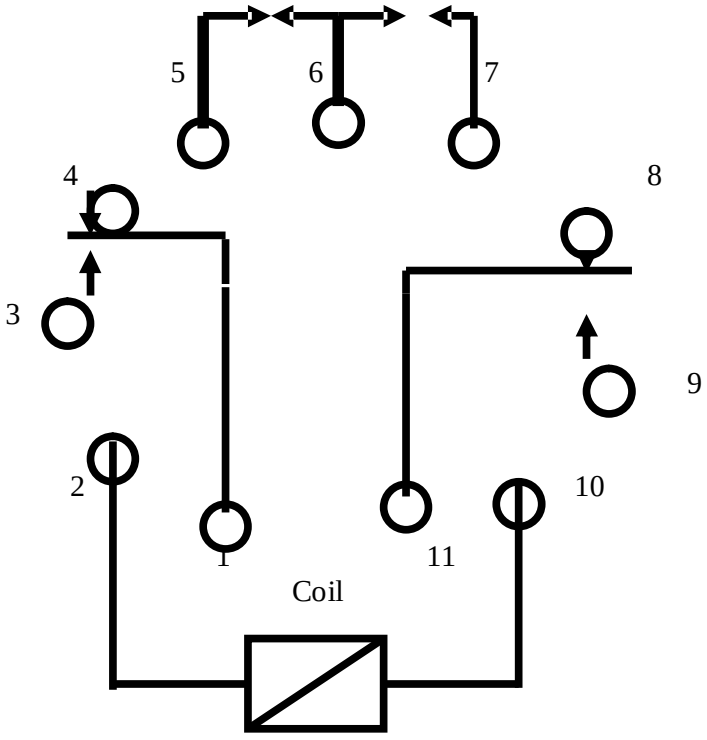


ELT – 7045:
This relay is 8-Pin relay. There are two types of 7045 relays are available one operates on 24V and other on 12V. These relays have two NC and two NO contacts. These relay are used in CSM , 09-3X and Unimat .

Pin Diagram

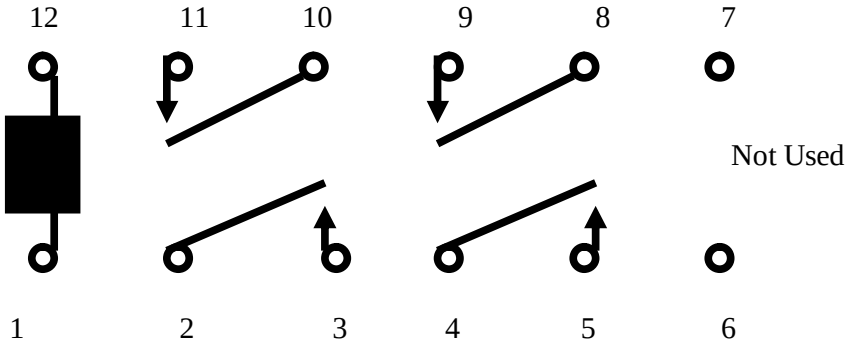


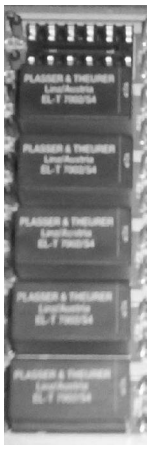
ELT – 7010:
This relay is 11 Pin relay operated by 24V. This relay has three NC contacts & three NO contacts. This relay is used in Engine panel of CSM, Unimat & Duomatic.



ELT – 7002/S4:
This relay is 12 Pin relay operated by 24V. This relay has all NO contacts. This relay is used as QL (Load relay) to operate solenoids in CSM, 09-3X , Unimat & DGS.

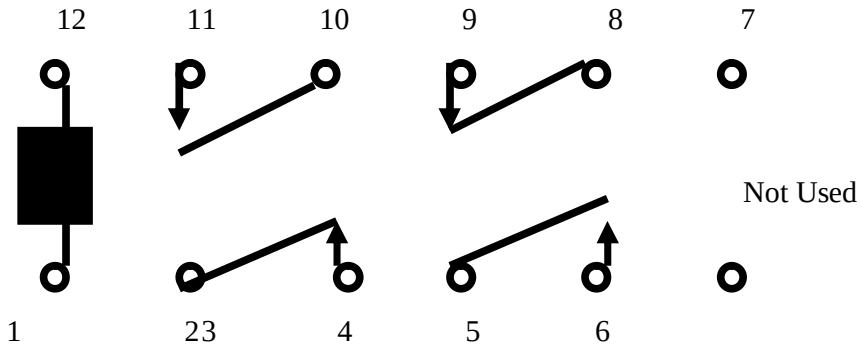
Pin Diagram





ELT – 7002/S2:
This relay is 12-Pin relay operated by 24V. This relay has two NC contacts and two NO-contacts. This relay is used in CSM & Unimat.

Pin Diagram



ELT – 7002/S2-L2:
This relay is 12-Pin relay operated by 24V. This relay has two NC and two NO-contacts opposite of contacts of ELT-7002/S2 . In This relay pin 6 & 7 are also used for Coil. It is used in Overslew PCB in CSM & Unimat & Duomatic.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical demonstration, **Session-12 :** Electronics Model Room for checking and testing of Relays

---

In electronic model room different types of relays are shown to the trainees and relays are checked with the help of multimeters.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical **Session-13:** Engine Circuit: Description, Function and Types

---

ENGINE CIRCUIT:

In the machine operation and safety of Engine is controlled through an electrical circuit which is called engine circuit. Engine circuit is mainly consists of batteries, selfstarter, shutdown coil alternator ,safety components(Pressure switch and temperature switch),stopper switch. Engine starts when it is cranked by selfstarter with the help of batteries and fuel is supplied by shutdowncoil. During running of engine lub oil pressure and tempreture are ensured .

FUNCTIONS:

Functions of engine circuit are as under:-

a) To start the engine.
b) To shut down the engine.
c) To charge the battery.
d) Safety of engine from high water temperature and low lub. Oil pressure.

Operation to start the engine.

a) Cranking the engine.

b) Fuel supply system should be ON.

c) Safety of engine is to be ensured.

- Ø Against low lube oil pressure (1.5 bar)
- Ø Against high temperature.
- Ø Emergency stop switch.
- Ø If ZF switch is ON then engine will not start.

Types of engine circuit:

1. Latch type
2. Non latch type

Latch type:

In these circuits hold relays are used as a multi stage safety device. These circuits gives better performance in terms of better safety.These circuits are provided in Unimat 2S &3S,09-3X,DGS,WST,BCM.

Non-latch type:

The circuit other than latch circuit is known as Non-Latch circuit. These circuits are provided in Unomatic, Duomatic and CSM

WORKING OF ENGINE CIRCUIT(CSM):-

1. For starting the engine 24V/180AH is required, two batteries of 12V/180Ah/25 plates are connected in series. Self starter type B55-24/SL5-24 of 6 BHP is provided to crank the engine.

2. After performing daily maintenance of engine battery main key should be ON.

3. Engine can be started from both the cabins starter switch are provided in both cabins working(rear) cabin and front cabin but ignition key(5b9) is provided only in the working cabin only, which should be ON.

4. Bypass switches no. 5b 58 or 11 b 22 has to be pressed while starting the engine .Before pulling starter switch(5b8) for cranking bypass switch should be pressed to switch on shutdown coil(1s6) for fuel supply. By pass switches No. 5b 58 or 11 b 22 has to be pressed till the lub. oil pressure builds up to 1.5 Kg/cm^2 & above after that it can be released. If lub.oil pressure falls below this level engine will stop because electrical supply of shutdown coil stops.

5. 7 nos. engine stopping switches are provided scattered all over the machine which cuts off fuel supply. These can be used in emergency.

6. Two nos. alternators are provided with the engine each of 24V/ 40 Amp. These are used to supply 24V DC to the indication & lighting system and charging of batteries. Also these supply power to recorder and GVA.

Safety Components of engine

- Against low lube oil pressure switch is provided (1.5 bar)
- Against high temperature switch is provided
- Emergency stop switch.
- If ZF switch is ON then engine will not start by relay 5u5 .

FAULTS & TROUBLESHOOTING :

S.no.	Fault	Probable Causes	Remedial Actions
1.	Engine does not start	1. Batteries	1. Check batteries : Terminals should be tight and clean , Voltage& gravity . Over-aged batteries should be replaced.
		2.Selfstarter	2.Check connections and solenoid.
		3. Emergency stop switch is pressed.	3.All emergency stop switch should be in release position.
		4. Shut down mechanism stuck	4. Check the electrical supply at coil if it is ok, then lubricate the piston of shut down coil mechanism with lub oil and operate it manually. If still not working, then coil may be defective. Replace it with new one.
		5. Misconnection of starting switch.	5. Check starting switch and if any misconnection is noticed, rectify it.
2.	Engine stops	1. Shut down circuit fails.	. 1 Check shutdown coil,relay13d1`fuse,emergency stopper switch lub oil pressure switch, temperature switch replace if found defective.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:15)

Lesson–III: Auto Electrical Components, **Session-15:** Z.F. Circuit: Description, Working, Safety Sensors, Faults & Troubleshooting

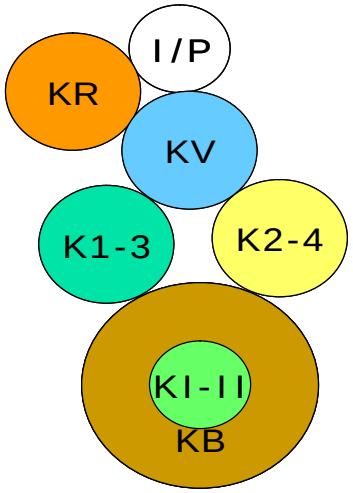
ZF GEARBOX ELECTRICAL CIRCUIT:

ZF Gearbox is the hydrodynamic gearbox which is provided in CSM,09-3X,Unimat2S&3S,DGS and WST machines. In this gearbox shifting of gears and safety is controlled by electrical circuit.This circuit mainly consists of relays, shifter assembly, lockup device and inductive transducer.

Shifter assembly:- It is brain of the gearbox.Hydraulic fluid is pressurised & supplied from this unit.Four solenoid valves are provided for various clutch operation.Measuring points are available for testing.

Gear Train

S.N.	Clutches	Speed	Solenoid	Position
1	KV	Forward	M1	On
2	KR	Reverse	M4	On
3	K1-3	1st &3rd	M2	On
4	K2-4	2nd &4th	M2	Off
5	KB	FD Slower	M3	On
6	KI-II	FD Higher	M3	Off



Working of ZF Circuit :

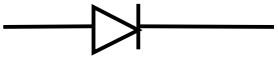
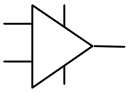
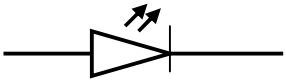
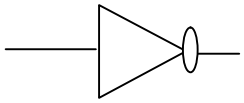
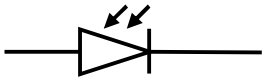
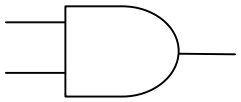
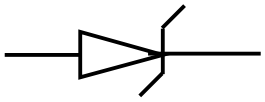
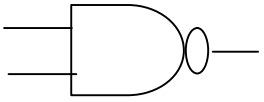
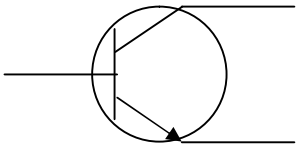
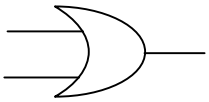
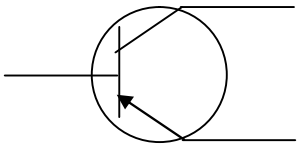
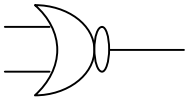
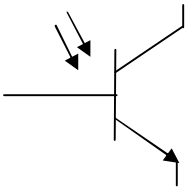
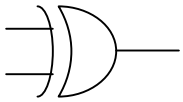
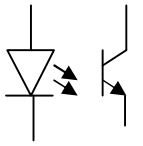
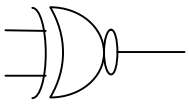
1. There are two main switches 5b34 an 11b24 which are responsible for selecting direction of movement. 5b34 is provided in the rear cabin where as 11b24 is provided in the front cabin. When we switch on one, it cuts off the other through relays 28d1 and 28d2.
2. Direction selector relays 28d1 and 28d2 get earth through relay28u2A. Which gets earth through 1(Working pneumatic, 2) Satellite gear if engaged, 3) Machine working gear is engaged, trailer gear engaged, 4) ZF filter is choked. 5) ZF temp. is more than 100^0C and 6) ZF pressure less than 10 from 1 to 4 all these action are indicated by LED if not locked or engaged combined effect of these is indicated by indicator lamp 11 h3.
   Mal functioning of any of above seven items will not allow driving which can be achieved by pressing push button 5b26 or 11b26 which gives direct earth to direction selecting relays 28d1 and 28d2.
3. When brake pressure of 3 Kg. or more is applied it acts through a pressure switch and cuts off earth from gear solenoids M_1 and M_4. One of which is invariably used either in forward or in reverse direction.
4. If any of the gear is engaged and engine is shut off, the engine can only be started after taking out gear. This action is achieved by providing + from M_1 & M_4 through terminal No. G-32 which is connected to starting relay.
5. Lock up position is achieved through RPM sensing transducer provided on turbine shaft it is achieved when turbine achieves 80% of the engine speed.

FAULT AND TROUBLE SHOOTING:

S.no.	Fault	Probable Causes	Remedial Actions
1.	No drive Transmission in all speed	1.Electrical supply cut off	1.If pressure at 65 no. point is 12-14 bar, current will be checked with the help of Pr.49 test kit - i) If no current in above, 5 Amp fuse may be damaged. Replace the fuse. ii) If fuse is Ok, then with the help of Pr. 78 Test Kit, current on switch output will be checked. If no current is found, controller is defective. Replace the controller. iii) If current is found on switch, output cable may be burst which should be replaced
2.	No function in 1st & 2nd speed.	1.Cut off switch in 'ON' position.	1. Cut off switch should not be in operated condition
		2.Current not supplied on corresponding solenoid.	2. Current at solenoids M1, M2, M3 and M5 will be checked with Pr.49 Test Kit. Prescribed current is 0.25 to 0.5 Amp.
		2. 3.Control valve assembly gets defective.	3. If current input is OK, control valve assembly needs repairing.
		4.Pressure switch of brake circuit defective.	4. If current on solenoids as per coding is not available, it indicate wrong coding, then pressure cut off switch will be checked by pressure 49. If there is no reaction, pressure switch of brake circuit is defective.
		5. Solenoid defective.	5. If coding is OK but signal is not coming, then change defective solenoid.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-I: Fundamentals of Electronics **Session-1:**Electronics Symbols and Nomenclatures

ELECTRONIC SYMBOLS			
Name & Letter Notation	**Symbol**	**Name & Letter Notation**	**Symbol**
Diode D or n		Operational amplifier IC	
LED		NOT Gate	
Photo Diode		AND Gate	
Zener Diode Zd or Tz		NAND Gate	
N-P-N Transistor		OR Gate	
P-N-P Transister		NOR Gate	
Photo Transister		EXOR	
Opto Coupler OC		EX-NOR	

NOMENCLATURES OF PCBS		**NOMINCLATURES OF DRAWINGS**	
EK	Plug In Type PCB	X	Input To Programmer (Yellow Led Indication)
ELT	Connection Type PCB	Q	Out Put From Programmer (Red LEd Indication)
SV	Power Supply PCB	Q^1	Time Delay Out Put Of Programmer
LV	Analog Control PCB	QL	Load Relay Output
V	Digital Control PCB	٧	OR
P	Programmer PCB	٨	AND
A	D.C. Motor Control PCB	--	Not Allowed
MC	Micro Controller PCB	P	Proportional Circuit(Tamping And Satellite Circuit)
DV	Data Sender And Receiveer PCB	R	Lining Control Circuit
E	Relay PCB	N	Levelling Control Circuit (Niv)
00,0a, 02	Modifications In PCB	E	Front Input Control Circuit
d,b,z	Connectors of PCB	D	Driving Control Circuit
		Z	Hook Control Circuit
		F	Multicheck Address
		ALC	Automatic Guiding Computer
		*ALC	Connectors Of Computer ALC
		GVA	Geometric Value Adjustment
		Tele	Laser System
		PCB	Printed Circuit Board (U)

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-I: Fundamentals of Electronics **Session-2:** Fundamentals of Electronics and Applications, Active components & Passive components

---

Introduction to Electronics

(i) Electronics Engineering

Electronic engineering is the branch of engineering in which we study operation and application of electronic components and devices.

Electronics = Electron + Mechanics

(ii) Electronic devices

A device in which conduction(flow of current) takes place due to movement of electrons and holes through semiconductors.

Difference between Electrical and Electronics.

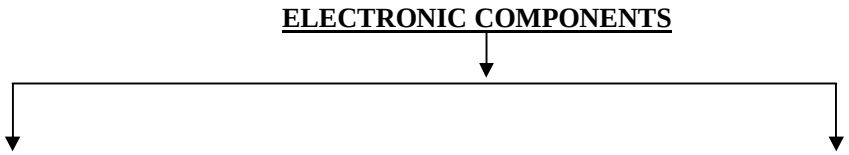
	Electrical		Electronics
1	Electrons are charge carriers. Current is the flow of electrons. The direction of current is in opposite direction of flow of electrons	1	There are two charge carriers Electron and Hole. Current flows due to movement of electrons and holes. Electron is negative charged and the hole is positive charged .
2	Medium isconductive materials .Current flows through conductors like copper, aluminum etc.	2	Current flows through semi conductors like Silicon and germanium etc.
3	Mainly A.C supply. is used Generally supply voltage is 220V,440V and in KV A.C.	3	Mainly D.C.supply is used. Generally supply voltage is 1.5V to 24V D.C.
4	The supply voltage are single phase, multi phase or Polly phase.	4	The supply voltage are Positive or Negative.
5	The electrical equipment are bulky and heavy.	5	The Electronic equipment are light and small in size.

Applications of Electronics

1. Communication & Entertainment
2. Consumer Electronics
3. Defence Applications
4. Industrial Application
5. Medical Sciences
6. Space Exploration

TYPES OF ELECTRONIC COMPONENTS:

There are various types of electronic components but they are divided into two categories**.**

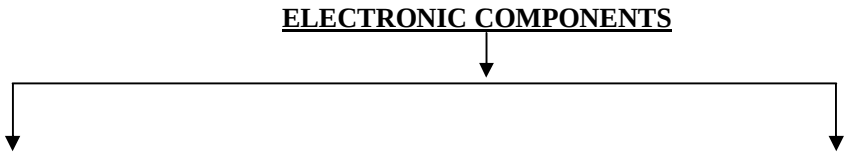


Passive Components
These components are not able to amplify
Or process the electrical signal themselves
e.g. resistor, capacitor, inductor.

Active components
These components can amplify and
process the electrical signal.
Transistors, Diode, lc.. etc.

TYPES OF ELECTRONIC COMPONENTS:

There are various types of electronic components but they are divided into two categories**.**



Passive Components
These components are not able to amplify
Or process the electrical signal themselves
e.g. resistor, capacitor, inductor.

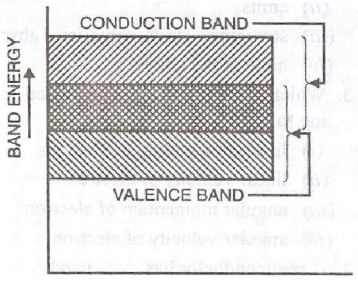
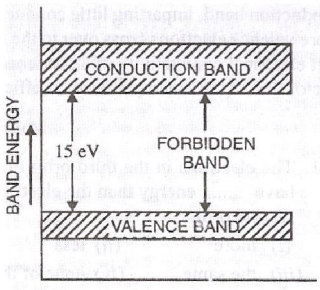
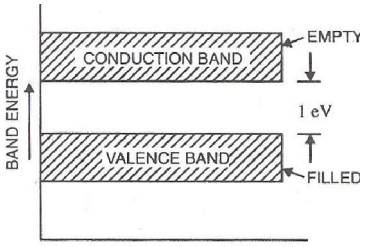
Active components
These components can amplify and
process the electrical signal.
Transistors, Diode, lc.. etc.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-II: Semiconductor Theory

Session-3: Difference between Conductor, Semiconductor & Insulator. Properties of Semiconductor, Covalent Bonds, Energy Bands, Types of semiconductor, i.e. Intrinsic, extrinsic, (P-Type, N-Type).

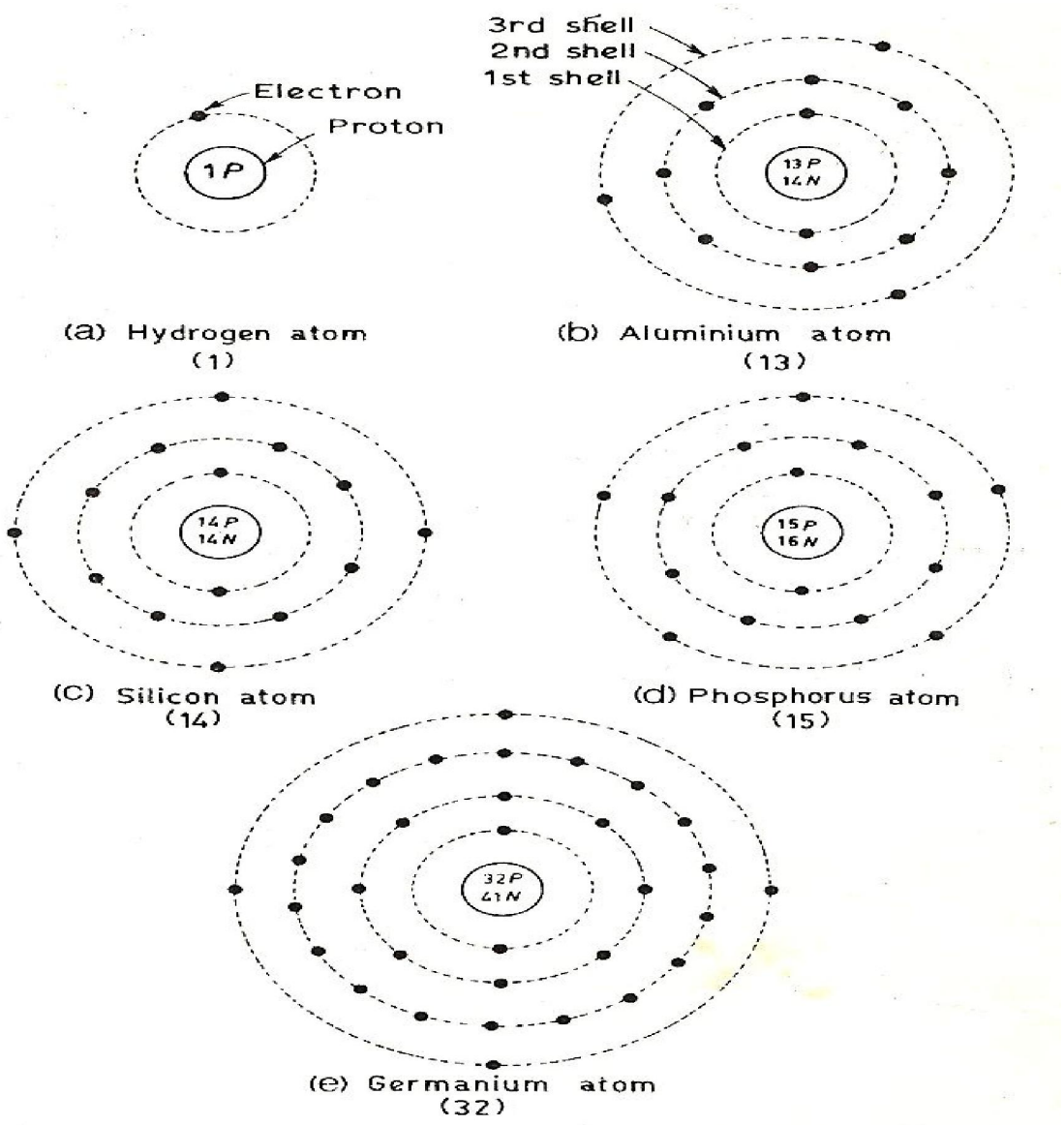
Difference between conductor, Insulator and Semi-Conductor

	Conductor(Metal)	Insulator	Semi-Conductor
1	Conductors consist of large numbers of free electrons. The free electrons move randomly inside a solid, and can carry charge from one point to another. In fact, there is no forbidden-energy gap between the valence band and conduction bands. The two bands actually overlap. The valence-band energies are the same as the conduction-band energies in the metal. It is very easy for a valence electron to become a conduction (free) electron. Therefore, without supplying any additional energy such as heat or light. A metal already contains a large number of free electrons ,there fore they are good conductors of electricity. 	Insulators do not consist of free electrons. It has a very wide Energy gap (15eV or more). Because of this, it is practically impossible for an electron in the valence band to jump the gap, to reach the conduction band. Only at very high temperatures or under very stressed (electrically) conditions, can an electron jump the gap. At room temperature, an insulator does not conduct because there are no conduction electrons in it. Therefore electric current does not pass through insulators. However, it may conduct if its temperature is very high or if a high voltage is applied across it. This is termed as the breakdown of the insulator. 	Semi-Conductors have numbers of free electrons less than conductors and more than insulators. In this case, the forbidden energy gap is not wide. It is of the order of 1 eV (for germanium, E_G = 0.72 eV; and for silicon E_G = 1.12 eV). The energy provided by the heat at room temperature is sufficient to lift electrons from the valence band to the conduction band. Some electrons do jump the gap and go into the conduction band. Therefore, at room temperature, semiconductors are capable of conducting some electric current. 
2	Conductors have minimum resistance and positive temperature co efficient ie resistance increases as temperature is increased.	Insulators have maximum resistance. There is no effect of normal temperature range. But at high temp they get break down.	Semi-Conductors have resistance more than conductors and less than insulators. They have negative temperature co-efficient. ie resistance decreases as temperature is increased.
3	Example: Gold, Silver, copper & Aluminum.	Example: Mica, Rubber, Asbestos, Porcelain & dry wood.	Example: Silicon & Germanium

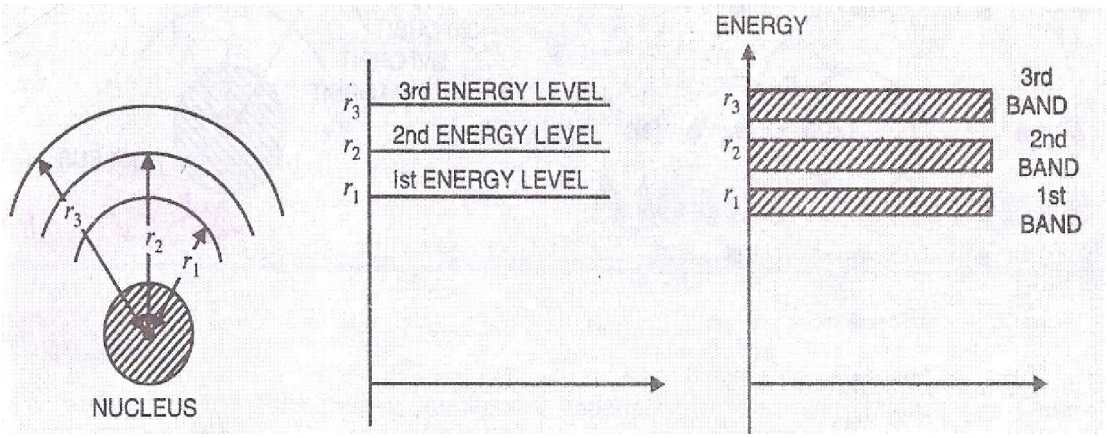
SEMICONDUCTOR THEORY:

The most fundamental unit of metal is atom. An atom consists of protons, electrons and neutrons. Protons and neutrons lie in a nucleus while electrons move around the nucleus in elliptical orbit.Electrons have – Ve charge (-- 1.6 x 10^{-19} Culombs). Protons have same positive charge. Neutrons have no charge, it is neutral. Properties of material depends upon number of electrons and protons in atom. Electrons are arranged in orbital shell around nucleus.

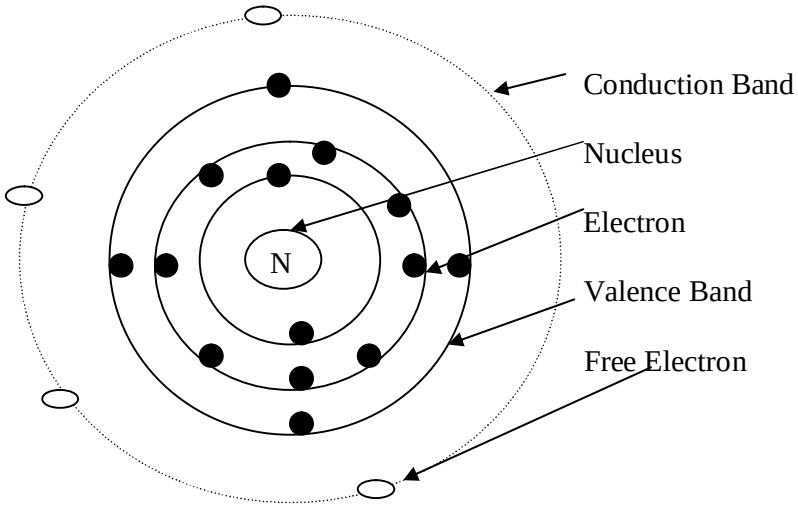
Atomic Structures of different materials



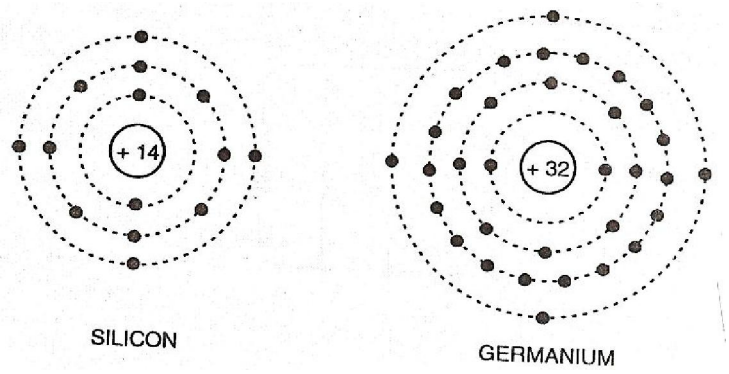
ENERGY LEVELS/ BANDS: Since we know that electrons revolve around the nucleus in different orbits, these orbits have different energy levels, as per their position. Electrons near to the nucleus have lower energy and tightly bound with nucleus in first shell. Electrons in outermost orbit have greater energy and they can be easily knocked out of its orbit. Energy Band Diagram is shown in fig.

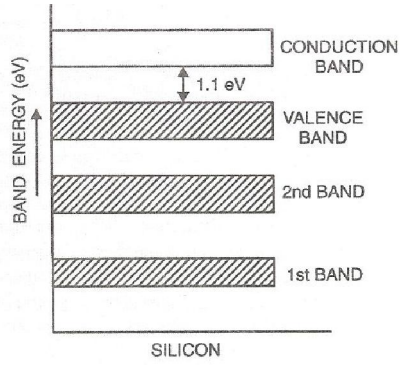


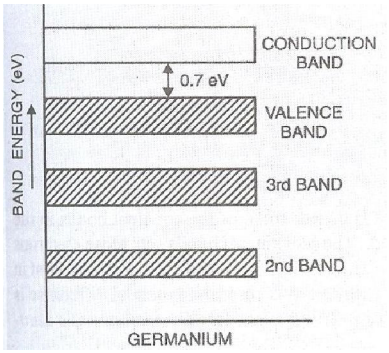
Above valency band, there is another band which is called conduction band. In semiconductors, normally electrons remain in valency band. When an external energy like temp. & light given to atom, then electrons of valency band gain more energy or we can say that they are excited. If this energy becomes more than Egenergy Gap (for silicon EG = 1.121eV, and germanium EG = 0.72ev) electron go to the conduction band. In this band, electrons do not feel any attraction force of nucleus. **They can move freely in Conduction Band work as charge carriers and constitute electrical current. These electrons are called free electrons. Larger the number of free electrons, larger is the conductivity of that material.**



Semiconductors:- Semi-Conductors have four electrons in valence shell. In Semi-conductors numbers of free electrons are less than conductors and more than insulators. Because the forbidden energy gap is not wide. The energy provided by the heat at room temperature is sufficient to lift electrons from the valence band to the conduction band. Semi-Conductors have resistance more than conductors and less than insulators. They have negative temperature co-efficient. ie resistance decreases as temperature is increased. **Example: Silicon (Si) & Germanium(Ge) are the semiconductor materials which are used in electronic components ie diodes, transistors and Ics .**



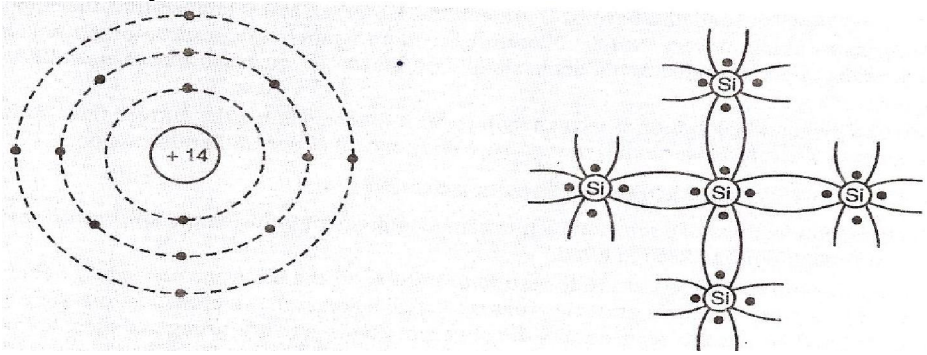




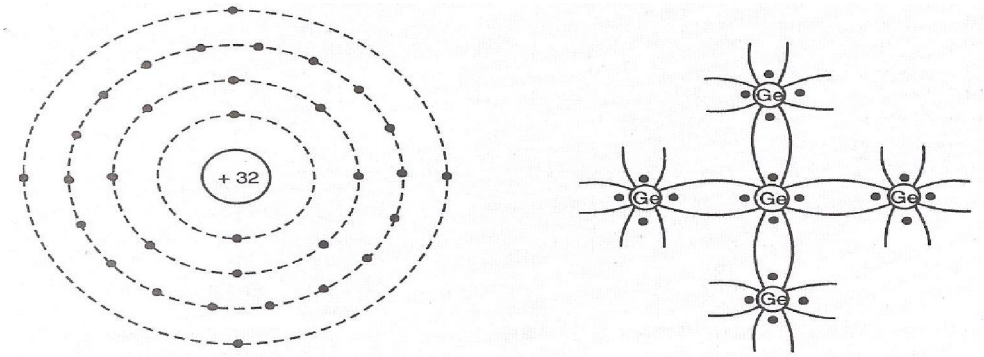
Covalent Bond in Semiconductors :

There should be eight electrons in outermost orbit of an atom. If it is not complete, then outermost orbit is called valence shell and electrons are called valence electrons. Atoms have tendency to complete the outermost orbit by sharing of electrons of other atoms of same element or that of the other element. Atoms of Silicon(Si) and Germanium(Ge) have four valence electrons in its valence shell. So to complete its outermost orbit, each atom shares electron from four neighboring atoms and complete its last orbit and forms covalent bond.

Each co-valent bond consists of two electrons, one from each adjacent atom. Both electrons are shared by two atoms.



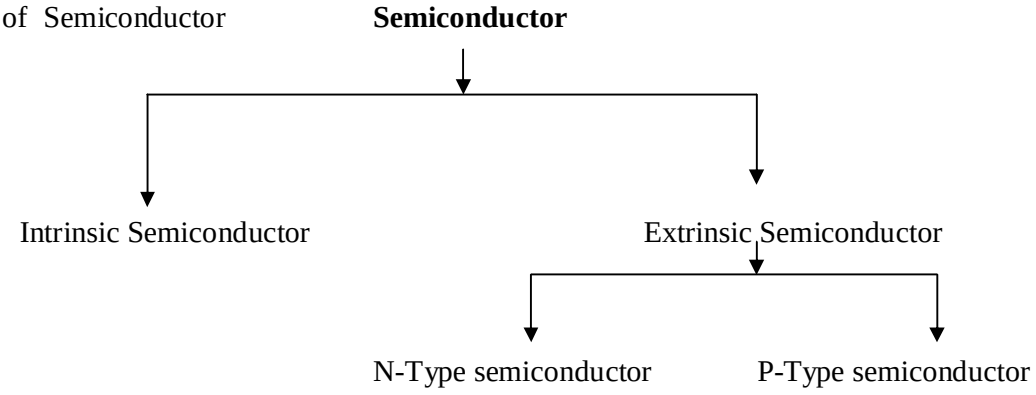
Covalent Bonds in Silicon Atoms



Covalent Bonds in Germanium Atoms

At absolute zero temp. (-273^{0}C), all the valance electrons are tightly bound to the parent atoms. No free electrons are available for electrical conduction. So semiconductor behaves as a perfect insulator at absolute zero.

Types of Semiconductor

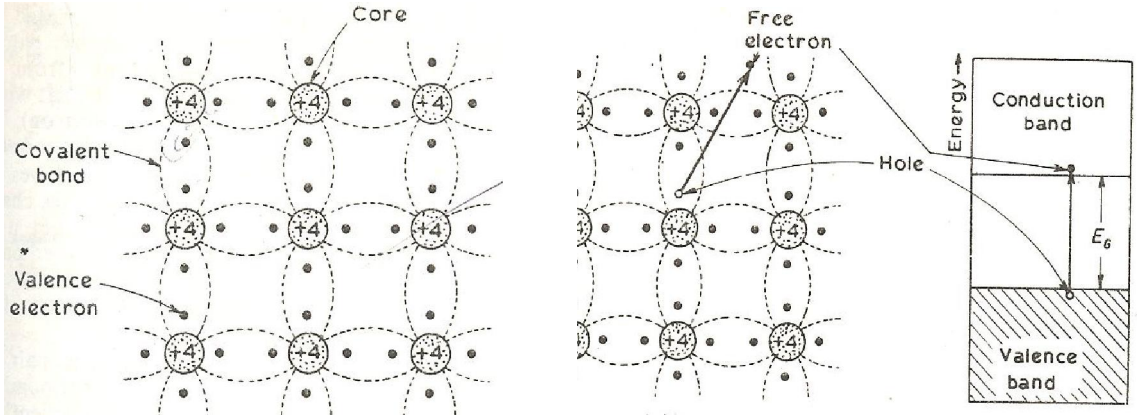


Intrinsic Semiconductor

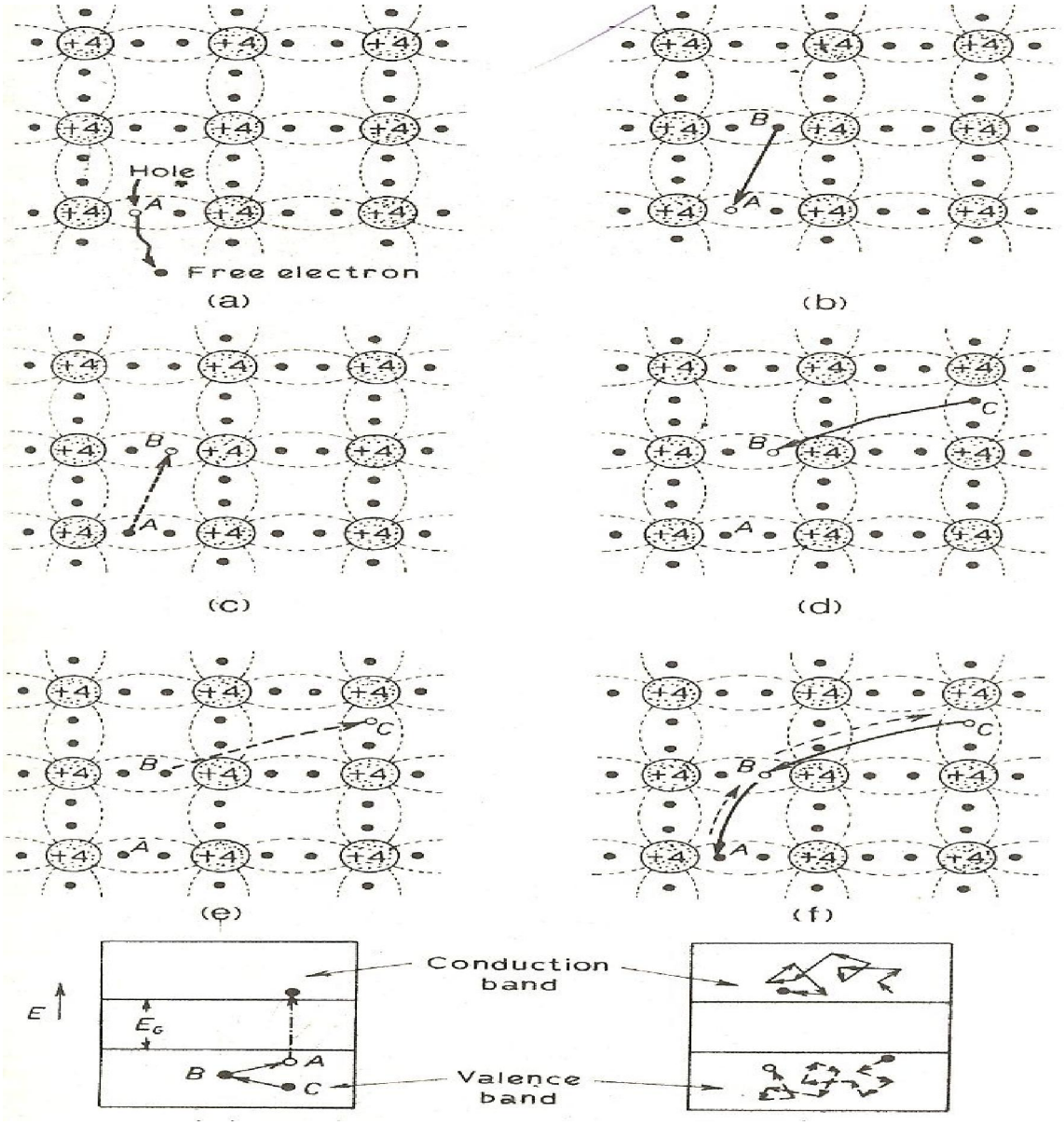
Semi conductor materials Silicon & Germanium in its purest form are called intrinsic semi-conductor.

CHARGE CARRIERS IN INTRINSIC SEMI CONDUCTOR:

At absolute zero temp. (-273^{0}C), intrinsic semiconductors behave like insulators because all electrons are tightly bound to atoms. So there are no free electrons. At room temp(25^{0}C), electrons in valance band acquire sufficient energy to jump from valance band to conduction band. Electrons move away from covalent bonds, thus a covalent bond is broken. When an electron moves away from covalent bond then a vacancy is created which is called '**Hole**'.When a free electron is generated, a hole is also created which has +Ve charge equal to that of electrons. In other words, holes & electrons are always generated in pairs. The concentration of holes & free electrons will be equal in intrinsic semiconductors.



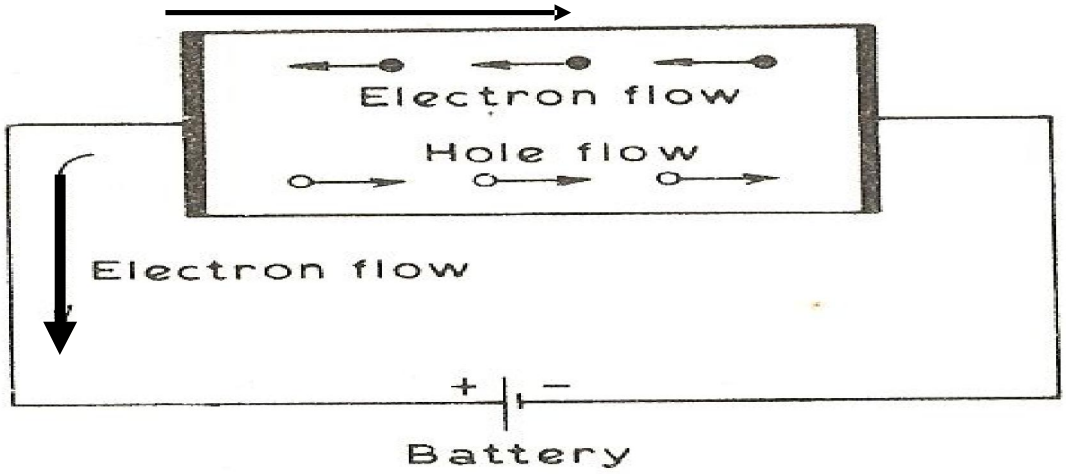
Movement of Hole and electron in Intrinsic Semiconductor



CONDUCTION IN INTRINSIC SEMICONDUCTOR

Semiconductors have two types of charge carriers electron & hole. Electron is –ve charge particle and hole is +ve charge particle.When battery is connected across semiconductor material i.e. silicon or germanium , the electrons experience attraction force towards the positive terminal of battery and holes toward negative terminal of battery. The free electrons move towards positive terminal and holes move towards –ve terminal of battery. The electric current flows through the semiconductor in the same direction as in which the holes are moving and opposite to the direction of electron movement.

Total current $I = I_e + I_h$



Although two types of charge carriers move in opposite directions, but current due to hole I_h & current due to electron. Ie are in same direction i.e. they add together and constitutes current I .

EXTRINSIC SEMICONDUCTORS: When some other material is added with intrinsic semiconductor as an impurity, then the semiconductor is called extrinsic semiconductor. The process of deliberately adding the impurities to semiconductor is called doping. So doped semiconductors are called Extrinsic Semiconductors.

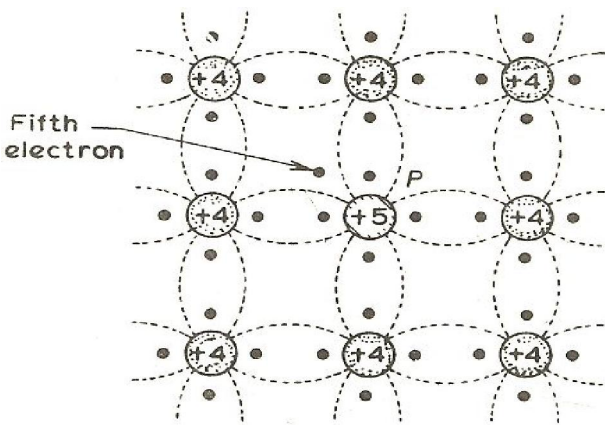
There are two types of extrinsic semiconductors:

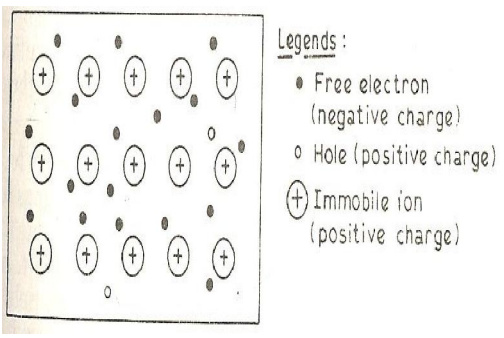
(1) N-Type Semiconductor **(2) P-Type Semiconductor**

(1) N-Type Semiconductor:-When elements of Vth group (Pentavelent elements i.e. phosphorus(15), Arsenic(33),Antemony(51)) are added or doped to semiconductors, then they are called N-Type Semiconductors.

Since impurity added to semiconductor is very small. So each impurity atom is surrounded by semiconductor atom . Suppose impurity of phosphorus is added to silicon, which is shown in fig. atom of phosphorus is surrounded by four atoms of silicon. Phosphorus has five electrons in its valency band. While silicon has four electrons in its valency band. Four electrons of phosphorus atom form **co-valent bonds** with four neighbouring electrons of silicon atoms. The fifth electron of phosphorus has no chance of forming a covalent bond , it remains free. this electron acquire energy at normal room temp. and becomes free from valency band & reaches to conduction band. In other words at room temperature each impurity atom donates one electron to the conduction band that s why this type of impurity js called **Donar type impurity .**

At room temp. electrons of covalent bond also get energy and they break covalent bonds, pairs of free electrons and holes are generated. There fore nos of free electrons will be more than the nos of holes . **In N-Type semiconductors, electrons are in majority and holes are in minority**. **Electrons are called majority charge carriers and holes are called minority charge carries.** It also consists of +ve immobile ions .





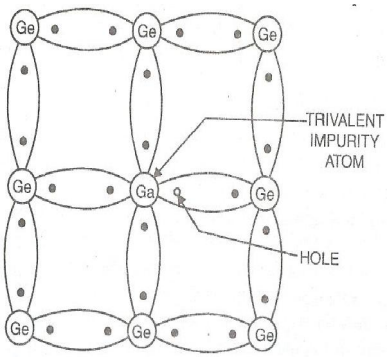
N-Type Semiconductor

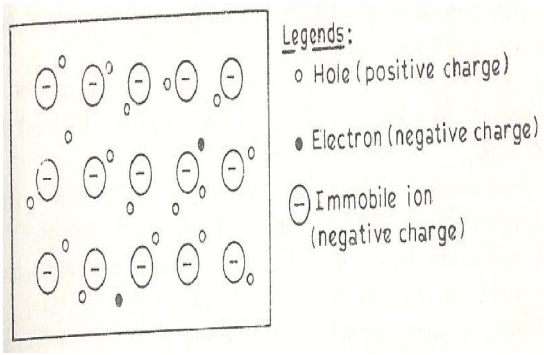
P-Type Semiconductor: When elements of IIIrd group (Trivalent elements i.e.Boron(5), Aluminium(13),Gallium(31) Indium(49)) are added as impurity to semiconductors, such type of semiconductors are called P-type semiconductors.

Suppose impurity of Gallium is added to silicon. Atom of Gallium is surrounded by silicon atoms. Gallium atom has three electrons in valency band. These electrons form covalent bonds with neighbouring electrons of silicon atoms. The fourth covalent bond remains incomplete because Gallium does not have fourth electron in valency band . So there is a deficiency of electron in bond. **The single electron in incomplete bond has the greater tendency to snatch the electron from the neighbouring atom.** This tendency is so great that an electron from an adjacent bond having additional energy can jump to occupy vacant position in incomplete bond.

When electrons jump to fill incomplete bond, A vacancy is created from where electron had jumped, which has +Ve charge called **Hole.** The bond in which electron jump to fill vacant position, it becomes –Ve charge ion which is immobile because it is held tightly in the crystal structure by covalent bond.Since the Gallium atom accepts the electron to complete covalent bond, so it is called acceptor impurity.

P-Type semiconductors have excess holes which are created due to the addition of acceptor type impurity , in addition with electron – holes pair generated due to breaking of covalent bonds. There fore nos of holes will be more than the electrons. **So P-Type semiconductors have holes in majority and electrons in minority**. It also consists of -ve immobile ions .

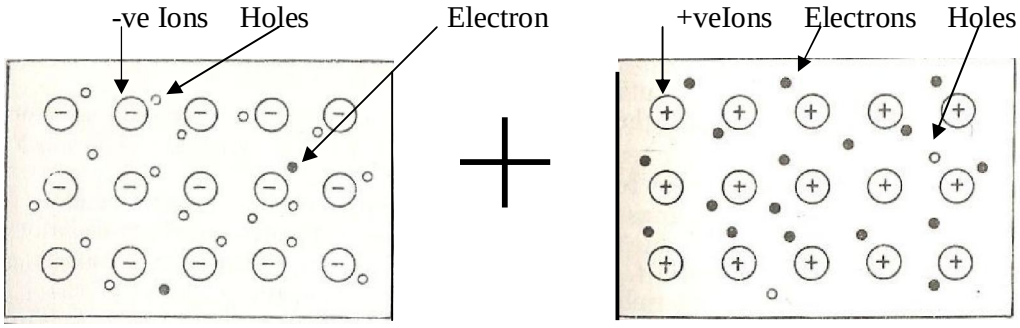




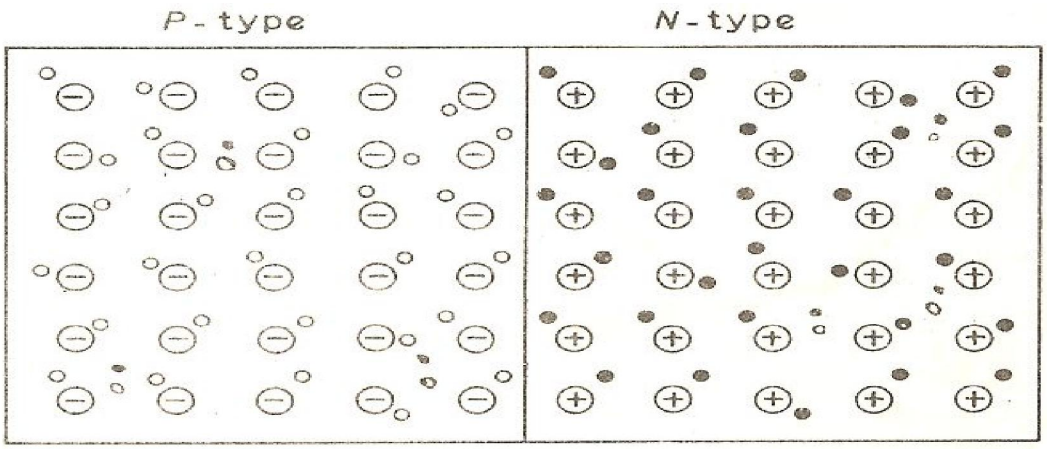
P- Type semiconductor

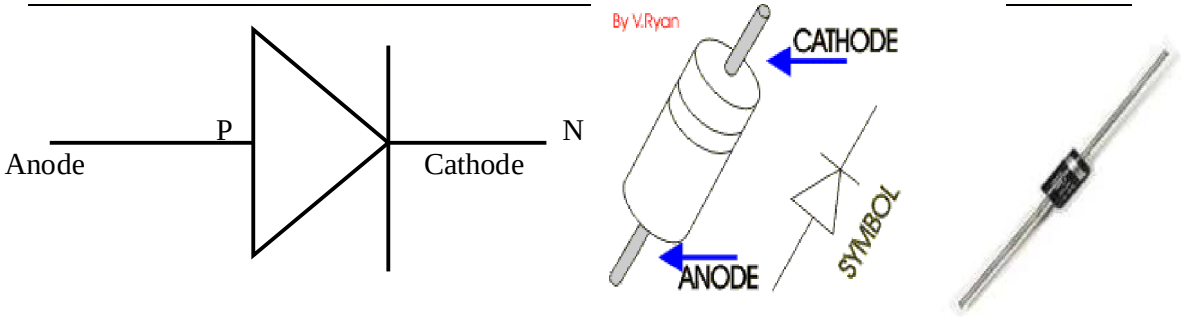
SEMICONDUCTOR DIODE:

P-N junction diode: When we join a piece of P-type semiconductor to a piece of N-type semiconductor with the help of special technique, A P-N junction is formed. Such a P-N junction makes a very useful device. It is called a P-N junction Diode or Semiconductor Diode. The most important characteristics of a P-N junction is its ability to conduct current in one direction only. In other direction, it offers very high resistance. It is a unidirectional device.



P- Type N-Type

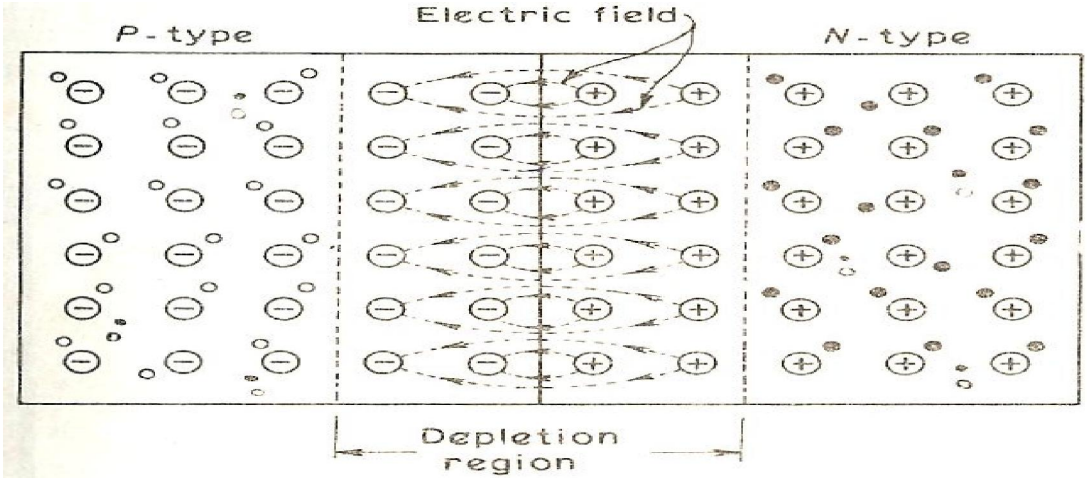




P-N Junction

P-N JUNCTION WITH NO EXTERNAL VOLTAGE:

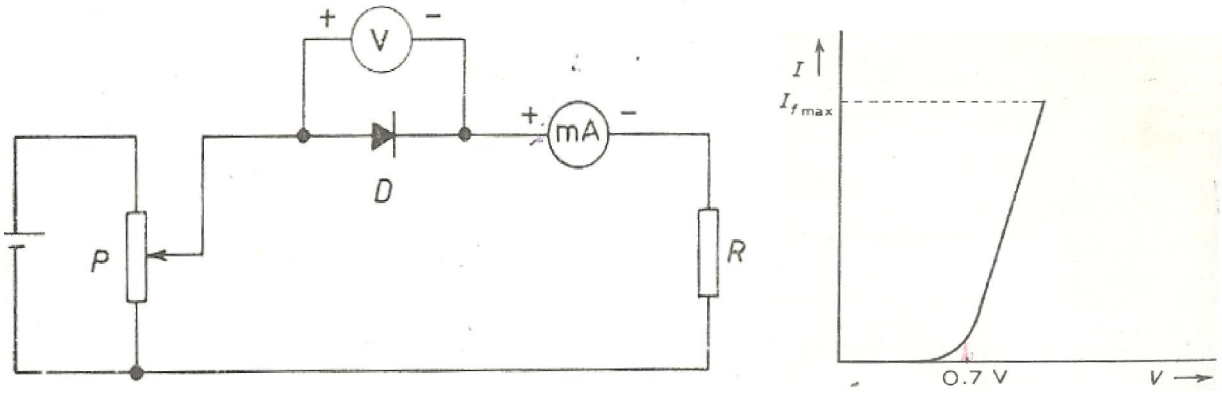
A P.N.-Junction just immediately after it is formed is shown in fig. Its left half is P-type and right half is N-type. The P- region has Holes in majority , Electrons in minority and negatively charged immobile ions. The N- region has Electrons in majority , Holes in minority and positively charged ions. Holes and electrons are the mobile charge carriers, but the ions are immobile.



As soon as the PN-junction is formed, the following processes are initiated:

(i) Due to difference in concentration of charge carriers in P and N regions , Holes near the junction in P- region diffuse into the N region. Where they recombine with free Electrons in the N- region near the junction.
(ii) Free Electrons from N- region near the junction diffuse into the P- region. These Electrons recombine with the holes.
(iii) The diffusion of Holes (from P- region to N- region) and Electrons (from N region to P- region) occurs for a very short time. After a few recombinations of Holes and Electrons near the junction, a restraining force is set up automatically. This force is called a Barrier. Further diffusion of holes and electrons from one side to the other is stopped by this barrier. For a Silicon PN-junction, the barrier potential is about 0.7V, whereas for a Germanium PN-junction it is approximately 0.3V.

PN-JUNCTION WITH FORWARD BIAS: When battery or DC supply is connected to the PN-junction diode such a way that the positive terminal of the battery is connected to the P-side (Anode) and the negative terminal to the N-side(Cathode) , as shown in (Fig…). In this condition the PN-junction diode is said to be in forward-biased.

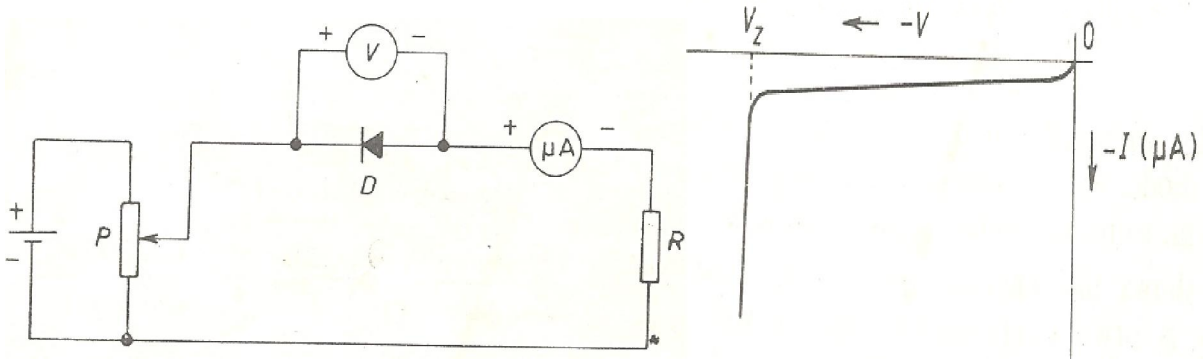


When the PN-junction is forward-biased, the holes are repelled from the positive terminal of the battery and are compelled to move towards the junction. The electrons are repelled from the negative terminal of the battery and drift towards the junction. Because of their acquired energy, some of the holes and the free electrons penetrate the depletion region. This reduces the potential barrier. The width of the depletion region reduces and so does the barrier height. As a result of this, more majority carriers diffuse across the junction. These carriers recombine and cause movement of charge carriers in the space-charge region.

For each recombination of free electron and hole that occurs, an electron from the negative terminal of the battery enters the N-type material near the positive terminal of the battery, an electron breaks a bond in the crystal and enters the positive terminal of the battery. For each electron that breaks its bond, a hole is created. This hole drifts towards the junction. Note that there is a continuous electron current in the external circuit. The current in the P-type material is due to the movement of holes. The current in the N-type material is due to the movement of electrons. The current continues as long as the battery is in the circuit. If the battery voltage is

increased, the barrier potential is further reduced. More majority carriers diffuse across the junction. This results in an increased current through the PN-junction.

PN-JUNCTION WITH REVERSE BIAS: When battery or DC supply is connected to the PN-junction diode such a way that the positive terminal of the battery is connected to the N-side (Cathode) and the negative terminal to the P-side(Anode) , as shown in Fig. In this condition the PN-junction diode is said to be in reverse biased.The holes in the P region are attracted towards the negative terminal of the battery. The electrons in the N region are attracted to the positive terminal of the battery. Thus the majority carriers are drawn away from the junction. This action widens the depletion region and increases the barrier potential .



The increased barrier potential makes it more difficult for the majority carriers to diffuse across the junction. However, this barrier potential is helpful to the minority carriers in crossing the junction. In fact, as soon as a minority carrier is generated, it is swept (or drifted) across the junction because of the barrier potential. The rate of generation of minority carriers depends upon temperature. If the temperature is fixed, the rate of generation of minority carriers remains constant. Therefore, the current due to the flow of minority carriers remains the same whether the battery voltage is low or high. For this reason, this current is called reverse saturation current. This current is very small as the number of minority carriers is small. It is of the order of nano-amperes in silicon diodes and microamperes in germanium diodes.

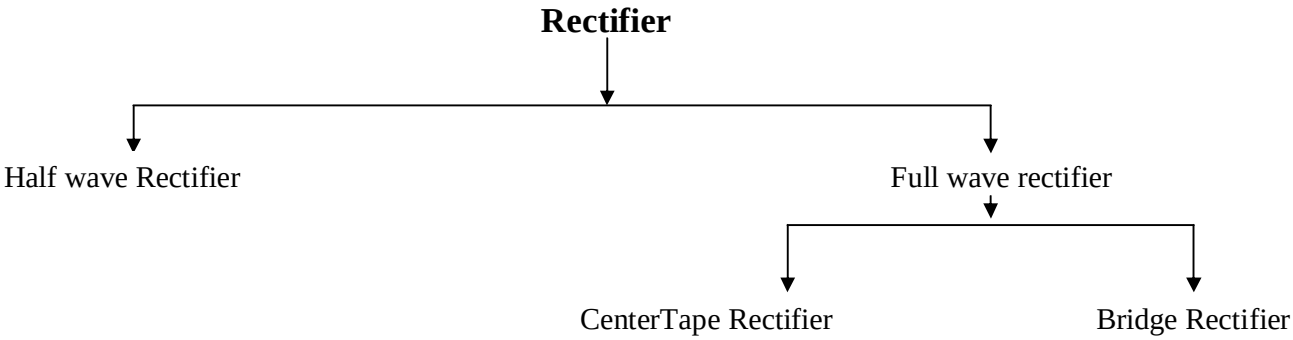
Reverse Breakdown - We have seen that a PN-junction allows a very small current to flow when it is reverse-biased. This current is due to the movement of minority carriers. It is almost independent of the voltage applied. However, if the reverse bias is made too high, the current through the PN-junction increases abruptly, the voltage at which this phenomenon occurs is called breakdown voltage. At this voltage, the crystal structure breaks down .In normal applications, this condition is avoided. The crystal structure will return to normal when the excess reverse bias is removed, provided that overheating has not permanently damaged the crystal.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

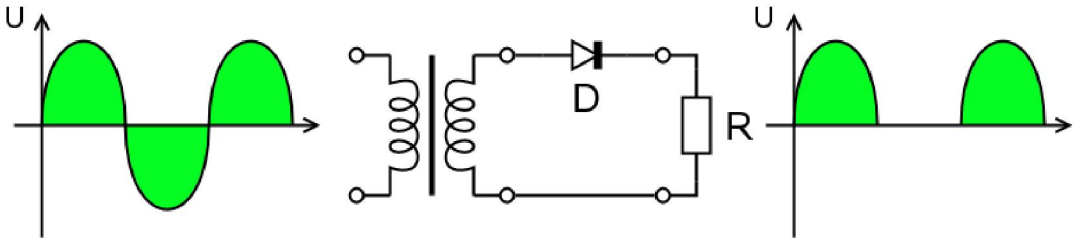
Lesson-III: Semiconductor Diode **Session-5:** Application of P.N. Junction Diode as Rectifier - Half wave & Full wave Rectifiers (Centre Tape and Bridge Rectifier), Polarity Protection Device

---

RECTIFIERS: Since Diode is an unidirectional device it operates or conducts only in one direction so it is used to convert AC to DC. AC to DC converters using diodes are called rectifiers. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC . Rectifiers are of following types.



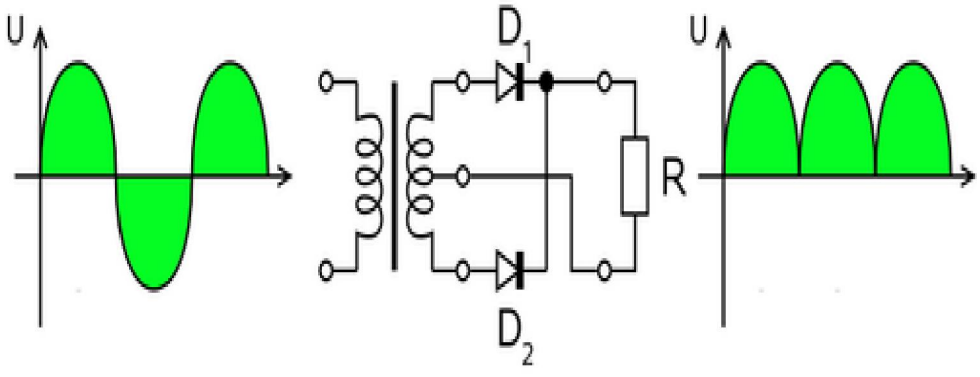
Half wave Rectifer:



In this type of Rectifier only one diode is used, which converts only half cycle of DC, so it is called Half Wave Rectifier.
As shown in figure during positive half cycle diode D is forward biased. It operates and passes the positive half cycle in the output. During negative half cycle the diode is in reverse bias. It does not operate and does not pass negative half cycle to the output.
The diode in this rectifier passes the positive half cycle (only half cycle)or rectify only halfcycle , so it is called half wave rectifier.It's efficiency is 40.6%.

To get smooth D.C. in output electrolyte capacitor can be connected in parallel as a filter in the output.

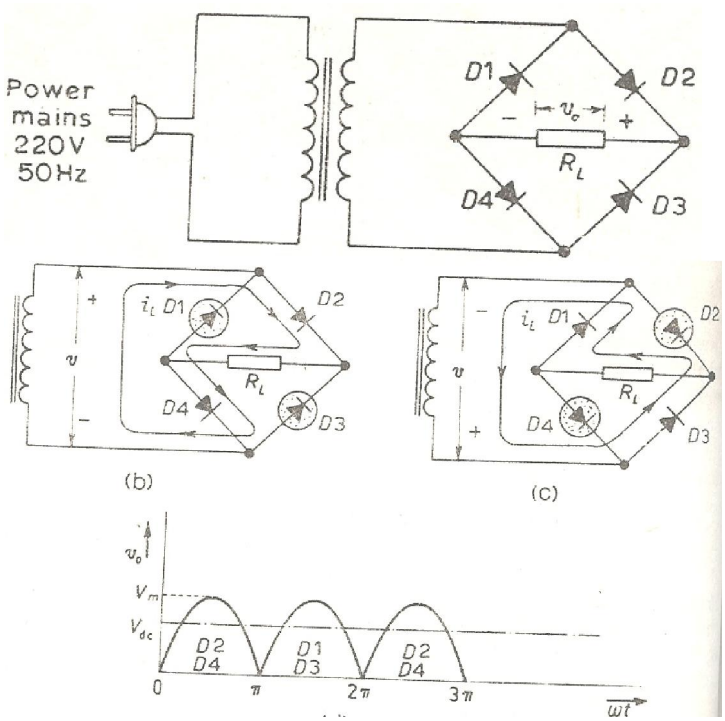
Full wave rectifier: Center Tape Rectifier:



In this rectifier center tape transfer and two diodes D1 & D2 are used. As shown in figure in positive half cycle diode D1 is in forward bias and diode D2 is in reverse bias. At this time D1 operates and D2 does not operate. Positive half cycle is passed on in the output.

During negative half cycle diode D2 is in forward bias and diode D1 is in reverse bias, D2 operates and D1 does not operate. Therefore diode D2 rectify the negative half cycle. By connecting a capacitor as filter in out put we get smooth D.C.
Efficiency = 81.2%.

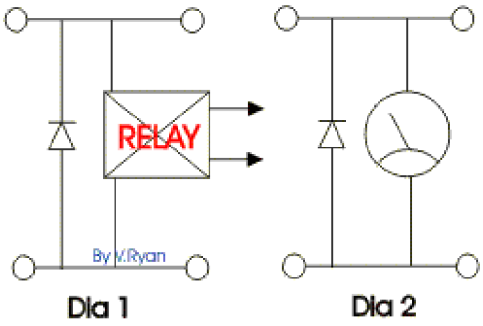
Bridge Rectifier:



This rectifier consists of four diodes D1,D2,D3 and D4 as shown in figure . During positive half cycle diode D2 and D4 are in forward bias , D1 and D3 are in reverse bias. So diode D2 and D4 operate and pass positive half cycle in the out put.
During negative half cycle diode D1 and D3 are in forward bias and D2 and D4 are in reverse bias. So diode D1 and D3 operate and pass the negative half cycle in the out put. By connecting a capacitor as filter in the output we get smooth D.C.Efficiency is 81.2%

1. Half wave - For general purpose.
2. Center tape - For high current use.
3. Bridge rectifier - For Audio Vidio use.

Polarity Protection Device



Since diode is unidirectional device so it is use as polarity protection device in analog meters ,relays and solenoids,

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

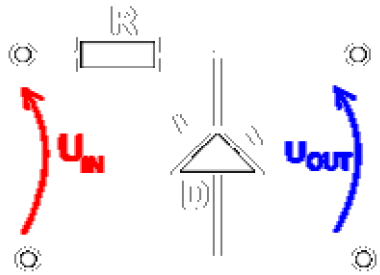
Lesson-III: Semiconductor Diode **Session-6:**Types of Diodes, Construction, Working Symbol and Application of Zener Diode, LED, Photo Diode, Opto-coupler.

Types of diode: -

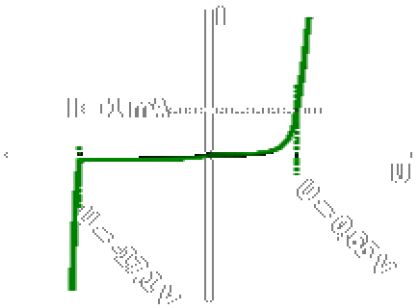
1.Zener Diode:

Zener diode is a special kind of diode which is made to work in reverse bias without damage. It is heavily doped to working in reverse bias.

In reverse bias, it is made to conduct at certain voltage V_Z called reverse breakdown voltage. When reverse voltage reaches to Vz, zener diode conducts. Before this voltage, it does not conduct. The breakdown occurs due to zener effect, and avalanche effect. When reverse bias is When reverse bias is increased, the electric field at the junction also increases. High electric field causes covalent bonds to break. Thus a large number of carriers are generated. This causes a large current to flow. This mechanism of breakdown is called zener breakdown.



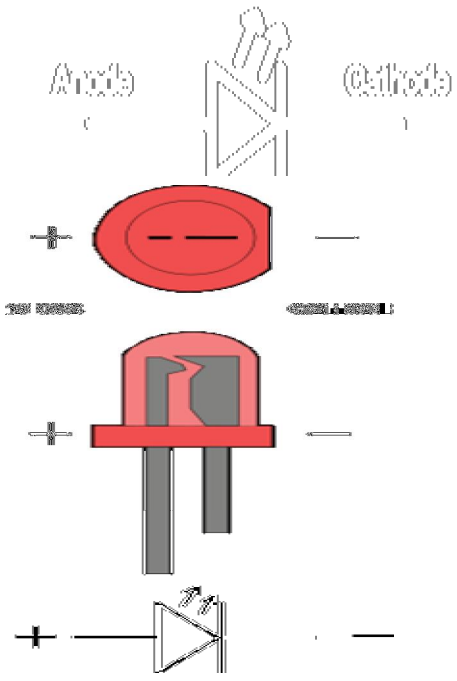
In case of avalanche breakdown, the increased electric field a uses increase in the velocities of minority carriers. These high energy carriers break covalent bonds, thereby generating more carriers. Again, these generated carriers are accelerated by the electric field. They break more covalent bonds during their travel. A chain reaction is thus established, creating a large number of carriers. This gives rise to a high reverse current. This mechanism of breakdown is called avalanche breakdown.



Characteristics are same as the characteristics of diode in reverse bias.

The most common application of a zener diode is in voltage stabiliser or regulator circuit.

2.Light Emitting Diode (LED) :



This is a special kind of diode. When it is operated it emits light. It is used in forward bias. In LEDs photo conductive materials such as gallium phosphate (GaP), gallium Arsenate (GaAs), Gallium Arsenate Phosphate (GaAsP) etc are used to emit lights of different colours

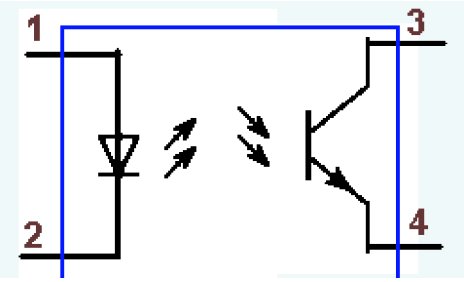
The operating voltage of LEDs is 1 Volt to 3 Volt and maximum current rating is 5 to 10 mA. These are used as indicators, calculators, and watches and intercom.

LED's have a number of advantages over ordinary incandescent lamps. They work on low voltages and currents and thus consumers less power. They require no heating, no warm up time and hence are very fast in action. Small in size & light in weight.

3.Photo Diodes:-

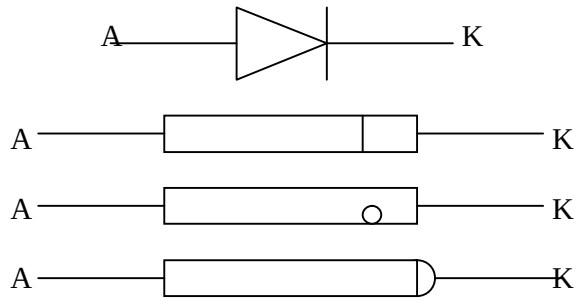
This is a special kind of diodes, which are made of photoconductive material (Cadmium sulfide). It operates when light falls on its junction. It is used in reverse bias. In reverse bias connection in the absence of light it does not operate but when light falls on its junction it starts conduction till the light falls on its junction. Photo diode is used in alarm system (Fire alarm, Burglar alarm etc).

Opto Isolator (Opto- Coupler:-



This is the combination of LED and Photo diode or photo transistor.When LED glows ,it's light falls on junction of photo diode or photo transistor then it also operates it is used for isolation of analog and digital circuit.

Identification and testing of diode.



Note: The marked side of diode is always Cathode side.

Checking of Diode:

Connect the diode to a multi tester in the Ohms Range. The following reading should be observed.

Forward Bias	- Low resistance
Reverse Bias	- High resistance

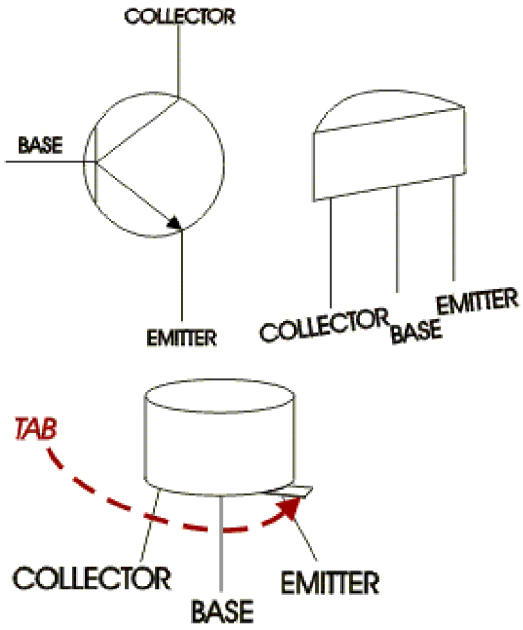
If the above condition is satisfied then the diode is in good condition otherwise change that.

TRANSISTOR: When a third doped element is added to PN junction in such a way that two PN junction are formed, the resulting device is known as transistor.A transistor has three sections of doped semiconductors. The section on one side is emitter, middle section is base and 3rd section is collector. These three sections form two junction emitter-base junction and collector-base junction.

1. **EMITTER:**Emitter is heavily doped than base and collector. It is heavily doped so that it can supply large no. of holes and electrons. It's area is kept between that of base and collector.

2 **BASE:**Base is very lightly doped than emitter and collector. Its area is also less than that of emitter and collector.

3. **COLLECTOR:**Doping of collector is kept larger than base and less than emitter but its area is larger than base and emitter. The junction is always reverse bias with respect to base.



TRANSISTOR WORKING:

- NPN Transistor is shown in figure with electrical connection.
- Emitter base junction is forward biased by battery V_E and collector base junction is reverse biased by battery V_C.
- Since emitter-base junction is forward biased, so electron from emitter junction diffuse towards base and holes diffuse towards emitter.
- Suppose 100 electrons enter from emitter to base. These electrons constitutes emitter current.
- Since base is very thin and very lightly doped so assume that only two electrons recombines with holes.
- To compensate deficiency of two holes in base, new two holes electrons pair generate due to battery V_E
- Two electrons come out from base terminal towards +ve terminal of V_E battery and constitute I_E current.
- 98 electrons diffuse from base to collector. These electrons experience an attractive force due to positive terminal of battery Vc.
- They travel out of the collector terminal and reach the +ve terminal of battery Vc- and thus constitute collector current. I_c

$$I_E = I_B + I_c$$

$$\beta = \frac{I_c}{I_E}$$

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-IV: Transistor **Session-8:** Mode of Connections, Amplifying function, Applications as Switch and Amplifier, Testing

---

THREE CONFIGURATION OF TRANSISTOR:

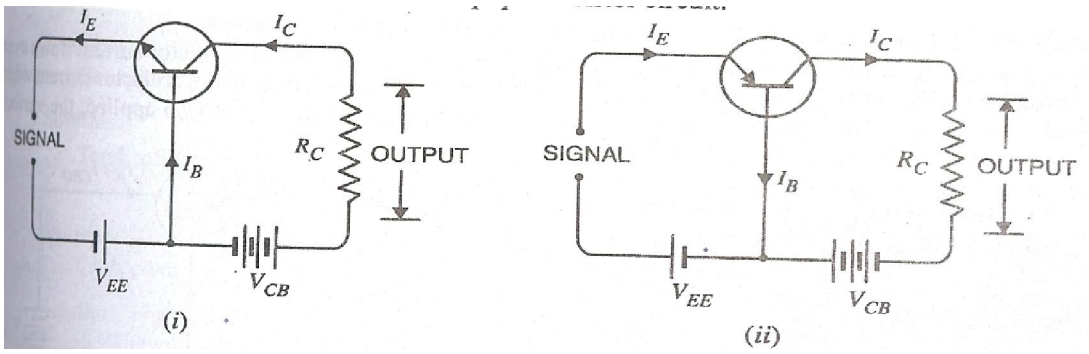
There are three modes of connections of transistor to use in the circuit.

(1) Common Base Configuration (C.B)

(2) Common Emitter Configuration (C.E)

(3) Common Collector Configuration (C.C)

1. COMMON BASE CONFIGURATION (C.B):



In this configuration base terminal is made common between emitter and collector. Input signal is applied between emitter-base terminal and output is taken across collector-base terminal.

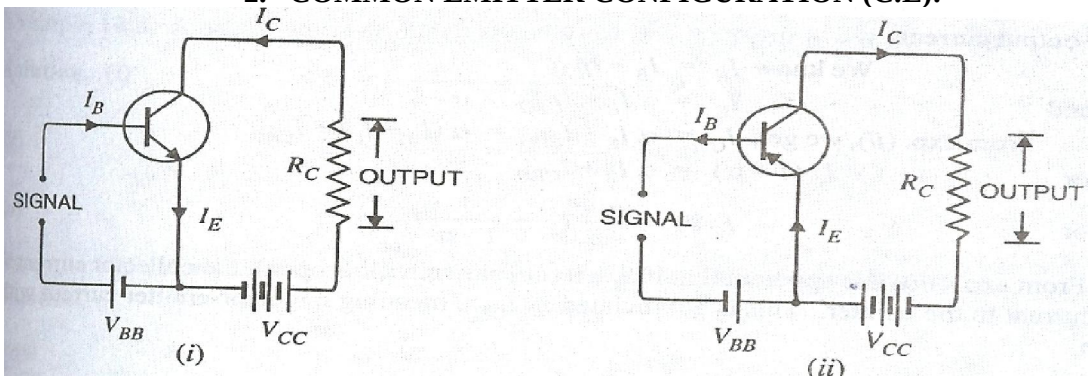
Input resistance = very low (20Ω)

Output resistance = very high (1MΩ)

Gain = $\alpha = \frac{I_c}{I_E}$ = Less than 1

USE: Voltage & power amplifier.

2. COMMON EMITTER CONFIGURATION (C.E):



In this configuration emitter terminal is made common between base and collector. Input signal is applied between base and emitter terminal and output is taken across collector emitter terminal.

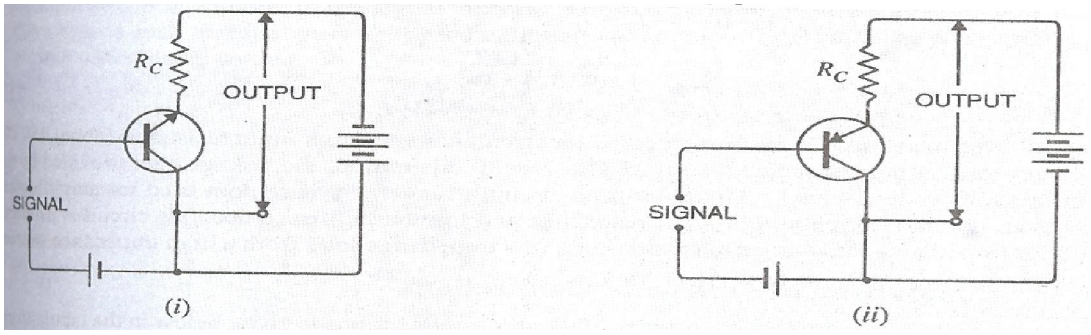
Input Resistance = 1 KΩ (approx.)

Output Resistance = approx 10 KΩ

Gain $\beta = \frac{I_c}{I_B}$ = approx 100

Use: A good amplifier.

3. COMMON COLLECTOR CONFIGURATION (C.C):

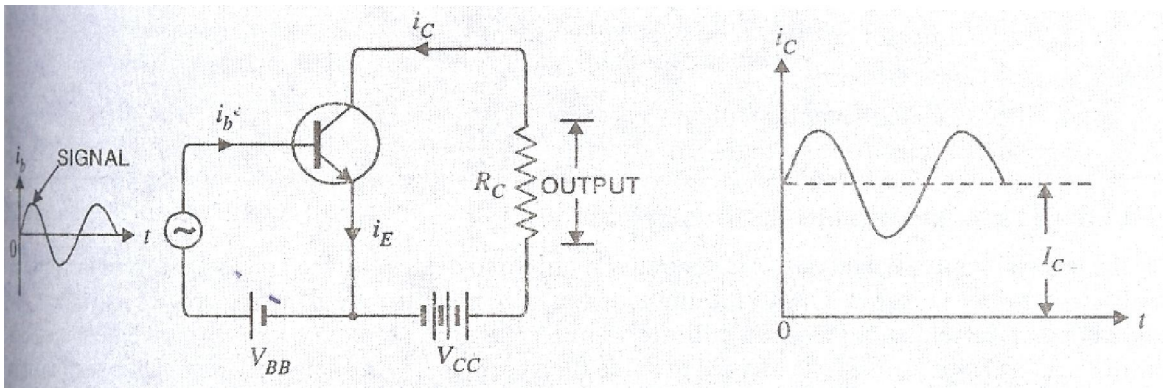


In this configuration collector is made common between base and emitted input signal is applied between base and collector terminal and output is taken across emitter and collector terminal.

Input Resistance = approx 150KΩ
Output Resistance = approx 800Ω
Gain $\gamma = \frac{1_E}{1_B}$ = less than 1

Use: In impedance matching and buffers.

TRANSISTOR AS AN AMMPLIFIER IN CE CONFIGURATION:



Transistor as an amplifier in C.E. configuration is shown in Fig… Input signal Vs is applied between base and emitter, output is taken across load resistor RL. During (+) ve half cycle of the signal the forward voltage across the emitter base junction is increased. Therefore more electrons flow from emitter to the collector via base. This cause increase in collector current. This collector current cause greater voltage drop across load resistor R_L
During (-) ve half cycle of the signal the forward bias voltage across the emitter-base junction decreases. Which cause collector current decrease. This results in the decreased output voltage. Hence an amplified output is obtained across load.

APPLICATION OF TRANSISTOR:

1. As an amplifier to amplify weak signal.
2. It is used in oscillator circuit.
3. It is used as a switch

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-IV: Transistor **Session-9:** Electronics Model Room for demonstration, checking and testing of Diodes and Transistors.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-V: Transducer **Session-10:** Definition, Principle, Classification, Types, Tamping Depth Transducer, Function and Calibration

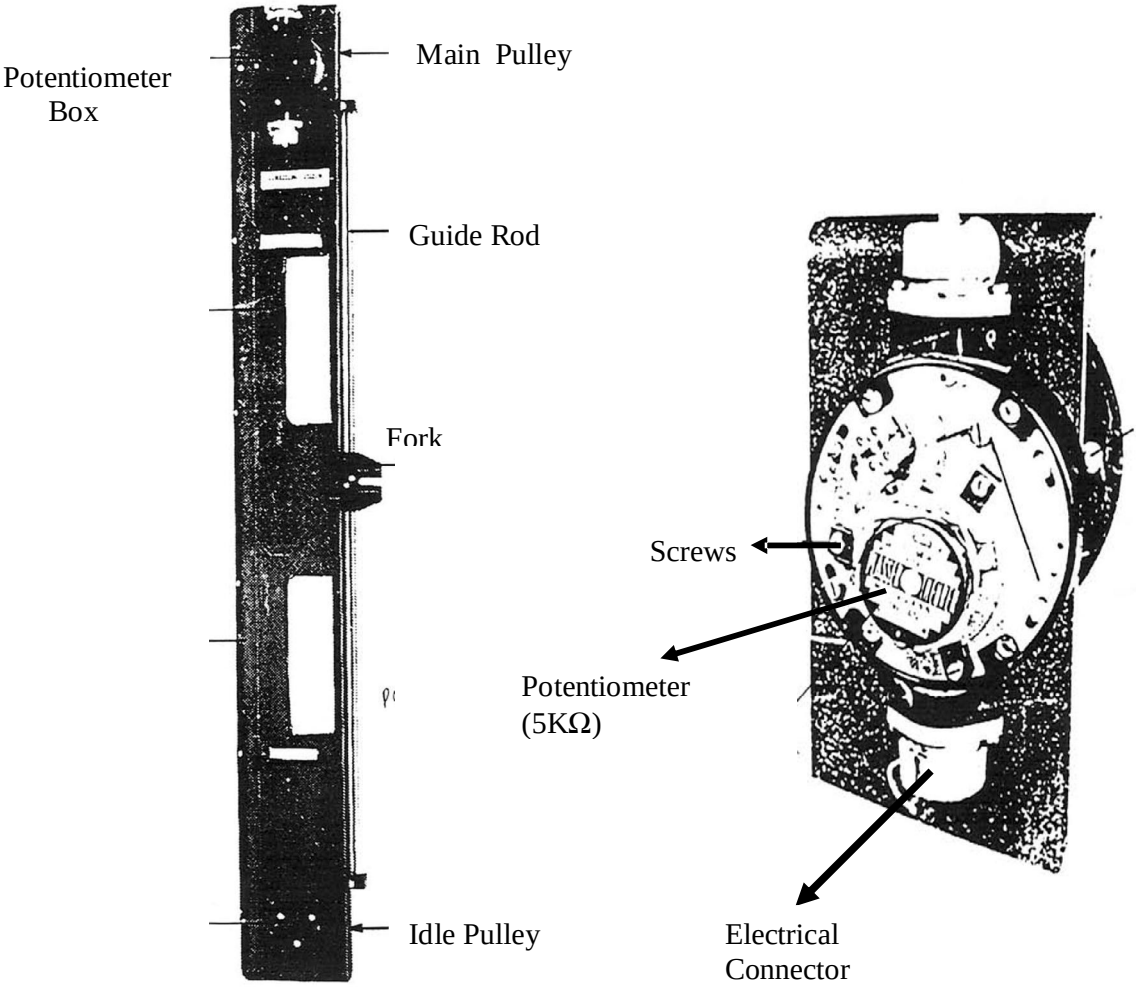
Transducer:

- Transducer is a device which converts mechanical energy into electrical energy.

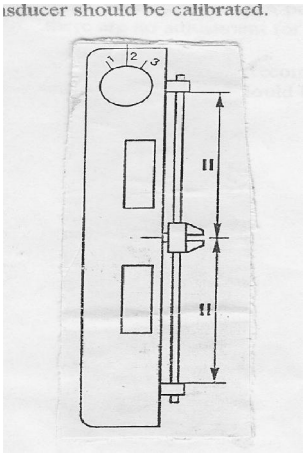
§ In Track Machines Transducers are used to convert track parameters (Cross Level, Long. level, versine) and Mechanical linear displacement (Tamping Unit, Satellites, Hook etc.) to electrical signal.

- In machines transducers are potentiometer type which is basically a variable resistance which shaft is rotated by mechanical arrangement and it generates electrical signal as per deflection.

TAMPING DEPTH TRANSUDCER: Tamping depth transducer converts displacement of taping unit to electrical signal at the rate of 19mv/mm. Output signal of this transducer is –ve if fork is above centre mark of the transducer and it will be +ve if fork is below centre mark. Multicheck address of transducers are F14 (for LH side) and F15 (for RH side). By using these address we can check output of LH or RH transducer.

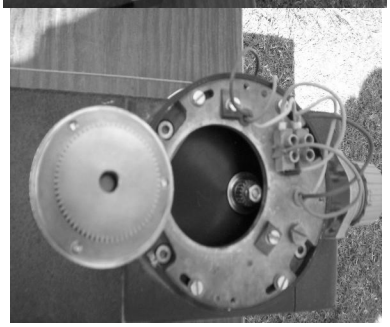


<u>CALIBRATION OF TAMPING DEPTH TRANSDUCER</u>: During working when transducer chord wire breaks we have to replace the chord wire. Detach transducer from machine replace the wire. After replacing wire check stroke of fork it should be equal both side of center mark of transducer.



Now keep fork of transducer at center mark of transducer for calibration. Then measure resistance between 1 & 2 or 2 & 3 terminal of potentiometer with the help of multimeter. It should be 2.5 KΩ (half of full value 5 KΩ). If resistance is not 2.5 KΩ then loose the screw of potentiometer and rotate potentiometer to get the 2.5KΩ resistance or value should be equal between 1 & 2 or 2 & 3 terminals of potentiometer.

If value 2.5KΩ is obtained. Tighten the screw of potentiometer keeping precautions that terminals of potentiometer should not touch with screws.



If value 2.5 KΩ is not obtained by rotating the potentiometer. Then loose the other three screws of potentiometer base plate and pullout potentiometer with gear. Now rotate the gear until same resistance is obtained between 1 & 2 and 2 & 3. After adjustment fit the potentiometer with base and tightened the screws.

NOTE: Three core cable is used for Transducers which has three wires Red(+10V), Blue(-10V) and yellow (output).

There is a 2KΩ resistance near potentiometer which comes in series with output 2nd terminal (centre) of potentiometer that should be properly connected in connector. It should not bypass

CALIBRATION OF PORTABLE TAMPING DEPTRH TRANSDUCER

After Replacement of wire fit the transducer in the machine , tamping unit should be locked .

Multi check address should be selected (F14 or F15),Tamping unit circuit should be on.

In this position output voltage of transducer should be -7.5V, if it is not loose the three screws of potentiometer ,turn it to get required voltage .after adjustment tight the screws and fit the cover .

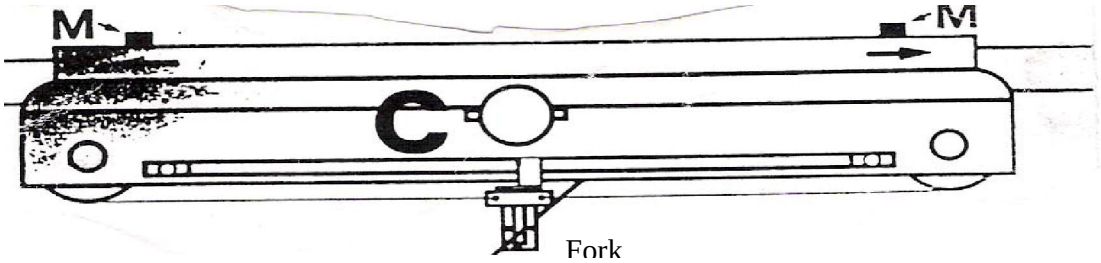
CALIBRATION OF PORTABLE TAMPING DEPTRH TRANSDUCER IN CSM-3X

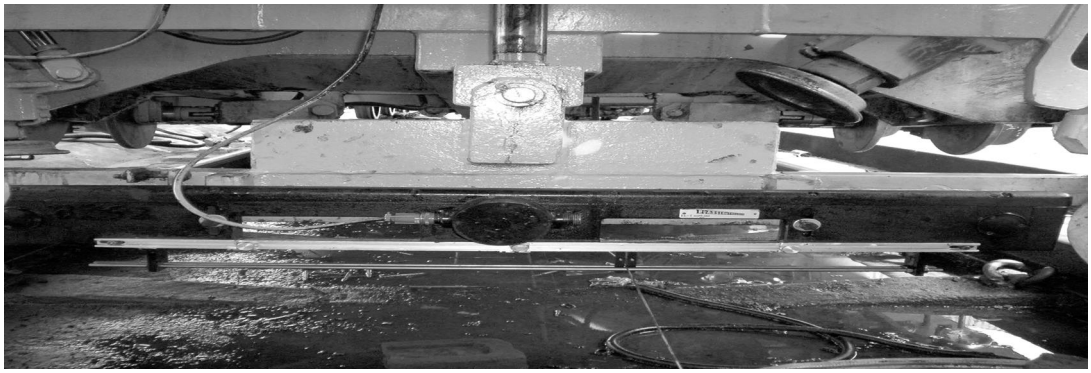
In CSM-3X output voltage of transducer in lock condition should be –4.6 Volt, if it is not loose the three screws of potentiometer ,turn it to get required voltage .after adjustment tight the screws and fit the cover .

Note:- Before calibration of transducers, supply to potentiometers +10V and –10V from PCB EK813SV should be checked with the help of multi position selector switch It's output voltage should be +15V , –15V, + 10V and –10V . If there is variation in +10V, it should be adjusted by potentiometer P1 and -10V can be adjusted by P2 in same PCB.

LINING TRANSDUCER:

Lining Transducer measures $\mathbf{H_1}$ value of versine and converts it to electrical signal at the rate of **23.1 mv/mm –ve if fork is deflected to right side & +ve if fork is deflected to left side**. It is mounted on lining trolley . It's multicheck address is **F01**.

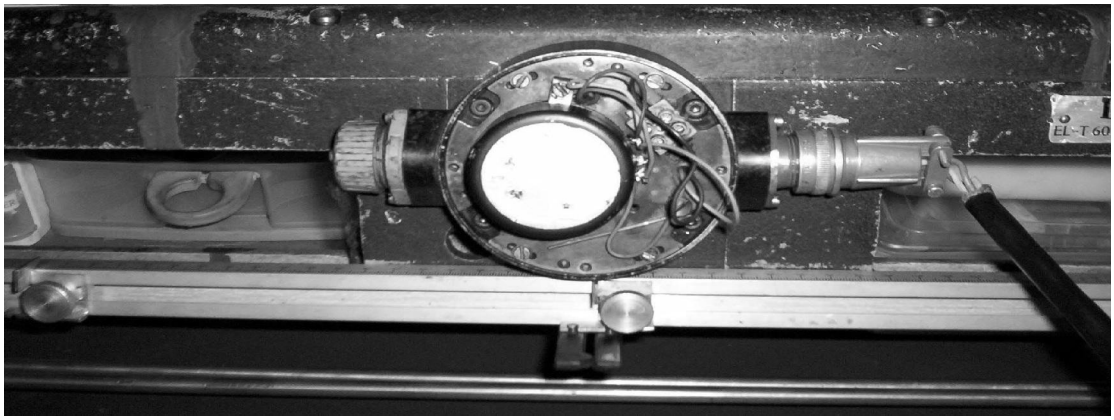




CALIBRATION OF LINING TRANSDUCER:

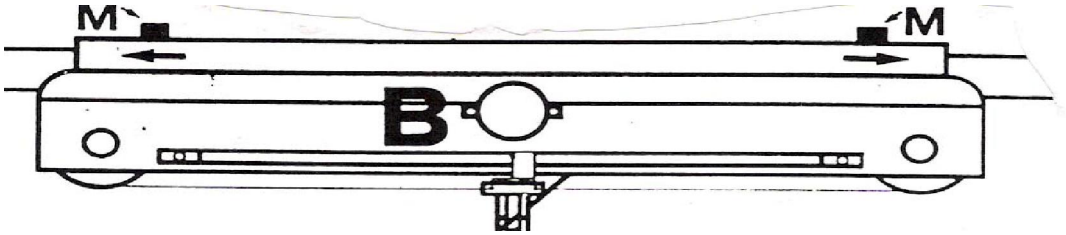
For calibration of lining transducer fix the fork of lining transducer at zero lock position, select multicheck address **F01** in multicheck PCB then display of multicheck should show 0v, if it is not showing zero volt then loose three screws of potentiometer and turn it to get zero volt . After adjustment tight the screws of potentiometer.

Before calibration of transducer voltage of potentiometer should be checked .It should be +10V and –10V. If there is any variation, then adjust +10v and –10v in EK813SV of lining circuit.



MEASURING TRANSDUCER:

Measuring transducer measures $\mathbf{H_2}$ value of versine and convert it to electrical signal at the rate of 23.1 mv/mm **+ ve if fork is deflected to right side** and **-ve if fork is deflected to left side**. It is mounted on measuring trolley .It's multicheck address is **F02**.It is used in 4-pt. lining.



CALIBRATION OF MEASURING TRANSDUCER:

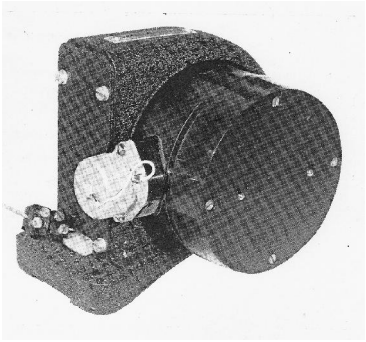
Measuring transducer converts **H2** value of versine to electrical signal at the rate of **23.1 mv/mm +ve for RH side and –ve for LH side.**

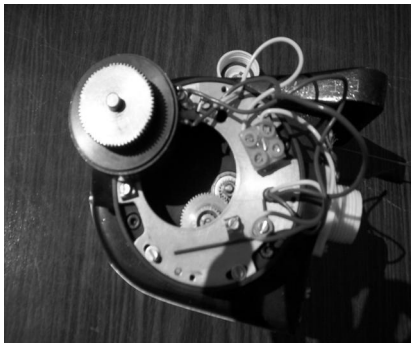
Calibration procedure of measuring transducer is same as lining transducer but for calibration of measuring transducer,4-pt lining and multicheck address F02 should be selected.

SATELLITE TRANSDUCER:

Satellite transducer converts displacement of satellite to electrical signal at the rate of **11mv/mm.**

This transducer is used in CSM and CSM-3X .Output of this transducer goes to satellite control PCB EK24V**(in CSM)** and EK202V(09-3X) at **6d** terminal of these PCBs.





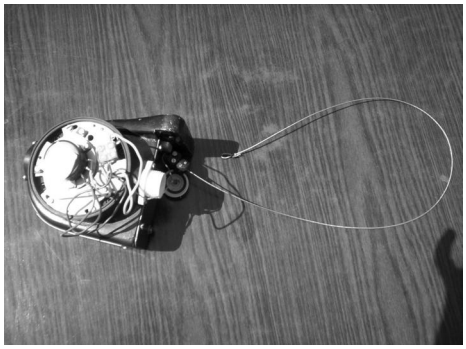
CALIBRATION OF SATELLITE TRANSDUCER IN CSM:

For calibration of Satellite Transducer. Put Machine in working mode, lock the satellite unit in front zero position. Measure output voltage of transducer or at 6d terminal of EK24V, it should be +8.2V.If it is not +8.2v, then open the cover of transducer and loose three screws of potentiometer and adjust it to get +8.2V . After adjustment tight the screws and fit the cover of transducer and release the satellite from front zero position.

Calibration of Satellite Transducer in CSM-3X

For calibration of satellite transducer in CSM-3X Satellite should be locked in rear position , in this position output voltage of transducer should be -8.6 V. If it is not then open the cover of transducer and loose the screw of potentiometer and adjust potentiometer to get -8.6V at 6d terminal of EK 202V.

HOOK DEPTH TRANSDUCER:



This transducer is provided in points and crossing machines Unimate-2S &3S in hook control circuit. This transducer converts displacement of hook to electrical signal at the rate of 23mv/mm .Multicheck address of hook Transducers are F18(L)and F19(R).

CALIBRATION OF HOOK DEPTH TRANSDUCER

For calibration of hook transducer hook should be in up position ,select multicheck address of hook transducer F18 or F19, in this position output voltage of hook transducer should be -2.2 Volt. If output is not -2.2 V then open the cover of transducer and loose three screws of potentiometer and adjust it to get -2.2 V.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-V: Transducer **Session-12:** Pendulum, Height Transducer, Encoder.

PENDULUM:

Pendulum is a transducer which converts cross level error to electrical signal at the rate of **25 mv/mm –ve for LH rail high and +ve for RH rail high .**

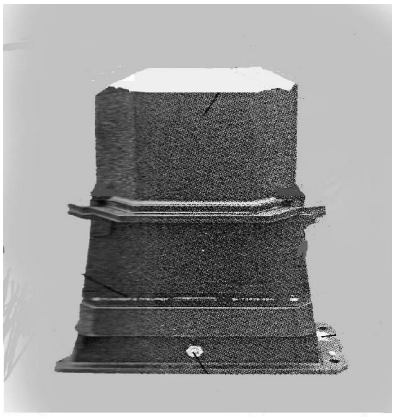
Pendulum consists of a potentiometer which shaft is attached with pendulum weight . Pendulum weight swings as per cross level difference therefore potentiometer's shaft also rotates and potentiometer generates electrical signal . Pendulum also consists of PCB. Potentiometer generates electrical signal at the rate of **2mv/mm**

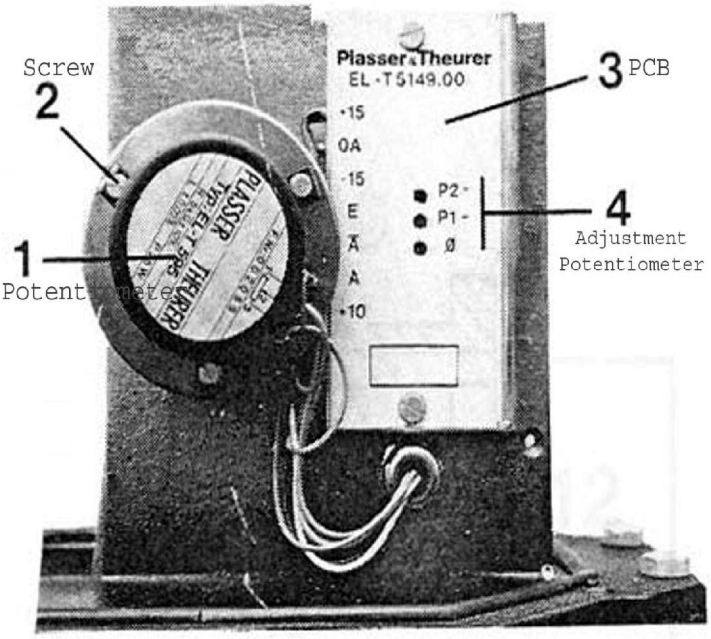
then PCB amplifies it at the rate of 25mv/mm This PCB consists of adjustment **potentiometers P1 , P2 and P3 .**

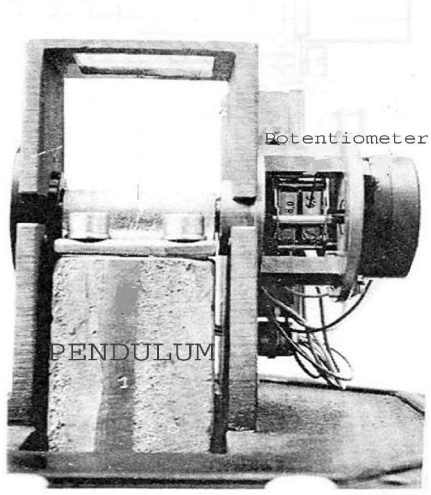
P1 --- Rigtht Side Cant Adjustment .

P2 -- Left Side Cant Adjustment.

P3 -- Zero Adjustment .







There are three pendulums used in CSM and CSM -3X , in other tamping machines only two pendulums are used .

Front Pendulum: This pendulum is mounted on front trolley . It measures cross level of front area before tamping.
Middle Pendulum: This pendulum is mounted on middle feeler rod . It measures cross level of tamping area .
Rear Pendulum: This pendulum is mounted on measuring trolley . It measures cross level after tamping .This pendulum participates in twist correction.

CALIBRATION OF FRONT PENDULUM:

Mechanical Adjustment: Lower the front trolley on track where cross level should be zero. Now check spirit level it should be on zero, if it is not zero then adjust check nut of front pendulum to get spirit level on zero.

Electrical Zero Adjustment: After mechanical adjustment check output of pendulum at 12b terminal of front input PCB EK345LV with the help of multimeter if output of pendulum is not zero then adjust potentiometer P3 in pendulum PCB to get zero volt at 12b.

Right Side Cant Adjustment: Place 100mm thick shim (Iron piece or wooden piece) under RH wheel of front trolley. Now measure voltage at 12b with respect to 32 db with the help of multimeter . It should be +2.5V, if it is not +2.5V then adjust P1 in pendulum PCB. After adjustment remove 100mm shim from wheel.

Left Side Cant Adjustment: Now place 100mm thick shim under LH wheel of front trolley. Measure voltage at 12b with respect to 32 db(OA) with the help of multimeter. It should be –2.5V. If it is not –2.5V then adjust P2 in pendulum PCB.

CALIBRATION OF MIDDLE PENDULUM:

Mechanical Adjustment: Lower the middle feeler rod on track where cross level is zero, check the spirit level of pendulum it should be on zero. If it is not in zero position then adjust check nut of middle pendulum to bring spirit level in zero position .

Electrical Zero Adjustment: Select Multicheck address F07, selector switch should be on 2nd position. Display should show zero volt ,if it is not zero volt then adjust potentiometer P3 in pendulum PCB to get zero volt on display.

Right Side Cant Adjustment: Place 100mm shim under RH side feeler rod and check output of pendulum on display . It should be +2.5V, if it is not +2.5V then adjust potentiometer P1 in pendulum PCB to get +2.5V.After adjustment remove shim.

Left Side Cant Adjustment: Place 100mm shim under LH feeler rod and check output of pendulum on display . It should be –2.5V, if it is not –2.5V then adjust potentiometer P2 in pendulum PCB to get –2.5V.

Rear Pendulum: Rear pendulum is fitted on rear feeler rod (Measuring trolley). It measures cross level after tamping and converts it to electrical signal at the rate of 25mv/mm(-ve if Left rail high).

Mechanical Zero Adjustment of Rear Pendulum: Lower the measuring trolley on track where cross level is zero. Check spirit level of rear pendulum. It should be in centre(zero position). if it is not in centre then adjust check nut of mounting of rear pendulum to bring spirit level at centre.

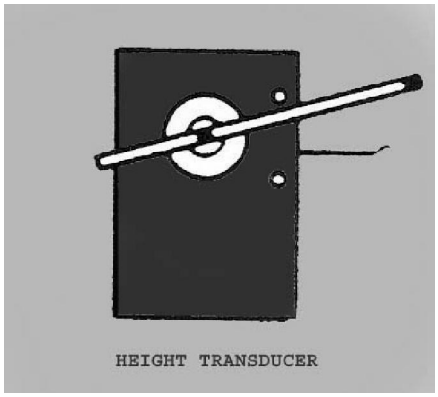
Electrical Zero Adjustment: After mechanical adjustment electrical output voltage of pendulum should be checked. Select multicheck address FO9 , check voltage on display ,it

should be zero volt on zero track, if it is not zero volt then adjust potentiometer P3 in pendulum PCB to get zero volt on display.

Right Side Cant Adjustment: Place 100mm shim under RH side wheel of measuring trolley and select multicheck address F09. Output of pendulum should be +2.5V if it is not +2.5V (less or more) then adjust potentiometer P1 in pendulum PCB to get +2.5V. After adjustment remove shim.

Left Side Cant Adjustment: Now place 100mm shim under LH side wheel of measuring trolley and check output voltage of pendulum it should be -2.5V if not adjust potentiometer P2 in pendulum PCB.

HEIGHT TRANSDUCER:



Height transducer converts longitudinal level to electrical signal at the rate of 90mv/mm +ve for lifting .There are two height transducers used in tamping machines one for left side and other for right side rail. Height transducers are mounted on middle feeler rod. Multicheck address of Height Transducers are F0D(LH) and F0E(RH)

CALIBRATION OF HEIGHT TRANSDUCER:

Arrange to make at least 30m track longitudinal & cross level free and provide shim if necessary to get zero longitudinal level track under all three feeler rods (Front, middle and rear.

- Switch on lifting circuit.
- Keep all input potentiometers (General lift,Cant and Cross level correction potentiometer etc.) at zero.
- Satellite should be in zero position.
- Apply levelling chord tension.
- select multicheck address of height transducers F0D or F0E

  Arm of height transducer should be parallel to track in horizontal and output signal should be 0V, pointer of lift indicator should in midlle position.

- If arm is not horizontal then adjust height transducer mechanically UP or DN as required.

- If arm is parallel to track and electrical signal is not zero then adjust potentiometer of height transducer by loosing screw. Signal should be checked on F0D for Left height transducer and on F0E for Right height transducer.

ENCODER:

This transducer is used in CSM, 09-3X, and DGS. This transducer converts displacement of machine to Digital signal at the rate of 1000 Pulse/meter. This is

PART NO. OF TRANSDUCERS AND POTENTIOMETERS USED IN CSM

SNO.	Name of Transducers	PART NO.
1.	Lining Transducer	ELT-609.00
2.	Measuring Transducer	ELT-609.00
3.	Front Pendulum	ELT 2021.00A
4.	Middle Pendulum	ELT-2036.00A
5.	Rear Pendulum	ELT-2036.00A
6.	Height Transducer	ELT-2013.00
7.	Tamping Depth Transducer	ELT-1330.00/ ELT-750.00
8	Satellite Transducer	ELT-1041.00
9.	Distance Measuring wheel	ELT-7055/700AF
	POTENTIOMETERS	
1.	Slew Potentiometer	ELT-1044
2.	Versine Potentiometer	ELT-1044
3.	Over Slew Potentiometer	20 KΩ +10 SKALA/200G
4.	Zero Adjustment Potentiometer	20KΩ +5 S KALA/200G
5.	Super Elevation Potentiometer	ELT-1044
6.	General Lift Potentiometer	ELT-1044
8.	±5mm correction Potentiometer	ELT-5140
9.	± 10mm Correction Potentiometer	ELT-1044
10.	Depth Selector Potentiometer	ELT-5016

PART NO. OF TRANSDUCERS AND POTENTIOMETERS USED IN DUOMATIC

SNO.	Name of Transducers	PART NO.
1.	Lining Transducer	ELT-609.00
2.	Measuring Transducer	ELT-609.00
3.	Pendulum	ELT 133.00
4.	Height Transducer	ELT-213.00
5.	Tamping Depth Transducer	ELT-1330.00
	POTENTIOMETERS	
1.	Slew Potentiometer	ELT-1044
2.	Versine Potentiometer	ELT-1044

3.	Over Slew Potentiometer	20 KΩ +10 SKALA/200G
4.	Zero Adjustment Potentiometer	20KΩ +5 SKALA/200G
5.	Super Elevation Potentiometer	ELT-1044
6.	General Lift Potentiometer	ELT-1062

PART NO. OF TRANSDUCERS AND POTENTIOMETERS USED IN UNIMAT2S&3S

Sl.NO.	TRANSDUCER	PART NO.
1.	Lining Transducer	ELT-609.00
2.	Measuring Transducer	ELT-609.00
3.	Pendulum	ELT 2036.00
4.	Height Transducer	ELT-2044.00
5.	Tamping Depth Transducer	ELT01330.00/ELT-750.00
6.	Hook depth Transducer	ELT-750.00
	POTENTIOMETERS	
1.	Slew Potentiometer	ELT-1044
2.	Versine Potentiometer	ELT-1044
3.	Over Slew Potentiometer	20 KΩ +10 SKALA/200G
4.	Zero Adjustment Potentiometer	20KΩ +5 SKALA/200G
5.	Super Elevation Potentiometer	ELT-1044
6.	General Lift Potentiometer	ELT-1044

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-V: Transducer **Session-13:** Electronics model room for demonstration of checking and calibration of Transducers..

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-VI: Operational Amplifier **Session-14:** Definition of Operational Amplifier, Symbol, Function of each terminal, Open loop, Close loop, +ve feed back,–ve feed back, Characteristics

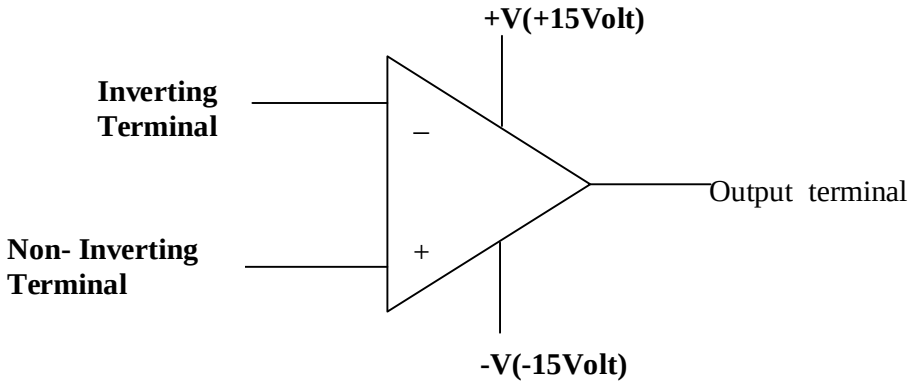
---

OPERATIONAL AMPLIFIER:

Operational amplifier is a direct coupled high gain amplifier usually consists of one or more stage of differential amplifier. It can amplify AC as well as DC input signals. Operational amplifier also can do mathematical operations such as addition ,subtraction ,multiplication , integration and differentiation etc. Commonly it is abbreviated to Op- amp .

SCHEMATIC SYMBOL:

The basic operational amplifier has two input and one output terminal input terminals are called inverting terminal and non-inverting terminal.



Characteristics Of Ideal Operational Amplifier:

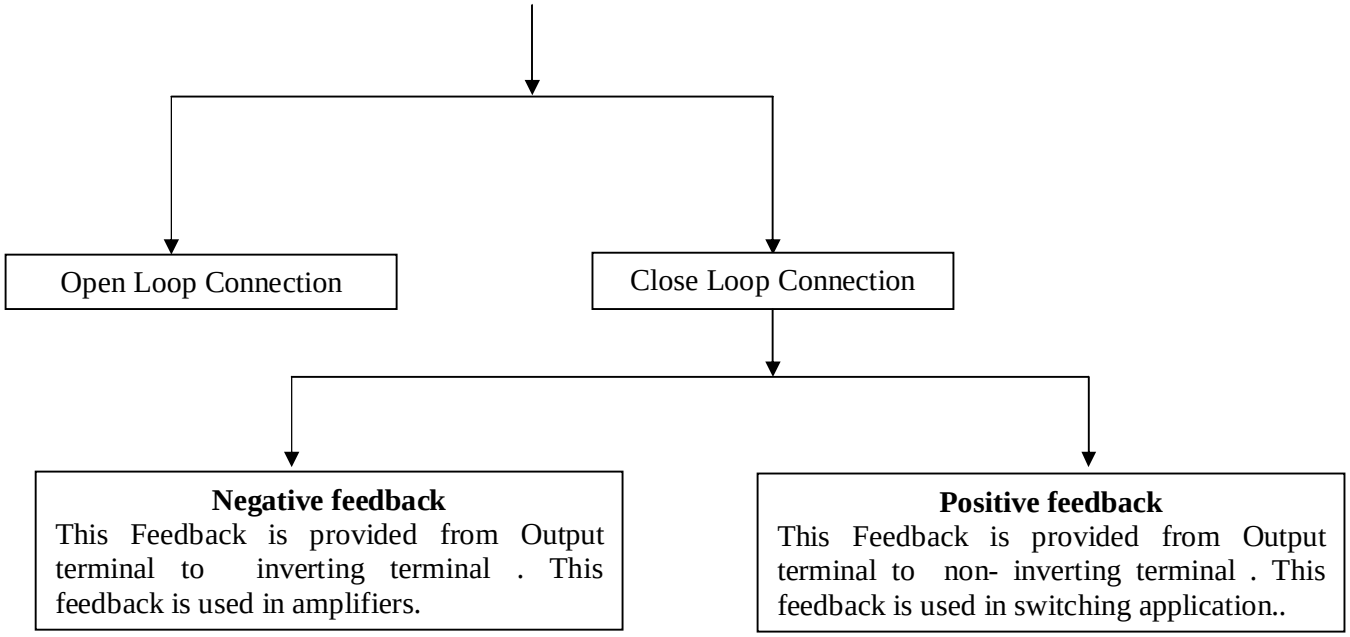
Input impedance	=	Infinite
Output impedance	=	Zero (0)
Gain	=	Infinite
Band width	=	Flat

Characteristics Of Practical Operational Apmlifier:

Practical operational amplifier has following characteristics:

- Input impedance = 10^6 (MΩ)
- Output impedance = 75Ω
- Gain = 10^6
- Band width = Almost flat

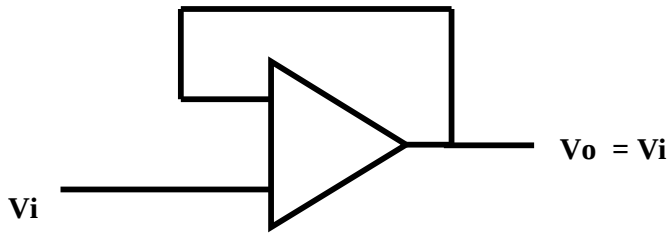
Modes of Connections of Operational Amplifier



SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

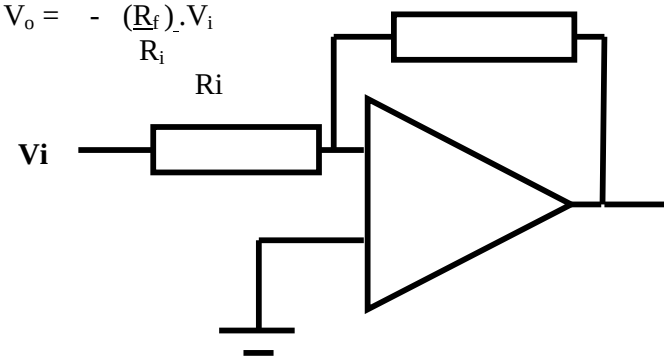
Lesson-VI: Operational Amplifier **Session-15:** Application of Operational Amplifier as Buffer, Inverter, Non Inverter, Adder, Sub-tractor, Integrator etc.

1.Buffer Amp :- It is an unity gain Amplifier, which output is equal to Input. This Op-Amp is used for isolation and impedance matching. In PCBs output of transducers are received through this amplifier



2.Inverting Amp :-This Amplifier Inverts the polarity of the input signaland amplifies as per formula given below.

$$V_o = - \frac{R_f}{R_i} . V_i$$



$$V_o = - \frac{Rf \; . \; Vi}{Ri}$$

Ri = Input Resistor
Rf= Feedback Resistor
Vi = Input voltage
Vo = Output voltage

Ex: (i) If R_f = 100KΩ
R = 10 KΩ
e_i = 1V

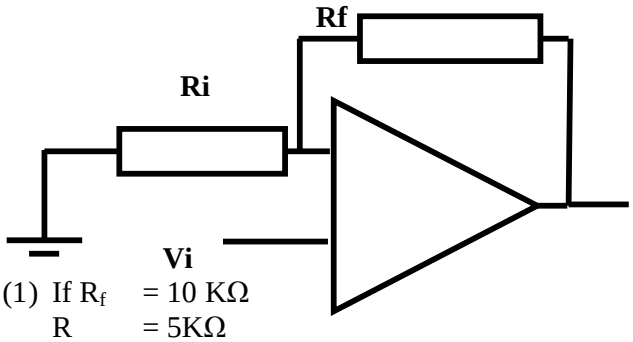
$$e_0 = - 1 \times \frac{100}{10} = -10V$$

(ii) R_f = 4KΩ

R = 2KΩ
e_i = -3V
C_0 = -(-3) x ($\frac{4}{2}$) = - (-3) x 2 = 6V

3. Non-Inverting Amp :-This Amplifier does not Inverts the polarity of the input signals and amplifies as per formula given below.

$$V_o = (1+\frac{R_f}{R_i}).V_i$$



$V_o = (1+\frac{R_f}{R_i}).V_i$
Ri = Input Resistor
Rf= Feedback Resistor
Vi = Input voltage
Vo = Output voltage

Ex. (1) If R_f = 10 KΩ
R = 5KΩ
e_i = + 2V

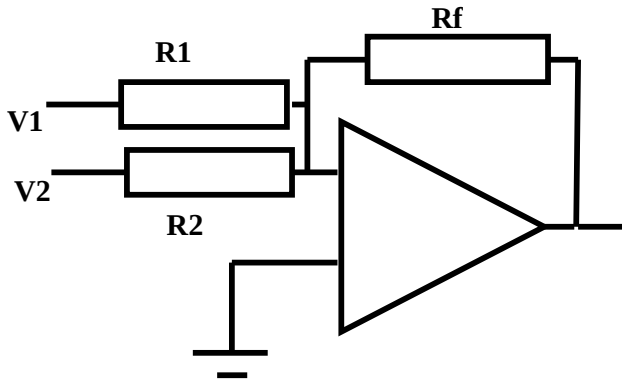
e_0 = +2 (1 + $\frac{10}{5}$) = + 6V

(2) R_f = 200KΩ
R1 = 100KΩ
e_i = -4V

e_0 = - 4 (1+ $\frac{200}{100}$) = -12V

4.**Summing Amp :-**This Amplifier add the input signals and amplifies as per formula given below.

$$V_o = -(\frac{R_f}{R_1}.V_1 + \frac{R_f}{R_2}.V_2)$$



$V_o = -(\frac{R_f}{R_1}.V_1 + \frac{R_f}{R_2}.V_2)$
R1&R2 = Input Resistor
Rf = Feedback Resistor
V1&V2 = Input voltage
Vo = Output voltage

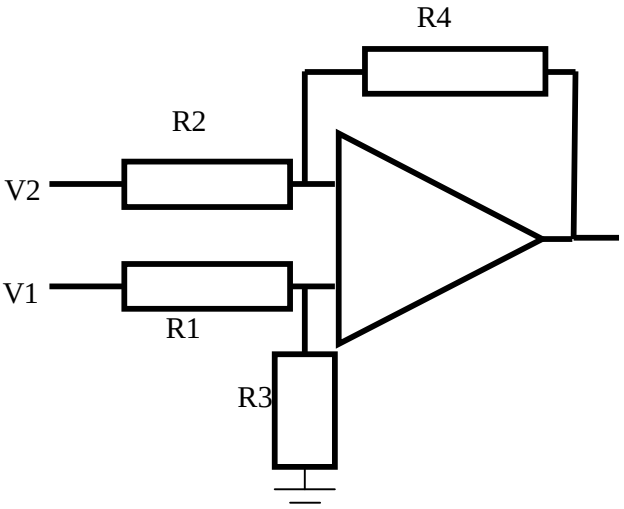
: (1) R_f = 10KΩ
R_1 = 5KΩ
R_2 = 5KΩ
e_1 = 1V,C_2 = 2V

e_o = $-\frac{RF}{R}(e_1 + e_2)$ = $-\frac{10}{5}(1+2)$

= $-\frac{30}{5}$ = -6V

5.Subtractor :-This Amplifier subtracts the input signals and amplifies as per formula given below.

$$V_o = - \frac{R_4}{R_1} .(V_1 - V_2) \qquad (R1 = R2 : R4=R3)$$



$V_o = - \frac{R_4}{R_1} .(V_1 - V_2)$

R1&R2 = Input Resistor

R4 = Feedback Resistor

V1&V2 = Input voltage

Vo = Output voltage

6 INTEGRATOR:

Output of this amplifier is integral of input voltage .This amplifier is also called ramp generator. This amplifier is used in signal generators to convert square wave to triangle wave or ramp signal .

7 DIFFERENTIATOR:

This amplifier perform the differentiation operation . Output of this amplifier is derivative of input signal . This amplifier is used in signal generators to convert triangle wave or ramp signal to square wave .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

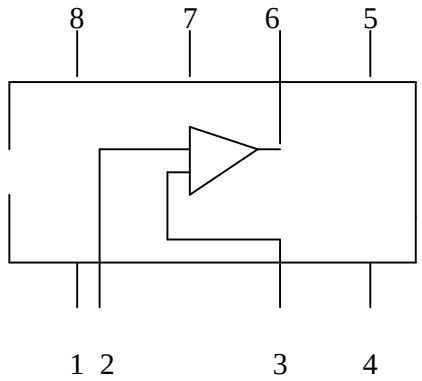
Lesson-VI: Operational Amplifier **Session-16:** Operational Amplifier ICs used in different PCBs in machines and their Pin diagrams

OPERATIONAL AMPLIFIER ICs USED IN DIFFERENT PCB's OF MACHINES

SINGLE OP – AMP:

OP02
741
OP50
LH0041 C G

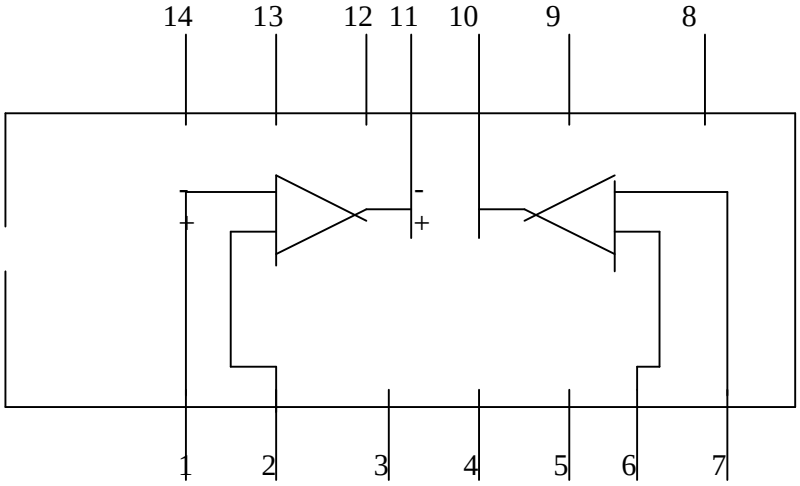
PIN DIAGRAM OF OP – AMP – 02:



PIN-1 → For null adjustment
PIN-2 → For Inverting terminal
PIN-3 → Non Inverting terminal
PIN-4 → For Negative Supply
PIN-5 → Null adjustment
PIN-6 → For Output
PIN-7 → For +Ve supply
and PIN-8 → No connection

OP-AMP ICs USED IN DIFFERENT PCBs OF MACHINES

DUAL OPERATIONAL AMPLIFIER
OP04
747
Pin Diagram of OP04



PIN – 1 →& 2 Input for Op Amp. –'A'

PIN – 3 →Null Adjustment of 'A'

PIN – 4 →VE supply

PIN – 5 →Null Adjustment of 'B'

PIN - 6 & 7 →Input For 'B'

PIN – 8 →Null Adjustment of 'B'

PIN – 9 →X Ve Supply

PIN – 10→ Output of 'B'

PIN – 11→ No connection.

PIN – 12→ Output For ‘A

PIN – 13 →X Ve supply

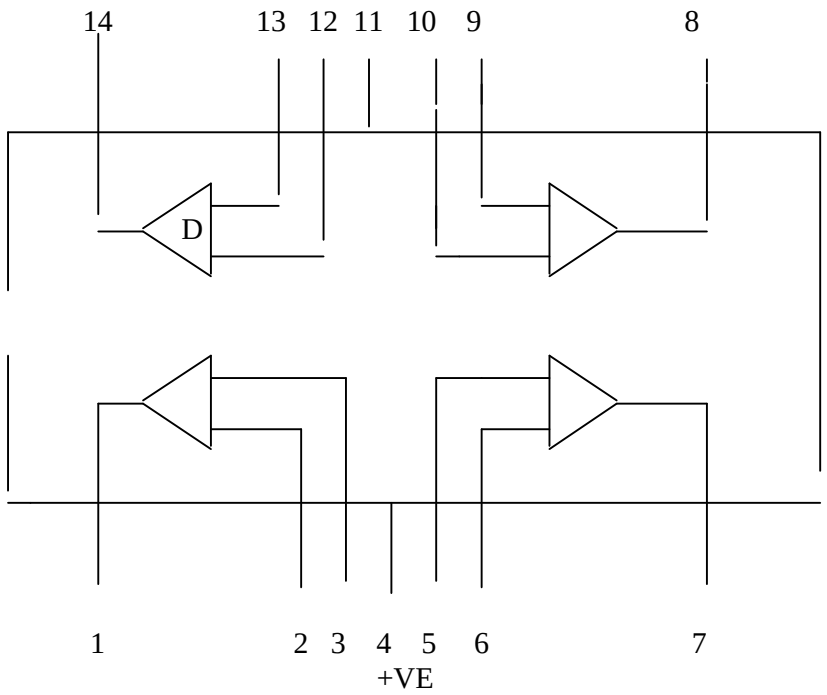
And PIN – 14 →Null Adjustment for ‘A’

OPERATIONAL AMPLIFIER ICs USED IN DIFFERENT PCB’s OF MACHINE

SINGLE OP – AMP:

OP 02
741
OP50
LH0041 CG

PIN DIAGRAM OF OP – AMP – 02:



PIN – 1→ OUTPUT OF ‘A’

PIN – 2 → INPUT OF ‘A’

PIN – 3 → + VE supply

PIN – 5& 6 → INPUT OF ‘B’

PIN - 7 → OUTPUT OF ‘B’

PIN – 8 → OUTPUT OF ‘C’

PIN – 9 & 10 → INPUT OF ‘C’

PIN – 11→ VE SUPPLY

PIN – 12 & 13 → INPUT OF ‘D’

And PIN – 14 → OUTPUT OF ‘D’

Session-17: Electronics Model Room for demonstration of working of Operational Amplifiers in different applications

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-VII: Digital Electronics **Session-18:** Number system i.e. Binary, Decimal, Hexadecimal,Logic Gates and Flip-Flop

---

Digital Electronics

Number Systems: There are four system which are often used in digital circuits. These systems are-

1. **Decimal –** It has a base (or radix) of 10 i.e. It uses 10 different symbols to represent numbers (0,1,2,3,4,5,6,7,8,9)

2. **Binary –** It has a base of 2 i.e. It uses only two different symbols – (0,1)

3. **Octal –** It has a base of 8 i.e. It was 8 different symbols – (0,1,2,3,4,5,6,7)

4. **Hexadecimal –** It has a base of 16 i.e. It uses sixteen different symbols – (0,1,2,3,4,5,6,7,8,9, A, B, C, D, E, F)

Binary system is extensively used by digital system like digital computer.
Hexa decimal number system is particularly suited for Micro Computer/Microprocessor based system.

LOGIC CIRCUITS

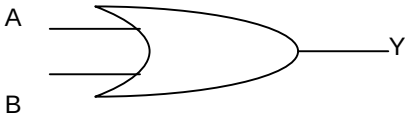
Logic Gates. Are logic circuits which process two or more signals logically. In essence, they are switches. Depending on the input voltage, the gate or switch will be either on or off. Inputs and output have only two stage "o"(Off) or "1"(On).
The first thing to learn about the different gates is their symbols. A logic gate symbol is simply a shorthand way of representing an electronic circuit that operates in a certain way. Understanding the logic symbols can make understanding the operation of a circuit much quicker and easier than if the circuit were represented by showing all the transistors, diodes and resistors .

Name of Gate:-

1. OR GATE.
2. AND GATE
3. NOT GATE
4. EX-OR GATE
5. NOR GATE
6. NAND GATE

1. **OR GATE:-** It has two or more than two inputs and one outputs. If any input is high (1) the output is high.

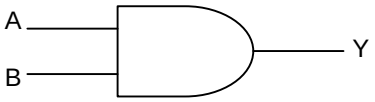
SYMBOL



TRUTH TABLE

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

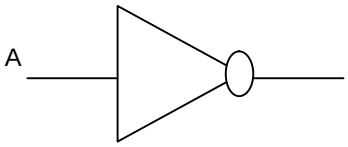
2.**AND GATE:-** It has two or more than two inputs and one out puts. If both the input are high then only the out put is high.



A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

3. NOT GATE: - It has only one input and only one out put. If the input is high then the out put is low and vise versa.

SYMBOL:-



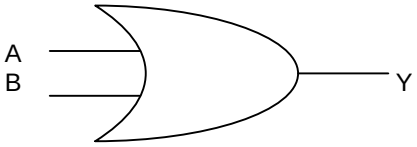
$Y=\overline{A}$

TRUTH TABLE

A	Y
0	1
1	0

4EX-OR GATE: It has two in put and only one out put. If input is different then output is high.

SYMBOL:

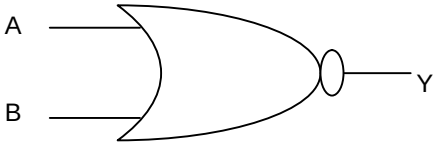


TRUTH TABLE

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

5. **NOR GATE: -** It has two or more then two inputs and one out put. If any input or all input is high then out put is low.

SYMBOL

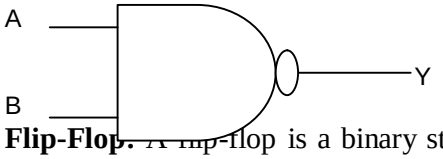


TRUTH TABLE

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

6. **NAND GATE: -** It has two or more than two in puts and one out put. If any or all the input are low then output is high.

SYMBOL

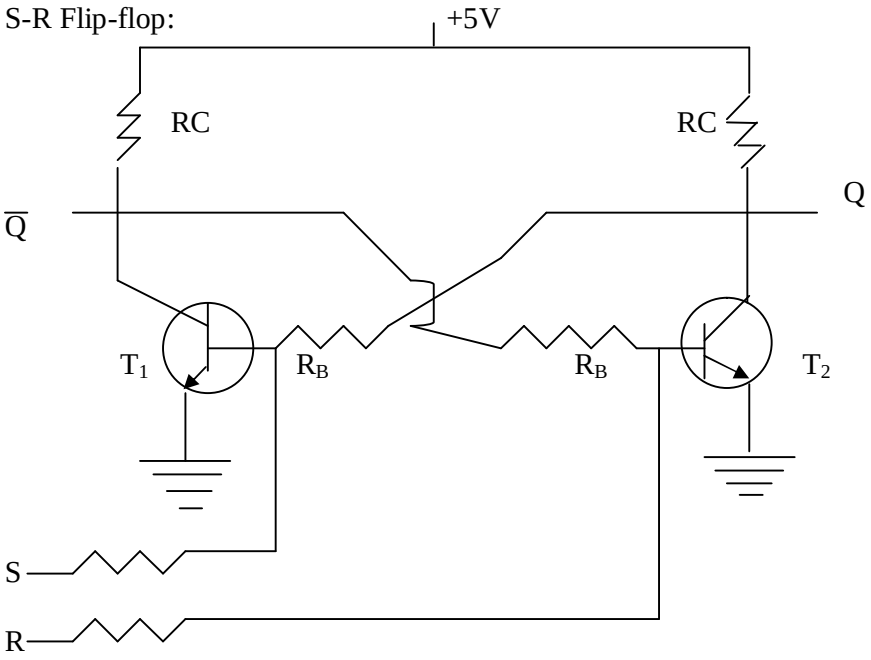


TRUTH TABLE

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Flip-Flop. A flip-flop is a binary storage device. It can store binary bit either 0 or 1. It has two stable states: high and low i.e. 1 and 0. It has the property to remain in one state indefinitely until it is directed by an input signal to switch over to the other state. It is a basic memory element.

S-R Flip-flop:



Truth Table

R	S	Q	Comment
0	**0**	**NC**	**No change**
0	**1**	**1**	**Set**
1	**0**	**1**	**ReSet**
1	**1**	**-**	**Racing**

In this ckt only of transistor is saturated and other is cut-off-suppose that transistor T1 is saturated and hence its collector voltage is approximately 0 volt. Now there is no base drive for transistor T2 so T2 is cut off and its collector voltage is approx +5V. The high collector voltage of T2 produces sufficient base current for T1 therefore T1 remains in saturation. The output is equal to +5V. Thus the circuit stores a binary bit. Similarly when T2 is saturate and T1 is cut off. The output is approx OV. In this condition the circuit stores a binary bit 0.

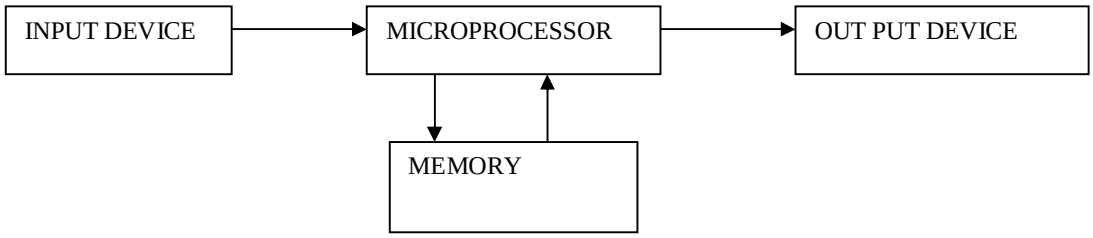
SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-VII: Digital Electronics **Session-19:** Electronics model room for demonstration of working of Logic Gates

Lesson-VII: Digital Electronics **Session-20:** Basic Idea of Microprocessor, Semiconductor memories, Multiplexer

MICROPROCESSOR:-

A CPU built into single chip is called a micro processor. It is latest development in the yield of computer technology. Digital computer whose CPU is microprocessor is called microcomputer. A microprocessor combined with memorial input out put devices forms a micro computer. The micro indicates its physical size, not its computing power.



The first microprocessor was introduced in 1971 by INTEL CO. USA. It was a 4bit microprocessor. 4 bit microprocessor means that the processor makes processing of 4bit data in parallel at a time. The first INDIAN microprocessor is SCL 6502. it is an 8bit Microprocessor Manufactured by Semiconductor Complex Ltd. The Number of bit that a digital computer can process in parallel at a time is called its word length. The Memory addressing capacity of Microprocessor depends on the width of its address Bus. If a Microprocessor has n-bit wide address bus it can directly address 2^n memory locations. Example of Microprocessor such that 8085, 8086, 80186,80286,80486, PENTIUM.

Memory:

The function of memories is to store program data and results. There are two kinds of memory:

1. Semiconductor memories
2. Magnetic Memory

Semiconductor memories are faster, smaller, lighter and consume less power. Semiconductor memories are used as the main memory of a computer.

Magnetic memories are slow but they are cheaper than semiconductor memories. Magnetic memories are used as secondary memory of computer for bulk storage data and information.

1. Semiconductor Memory:

(i) **RAM:** The read and write memory of a computer is popularly known as RAM. It is also called R/W memory. Information's can be read from and written into it during normal operation. It has random access property. RAM stands for random access memory. The RAM is a volatile memory i.e.. It is contents are lost when supply is interrupted.

(ii) **ROM:** It is a read only memory. It is non volatiles. It is used for permanent storage. It has also a random access property. The contents of ROM are decided by manufacturer. Contents are permanently stored in a ROM at the time of manufacturing.

(iii) **PROM:** It is programmable ROM. The contents of PROM are decided by the user. A special equipment for the programming of PROM is called PROM programmer.

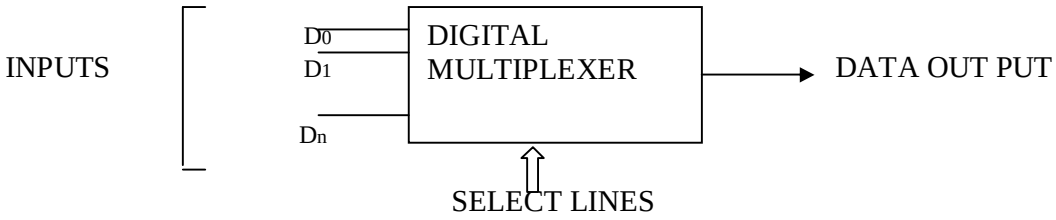
(iv) **EPROM:** It is an erasable PROM. The contents are erased by exposing EPROM to high intensity short were ultra violet light for 10 to 20 minutes. The user can not erase the content of a single memory location. The entire contents are erased.

(v) **E^2PROM:** It is electrically erasable PROM. They need not to be removed from Microcomputer board for erasing. A single byte of data or the entire device can not be erased in about 10MS. Erasing and Programming of E^2PROM is much easier.

2. Magnetic Memory:

Magnetic memories are non volatile. They are slower than semiconductor memory. They are used in computer system mostly for bulk storage. The important types of magnetic memories are: Magnetic Tape, floppy disc, hard disc and magnetic bubble type memory.

DIGITAL MULTIPLEXER/DATA SELECTORS:- A digital Multiplexer has N inputs and only one output. It selects one out of N inputs and makes it available at the out put. It also called data selectors. There are a select logic which decides which input is to be selected.



SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-VIII: Electronic Circuits and PCBs: **Session-21**: Discrete Circuit & Integrated Circuit, Advantage & Disadvantage ,PCBs used in different machines, Description, Name Quantity and their Functions

---

CIRCUITS:- There are two types of circuits :-

(i) Discrete circuit.
(ii) Integrated circuit.

DESCRET CIRCUIT:- In this circuit Electronic Components like resistor, capacitor, diode and Transistors are connected with conductor plate (track) on Printed Plates by soldering.

Advantages:-
(i) Rectification of fault is easy.
(ii) Power rating of ckt is high.
(iii) Manufacturing is easy.

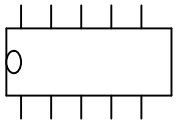
Dis-advantages:-
(i)Costlier than I.C.
(ii)Bulky
(iii)Occupied more space.
(iv) Soldering problem may arise (dry solder).

2. **INTREGRATED CIRCUIT**:- In this circuit all the electronic component except Inductor is connected(constructed) on a silicon chip. The size of component is very small, so this is done with the help of magnifying lens and computer.

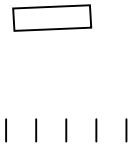
Advantages:-
(i) Cheaper than Discrete circuits
(ii) Light weight.
(iii) Occupied very less space.
(iv) No problem of dry soldering.

Dis advantages:
(i) it is non repairable.
(ii) If any component of an I.C is damaged then I.C has to be replaced.
(iii) Less power carrying capacity.

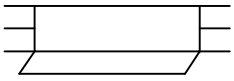
I.C PAKAGING:
(I) dip type(Dual in line pakage) used in our Machine.
(ii) TO TYPE(Top-Hat)
(iii) FLAT TYPE.



(1)

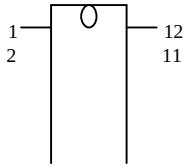


(2)



(3)

I.C SYMBOL: There are consists of either a triangle or a rectangle.



3	10
4	9
5	8
6	7

TERMINAL NUMBERING:-
Anticlockwise from mark position , grooved or nose.

PCBs used in Unomatic/Duomatic

Sl. No.	PCB Part NO.	Function of PCB	Quantity	Location Panel Box No.
1.	EK813 SV00	DC to DC convertor Power supply 24V→±15 & ±10V	4 Nos	B4 B7 B2 1 2 1
2.	EK 16 V 00	Tamping unit UP/DN control.	2 Nos	B2
3.	EK277 LV00	Middle pendulum control	1 No.	B7
4.	EK229 LV00	Track lifting	2 Nos.	B7
5.	EK 79 V00	3- stage lifting Regulator	1 No	B7
6.	EK255 LV00	Auto levelling	1 No	B4
7.	EK217 LV00	Front pendulum control	1 No.	B4
8.	EK 708 A00 or EK 715 A00	DC Marli Motor control For levelling Control	2Nos.	B4
9.	EK335 LV00	Lining control	1 No.	B7
10.	EK290 LV00	Over slew control	1 No	B7
11.	EK 80 LV00	3-stage lining Regulator	1 No.	B7
12.	EK275 LV00	Design lining	1 No.	B4
13.	ELT 631 00	Inter com.	1No.	B4
14.	ELT 1116.00	Semi-auto work	1 No.	B2

P.C.Bs used in 09– CSM

Sl. No.	PCB Part No.	Function of PCB	Quantity	Location Panel Box No.

1.	EK812 SV00	DC to DC convertor 27V→ 24V and 12V	1 No.	B20
2.	EK 813SV00	DC to DC Convertor Power Supply 24V → ± 15V & ±10V	5 Nos.	B4, B6, B10 1 2 2
3.	EK 851SV00	DC to DC converter 24V→ 12 V and 5 V	1 No.	B 19
4.	EK 16 V00	Tamping unit UP /DN control	2 Nos.	B10
5.	EK 24 V00	Satellite control	1No	B10
6.	EK 28 LV00	Multiplexer	1 No.	B6
7.	EK 99V00	Distance simulator	1 No.	B19
8.	EK 100 V00	Auto Positioning	1 No.	B10
9.	EK110 LV00	Pendulum Compensation	1 No.	B6
10.	EK290 LV00	Over slew Control	1No.	B10
11.	EK 319 LV00	Work drive control	1No.	B6
12.	EK 345LV00	Front input	1 No.	B4
13.	EK346 LV00	Pendulum control	1 No.	B6
14.	EK347 LV00	Track lifting	2 Nos.	B6
15.	EK348 LV00	Satellite compensation	1 No.	B10
16.	EK349 LV00	Lining control	1 No.	B10
17.	EK 501 P00	Programmer PCB	1 No.	B20
18.	EK 552 P00	Time Delay	1 No.	B20
19.	EK 553 P00	Programmer input/output	9 Nos.	B20
20	EL-T 631.00	Intercom	1No	B40
21.	VT 3005	Work drive amplifier	1No	On Chasis

LIST OF PCBs USED IN CSM-3X

Sl. No.	PCB Part No.	Function	Quantity	Location Panel Box No.
1.	EK 805 SV00	DC to DC Convertor 24V → +5V	1 No	B20

2.	EK812SV00	DC to DC Convertor 27V→ +24V & +12 V	1 No	B 10
3.	EK 813SV00	DC to DC Convertor 24V → ± 15V,±10V	2 Nos	B6 B10 1 1
4.	EK 816SV00	DC to DC Convertor 24V → ± 15V,±10V & +5V	4 Nos.	B4, B6, B10, B20 1 1 1 1
5.	EL-T7155	DC to DC Convertor 24V → +16V	1 No.	B7
6.	EK2343LV00	Front input	1 No.	B4
7.	EK 2361 LV00	Lining input	1 No.	B10
8.	EK 2140 LV00	Lining output and Over slew	1No.	B10
9.	EK 3069LV00	Track lifting	2 Nos.	B6
10.	EK 2351LV00	Pendulum Control	2 Nos.	B6
11.	EK 526MC00	Micro controller for Satellite compensation	2 Nos	B10 B6 1 1
12.	EK 1AP7	Tamping Unit Control	4 Nos	B6
13.	EK 140V00	Squeezing Control	1 No.	B10
14.	EK 202V	Proportional satellite control	1No	B10
15.	EK2360L00	Drive pump control	1 No	B10
16.	EK 2349LV00	Drive speed display of machine	1 No .	B10
17.	EK 193V	Drive control	1No.	B10
18.	EK 207V00	Multiplexer	2 No.	B10
9.	EK 650 P00	Programmer	1 No	B20
20	EK 651P00	Subroutine	5 No.	B20
21	EK 652 P00	Time Delay	6 No.	B20
22	EK 653 P00	Programmer input/output	28Nos	B30 B31 16 12 17
23	EK654P00	QL (Load Relay)	2Nos	B20
24	EK 658P00	Watch Dog	1 No.	B20
25.	EK 602E 00	Relay Plate	3Nos	B6 B10 2 1
26	EK150V00	Auto Positioning 65cm sleeper	1No	B6

27	EK 2324 LV00	Satellite Lateral Movement	1 No.	B10

PCBs used in Unimat-2S

Sl. No.	PCB Part No.	Function	Quantity	Location Panel Box No.
1.	EK 812 SV00	DC to DC Convertor 24V → + 24V and + 12V	1 No.	B20
2.	EK 813 SV00	DC to DC Convertor 24V → ± 15V&,±10V	4 Nos	B4 B6 B10 1 1 2
3.	EK 132 LV00	Tamping unit UP/DN control	2 Nos	B6
4.	EK 2072 LV00	Front input	1 No.	B4
5.	EK 2038 LV00	Lining control	1 No.	B10
6.	EK 719 A00	D.C Motor Control for Lining chord follow up	1 No.	B10
7.	EK 144 LV00	Hook and 3-stage lining & lifting control	1 No.	B6
8.	EK 2041 LV00	Track lifting (Leveling control)	2 No.	B6
9.	EK 2042 LV00	Pendulum control	1No.	B6
10.	EK 28 LV00	Multiplexer	1 No.	B6
11.	EK 290 LV00	Over-slew Control	1 No.	B10
12.	EK 502 P00	Programmer	1 No.	B20
13.	EK 552 P00	Time Delay	1 No.	B20
14.	EK 553 P00	Input/Output of Programmer	12 No.	B20
15.	EK 554 P00	QL-Relay	5 Nos.	B10
16.	EL-T 631.00	Intercom	1 No.	B40

PCB's used in Unimat - 3S

Sl. No.	PCB Part No.	Function	Quantity	Location Panel Box No
1.	EK 813 SV 00	DC to DC Convertor 24V→ ± 15 V and ± 10V	4 Nos	B4, B6, B10 1 2 1
2.	EK 812 SV00	DC to DC Convertor 24V→ +24V and + 12V	1 No.	B20
3.	EK 2072 LV00	Front input	1 No.	B4

4.	EK 2173 LV00	Lining Inputs control	1 No.	B10
5.	EK 2140 LV00	Lining Output& Over Slew control	1 No.	B10
6.	EK 2041 LV00	Track lifting	2 Nos.	B6
7.	EK 2042 LV00	Pendulum control	1 No.	B6
8.	EK 120 V00	Hook Control	1 No	B6
9.	EK 140 A00	Proportional squeezing	1 No.	B6
10.	EK 132 V02	Tamping Unit UP/DN control	2 Nos.	B6
11.	EK 28 V02	Multiplexer	1 No.	B6
12.	EK 502 P00	Programmer PCB	1 No.	B20
13.	EK 552 P00	Time Delay	1 No.	B20
14.	EK 553 P00	Programmer Input/output	13 Nos.	B20
15.	EK 554 P00	QL-relay	5 Nos.	B10
16.	EL-T 631.00	Inter com.	1 No.	B40

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-IX: Power Supply: **Session-22:** Need of Power supply, Types of power supply, DC to DC Converter & Regulator

---

POWER SUPPLY PCBs:

Power supply source on machine are batteries . Battery give 12 volt output .By connecting two batteries in series we get 24 volt .This 24v is used for starting of engine , to operate the solenoids, to operate the relay, for programmer .These batteries are not capable to supply voltage to all above circuit at same time for longer period . Battery get discharge in short period .It need charging during working for that purpose alternators are provided in machines.

Besides 24volt , ±15V, ±10V,+12V,+5V are also used .

±15V need for operational amplifier supply and calibration potentiometers in PCBs .

±10V is used for transducers and potentiometers in panel box .

+12V is used in programmer PCB .

+5V is used for digital display .

It is not possible to provide separate battery and it' charging arrangement for each supply voltage .

So 24 volt is converted to ±15V , +12v and +5v by DC to DC converters

.DC to DC converters which are used in machine are regulated power supply PCBs .

POWER SUPPLY PCBs USED IN DIFFERENT MACHINES

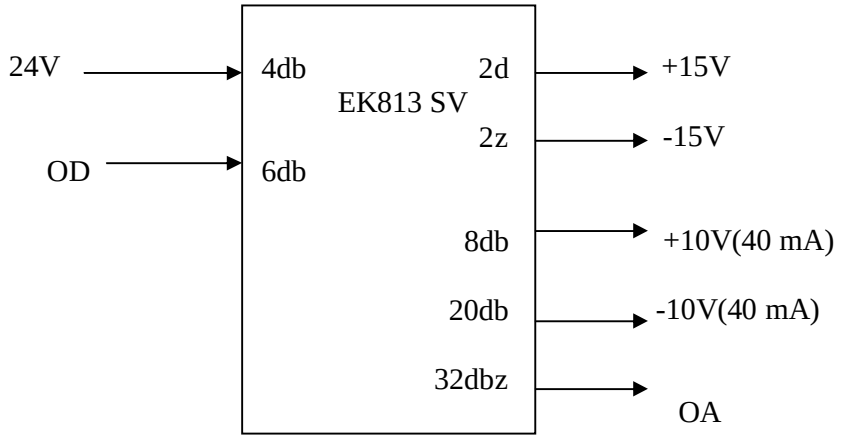
- **PCB EK813SV** :This PCB converts 24v to ±15v &±10v. This PCB is used in Uno/Duo. CSM, Unimat2S/3S,09-3X machines.
- **EK816SV :**This PCB converts 24v to ±15v, ±10v &5v.This PCB is used only in 09-3X machine.
- **EK812SV :**This PCB converts 24v to24v &12v.This is used in CSM/UNIMAT/09-3X/DGS etc.
- **EK851SV :**This PCB converts 24v to 12v & 5v.This PCB is used in CSM.
- **EK805SV :** This PCB converts 24v to 5v.This PCB is used in 09-3X.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-IX: Power Supply: Session-23: Functional description of Power supply PCBs EK813SV, EK816SV, EK851SV, Calibration, Testing & Troubleshooting

---

1. **EK813SV:** This PCB converts +24V DC to ±15V DC and ±10V DC. ± 15V is used for operational amplifier supply and calibration potentiometers in PCBs . ±10V is used for transducers and potentiometers .This PCB mainly consists of a power pack which converts +24v to ± 15v .Then + 15v is converted to 10v by regulator Ic REF 01.Output of REF 01 Ic has less current capacity ie 15mA . So to increase this current to 40 mA current booster circuit is used which has output of +10 v with current capacity of 40mA. Output of REF 01 Ic is converted to --10v(40mA) by inverter and current booster .This PCB consists of two adjustment potentiometers P1 and P2. P1is used to adjust +10v and P2 is used to adjust -10v.There are no arrangement for adjustment of +15v and -15v .
   Note --- As per plasser variation in output of EK813SV is permissible upto ± 150mv .



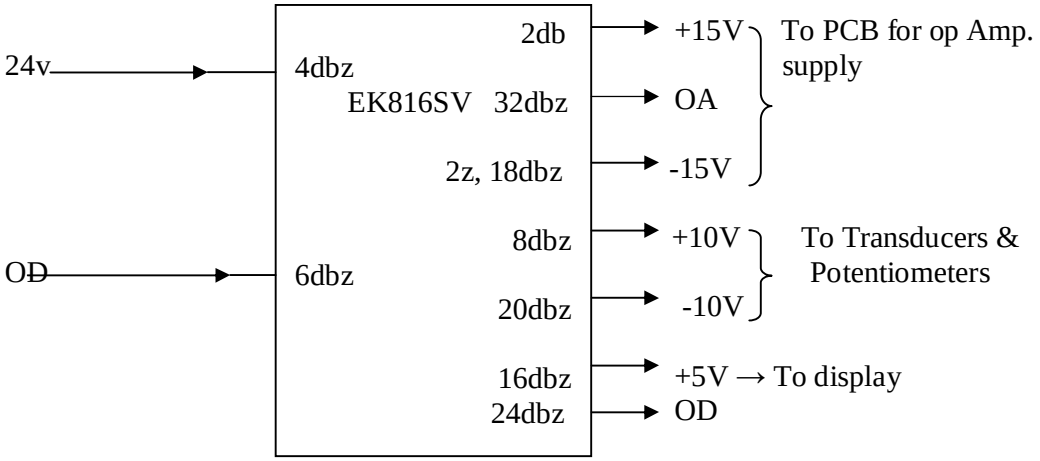
Nos of power supply PCB EK813SV used in CSM
In lining control circuit --- ----------1no
In leveling control circuit ----------1no
In front input circuit ----------1no
In tamping unit and satellite control circuit ---- 1no
In work drive control circuit ---------- 1no
Total---------- 5nos

EK813SV used in CSM-3X ---2nos
EK813SV used in Duomatic----4 nos
EK813SV used in Unimate ----4nos

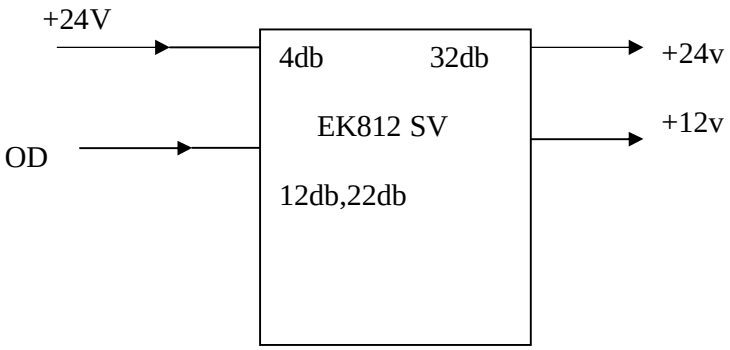
2. **EK 816 SV**: This PCB converts +24V DC to ±15V, ±10V, and +5V. Difference between EK 816 SV and EK 813 SV is that EK 816 SV has an additional output of + 5V for that two power pack are provided in this PCB one power pack converts +24V to ±15V, other power pack converts +24V to +5V . This PCB also has same circuit as in EK813SV.There are also two adjustment potentiometers P1 and P2 in this PCB.P1 for +10v adjustment and P2 for -10v adjustment .There are no adjustment for +15v and -15v.

There are four EK816 SV in CSM-3X.

(1) 20U15 → In Driving control circuit .
(2) 6U1 → In Leveling + pendulum control circuit .
(3) 10U3 → In Lining control circuit.
(4) 4U1 → In Front Input circuit



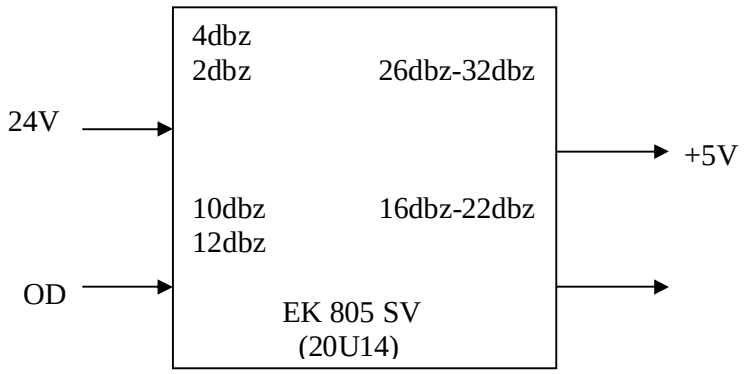
EK 812 SV: This PCB converts + 24V dc to 24V & +12V. This PCB is used for programmer in CSM, Unimat, & DGS. This circuit, supplies the power to Microprocessor at a constant rate of 24V and 12V.The main supply of battery ranges between 24V to 27V, of DC.When battery is fully charged its voltaged goes up to 27V. Also this battery is connected to Alternator when RPM of alternator is 2000, then its output is 27V.But Microprocessor requires + 24V DC at constant rate. The fluctuation in voltage can cause damage to microprocessor IC and other IC's also get affected, for the function of microprocessor +12V is supplied for microprocessor/input/output circuit. This is also done by DC to DC convertor.This circuit is different from EK813SV00 EK851SV00 etc.
Its drawings have not been supplied by the manufacturer.



EK 851 SV:
This PCB converts + 24V dc to +12 & +5V this PCB is used in CSM and unimate.

EK851SV00. This PCB is also DC-TO-DC converter to 12V and 5V. 12V is used for Recorder circuit and 5V is used for digital display. The circuit design of this PCB is different from EK 813SV00. When P type and N type layer is formed in a chip of semiconductor, they form a barrier potential of 0.7v for Si and .3v for Ge. When an external power supply is applied in forward bias then this chip of semiconductor (diode) conducts only when applied voltage overcome this barier voltage. This barrier potential acts as a resistance to drop .7v or.3v depending on semi conductor material. This draw back of PN junction is used to our advantage, in the D.C. to D.C conversion. Because each crystal diode drops .7v (Si). So adding a No. of diodes back to back we can drop the applied voltage to our required voltage. This EK 851SV00 is designed on this principle. In put voltage is 24V DC to 27V DC.
IC's 7812 &7805 are voltage Regulator (+Ve voltage regulator). These IC's keeps the output a constant rated voltage. The input for these IC's 7812 &7805 is max.Volt of 1.5 x rated voltage. Suppose IC No. is 7812,it means, that output of this IC is + 12V.Then input for this IC shout not exceed 12 ×1.5 = 18V. This 18V.input for 7812. + 18V is achieved by dropping the battery voltage by means of connecting back to back of silicon diodes.

EK 805 SV: This PCB converts +24V DC to +5V. This PCB is used in programmer circuit of CSM-3X. There is only one EK 805SV used in CSM-3X .



SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-IX: Power Supply: **Session-24:** Electronics Model Room for demonstration, checking and calibration of PCB EK813SV

There is a 24 position selector switch (18b4) provided along with digital display (18g4). By selecting different position we can do different measurement.
Detail of different positions of selector switch are given below:

Position 1 →DISPL → To use display as volt meter.

With the help of this display we can measure upto ±15V. We can check signals in side the PCB using test prob.

Position 2 →Multiplex→ If we want to use multiplexer PCB EK28V to check output of transducers, input and output of PCBs then selector switch should be on 2nd position.

Position 3 →N51 (-15V)
Position 4 →N50 (+15V)
(-10V)
Position 6 →N52 (+10V)

} Output of power supply PCB EK813SV of Position 5 →N53 leveling circuit.

Position 7 →D51 (-15V)
Position 8 →D50 (+15V)
Position 9 →D53 (-10V)
Position 10 →D52 (+10V)

} Output of power supply PCB EK813SV of driving circuit.

Position 11→ R51 (-15V)
Position 12 →R50 (+15V)
Position 13 →R53 (-10V)
Position 14 →R52 (+10V)

} Output of power supply PCB EK813SV of lining circuit.

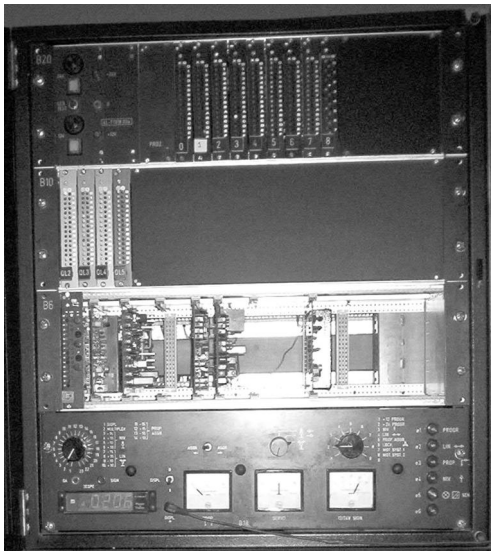
Position 15 →P51 (-15V)
Position 16 →P50 (+15V)
→P53 (-10V)
Position 18 →P52 (+10V)

} Output of power supply PCB EK813SV of Position 17 Tamping control circuit.

Position 19 to 24 → Spare

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-X: Programmer unit and Logic Plan. Session-25: Function and Description of Programmer Unit, Description of different PCBs of Programmer Unit i.e. EK 501P, EK553P



Programmer Unit :

Programmer Unit is the microprocessor based system which is provided in 09-series machines & Unimat, DGS for measuring the various electrical signals and monitoring input and output of microprocessor.

- This unit controls functions of machines.
- This unit consists of Programmer PCB which has Processor & Memory(EPROM). Program of machine is stored in memory
- This PCB receives inputs X(yellow LED),when inputs are same as in Program then outputs command Q(Red LED) are generated to allow the functions.

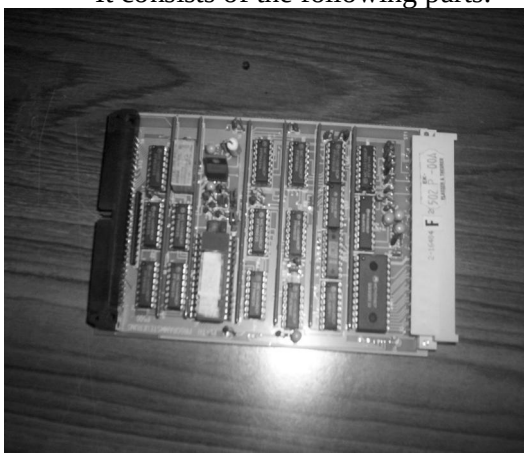
With the help of multi-check we can do-

(i) Monitoring of power supplies of different units.

(ii) Measuring analogue electrical signals coming from different transducers and PCBs.

(iii) Indication of all inputs and outputs of microprocessor in the form of coloured LEDs.

It consists of the following parts:



1. Logic controller or Programmer PCB :

This PCB consists of Processor & EPROM (memory IC). Program of particular machine as per functions is stored in EPROM, this program is different for different machine i.e CSM, CSM-3X, Unimat, DGS,

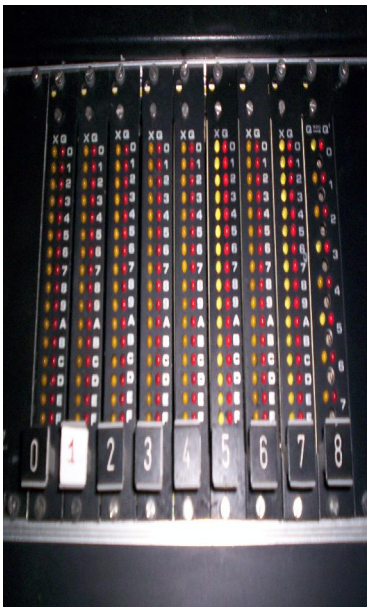
- Programmer PCBs used in different machines

CSM	Unimat	DGS	CSM-3X
EK501P	EK502P	EK503P	EK650P

This programmer is EK 501(CSM) P/EK 502P (UNIMAT) or control unit in the machine which is programmed as per machine functions. It receives input signals and generates output signals as per conditions of Input signal. It consists of mainly microprocessor and EPROM.

Input output PCB (I/0 PCB) EK553P:

X	Q	
O	O	0
O	O	1
O	O	2
O	O	3
O	O	4
O	O	5
O	O	6
O	O	7
O	O	8
O	O	9
O	O	A
O	O	B
O	O	C
O	O	D
O	O	E
O	O	F



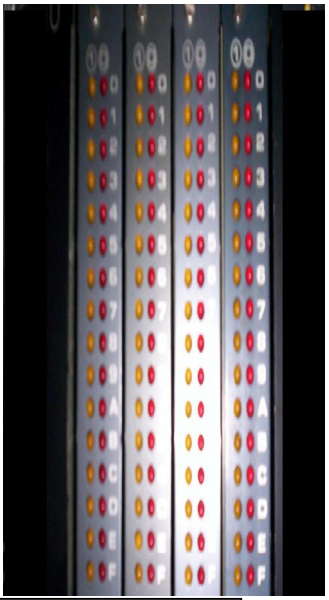
EK553P PCB is Input-Output PCB. This PCB indicates Inputs & Outputs of Processor. I/0 PCB has yellow LEDs with **X** mark which indicates input to Processor and red LED with **Q** mark which indicates output from Processor. Each PCB consists of 16 nos. of yellow & Red LEDs (0 to F).When any input goes to Processor from switch, pedal switch , relay ,sensor, limit switch, transistor then concerning yellow LED glows. When output comes from Processor then red LED glows.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-X: Programmer unit and Logic Plan. **Session-26:** Description of EK554P, EK552P, Different Parts of Logic Plan

---

O	O	
O	O	0
O	O	1
O	O	2
O	O	3
O	O	4
O	O	5
O	O	6
O	O	7
O	O	8
O	O	9
O	O	A
O	O	B
O	O	C
O	O	D
O	O	E
O	O	F



Q		Q^I
O	O	O 0
O	O	O 1
O	O	O 2
O	O	O 3
O	O	O 4
O	O	O 5
O	O	O 6
O	O	O 7

QL Relay PCB EK554P:-

The outputs of I/0 PCB EK553P are only capable to operate small loads i.e. transistors, LEDs. EK553P can not operate solenoids directly.To operate solenoid load relays(QL relay) are used which are provided on PCBs. These PCBs are called QL PCBs EK554P. Output of EK553P operates QL relay in EK554P and QL relay operates solenoids .

Each PCB consists of 16 Nos. of load relays (0 to F) and 8 fuses. Two relays are connected with one fuse. QL PCB also consists of yellow & red LEDs. In normal condition when relay is de-energized then red LED will glow, yellow LED remain off. When relay is energized then yellow LED will glow, red LED becomes OFF. If solenoid connections are open or no connection to QL relay then both yellow and red LED will glow simultaneously.

Time Delay PCB EK 552 P

In the machine in different functions (tamping cycle) certain time delay is required which are provided by time delay PCB EK552P .

Time delay outputs are denoted by Q^1 . This PCB has Eight nos of yellow & red LEDs.

When time starts yellow LED glows, and when time is over then red LED glows. This PCB consists of 8 nos of potentiometers by which time can be adjusted .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-X: Programmer unit and Logic Plan. **Session-27:** Electronics Model Room for demonstration, checking and testing of Programmer unit

---

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-X: Programmer unit and Logic Plan. **Session-28:** Reading of Logic Plan and Input & Output of Programmer with the help of Logic Plan

---

MEANING OF MARKS PRINT ON LOGIC PLAN:

X	-	INPUT TO MICROPROCESSOR (YELLOW LED INDICATION)
Q	-	OUT PUT FROM MICROPROCESSOR (RED LED INDICATION)
Q^1	-	TIME DELAY OUT PUT OF MICROPROCESSOR
QL	-	LOAD RELAY OUTPUT
٧	-	OR
٨	-	AND
___	-	NOT ALLOWED

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-X: Programmer unit and Logic Plan. **Session-29:** Electronics Model Room for demonstration of Logic Plan .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XI: Multi-check/ Multiplexer PCB. **Session-30:** Description of Multi-check PCB EK28V, Different measurements taken by Multi- check PCB.

MULTIPLEXER/Multicheck PCB EK28V:

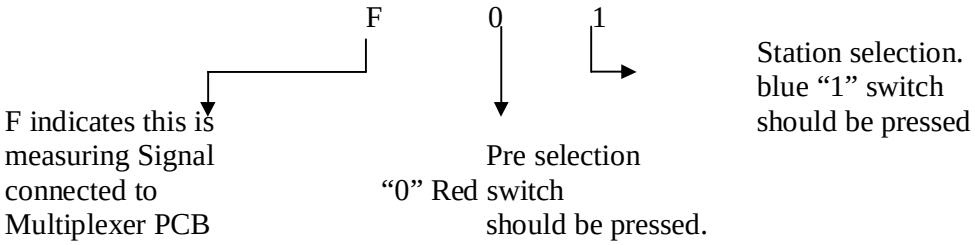
This PCB is used to check, signals of transducers, potentiometers, inputs and outputs of PCBs. This PCBs receives around 28 measuring signals. But this PCB is connected with only one digital display (18g4). Each signal has it's address by feeding address in this PCB we can see that signal in digital voltmeter. For feeding address this PCB consists of three red switch designated as 0, 1, 2. 1 and 2 switch have red LED indication. It also consists 16 small blue switch with yellow LEDs designated as 0 to 9 and A to F.

Signals which are connected with multiplexer PCBs are designated by "F"

METHOD OF USE OF MULTIPLEXER PCB:

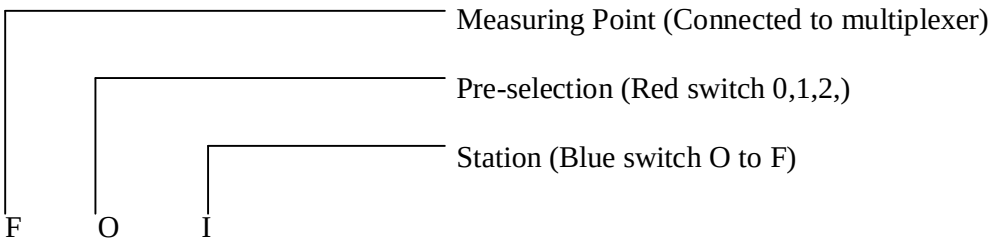
If we want to use the multiplexer PCB EK28V to check signal of transducer or PCB. Multiposition selector switch (18b4) should be on 2nd position, display should be "ON".

Suppose we want to check the signal of lining transducer which address is F01.



(i) First press "0" red switch
(ii) Now press "1" blue switch.
Now signal of lining transducer will appear in digital voltmeter.

MULTICHECK ADDRESS OF DIFFERENT SIGNALS IN CSM



For using multi check, keep selector switch in Panel No. 18 on 2nd position and then feed the address of Transducer signal then signal will display on digital indicator.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XI: Multi-check/ Multiplexer PCB. **Session-31:** Electronics Model Room for demonstration of Multi-check PCB.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/3X /Unimat

Session-32: Functional Description of Tamping Unit Control Circuit, Function and Calibration of Depth Selector and Depth Transducer

---

Functions of tamping Unit Control Circuit :

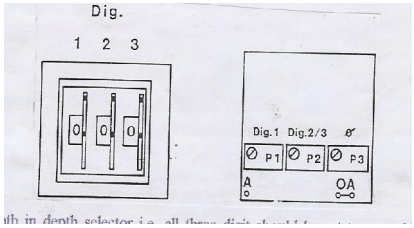
- This circuit controls the UP/DN movement of tamping unit.
- It controls the lowering & lifting speed of tamping unit.
- It controls the target depth of tamping tools.
- It controls the squeezing time.

Tamping Unit Control PCBs in Different Machines

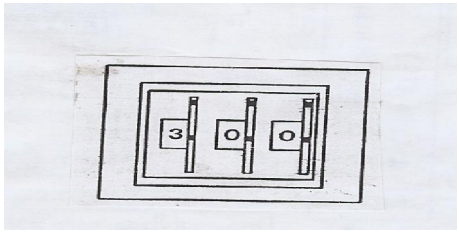
- In UNO/DUO/CSM :-EK 16 V 00.
- In UNIMAT2S/3S :-EK 132V00.
- In 09-3X :-EK 1AP700.
- In New Duo/MPT :-EK 176V00

DEPTH SELECTOR: Before tamping proper tamping depth should be selected. This depth depends upon types of sleepers and rail. Tamping depth is fed in depth selector. Depth selector converts depth to electrical signal at the rate of 25mv/m. This depth selector consists of small PCB. There are three potentiometers in depth selector PCB.P1.P2 and P3. Signal of depth selector can be checked at multicheck address F13.

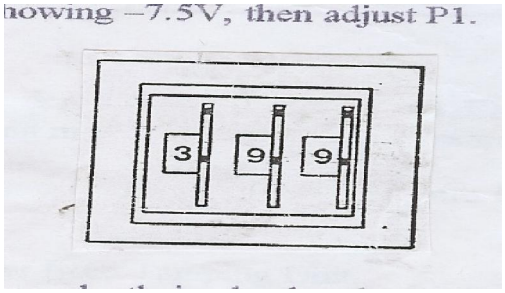
DEPTH SELECTOR CALIBRATION:



(1) Select Zero depth in depth selector i.e. all three digit should be set to zero. Now select multicheck address F13 in multiplex PCB and keep selector switch in 2nd position Now display should read OV. If it is showing some value then adjust potentiometer P3 to get zero volt.



(2) Now select 300 MM depth in depth selector then. Output of selector will be –7.5V if it is not6 showing –7.5V, then adjust P1.



(3) Now select 399m depth in depth selector output of depth selector in display should be –9.975V if it is not, adjust potentiometer P2.

TAMPING DEPTH TRANSUDCER: Tamping depth transducer converts displacement of taping unit to electrical signal at the rate of 19mv/mm. Output signal of this transducer will be –ve if fork is above centre mark of the transducer and it will be +ve if fork is below centre mark. Multicheck address of transducer is F14 (for LH side) and F15 (for RH side). By using these address we can check output of LH or RH transducer.

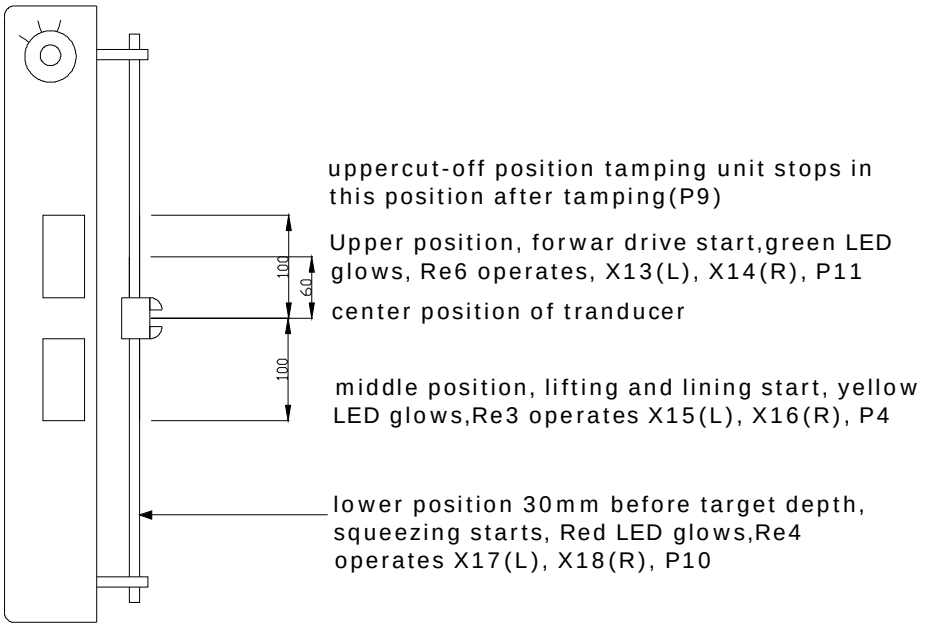
SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/09-3X /Unimat2S&3S

Session-33: Different Positions of Tamping Unit & their Description, Current of Proportional valve

---

Different Positions of Tamping Unit :-



1.Upper Working Position:

The upper break point should be set at approximately 40mm before the upper working position (120mm above the zero point), which and be adjusted by P11 if necessary. At this point, the comparator OP5B switches from high to low illuminating the green LED and energizing relay Re6.

2. Middle Position:

When the tamping banks reaches approximately 100mm below the zero point, the comparator OP10 switches from high to 1cw, energizing relay Re3 and illuminating the yellow L.E.D. contact Re3/2 closes, connecting an earth to input x15 (x16 for the r.h.s.) which can be used to initiate lift and lining.

The point where Re3 energizes can be adjusted by P4, which allows adjustment of ± 260mm about the zero point.

3. Lower Position:

When the tamping banks reach approximately 30mm before the lower position (top of tamping tools 15mm below sleeper), the comparator OP5A switches from low to high

illuminating the red L.E.D. and energizing relay Re4. This point can be adjusted by P10. Contact Re4/2 closes connecting an earth to input x17 (x18 for the r.h.s.) This input is used for automatic squeeze.

Current of Proportional Valve:

To monitor the current drawn by the tamping bank solenoids, there is a gauge fitted with a switch on box 18. By turning the switch 18b3 to position 1, the left hand tamping bank solenoid current is displayed on gauge 18g3. By turning the switch to position 2 the right hand side in monitored position 3 monitors the, satellite proportional current.

by turning switch 18b3 to position 1 or 2, connects the gauge to terminal 10bof 10u6 or 10u7; the other side of the gauge connects to earth. This places the gauge across a 1 ohm resistor (R76) which is measured by the gauge 18g3 which is a voltmeter. Therefore with 750 mA following through the resistor, there will be a volt drop of 750 mV across if which is displayed as a percentage on the gauge 18g3, i.e. 750 mV = 750 mA = 100%.

Current of Proportional Valve in Different Machines

Machines	Lowering Current	Lifting Current	Basic Current
Duomatic/WST/CSM	650mA	600mA	250mA
Uno/Unimat/09-3X/MPT	600mA	550mA	250mA
Calibration Potentiometer	P7	P12	P8

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/09-3X /Unimat2S&3S

Session-34: Functional Description of Tamping Unit control PCBs EK16V, EK132V

TAMPING UNIT (PROPORTIONAL) CONTROL CIRCUIT OF CSM

PRINTED CIRCUIT BOARDS:

10u5	-	power supply board	-	EK 813 SV 002
10u6	-	proportional control 1.h.s.	-	EK 16V-00 (02)
10u7	-	Proportional control r.h.s.	-	EK-16V-00 (02)

TRANSDUCERS:

1f14	-	Depth transducer 1.h.s.
1f15	-	Depth transducer r.h.s.

Switches:

1x10	Tamping bank lowering pedal.
1x11	Working drive pedal
2x19	Tamping system ON
2x1A	Penetration assist OFF
2x27	Auto cycle 1 x position.
2x28	Auto cycle 2 x position.
2b43	Both tamping units manual lift.
51x1D	Only left hand tamping unit.
51x1E	Only right hand handing unit.

FUNCTIONAL DESCRIPTION OF TAMPING UNIT CONTROL PCBS EK16V/ EK132V

The control of the tamping unit with proportional valves should result in:

a) a smooth start of lifting and lowering and
b) an accurate and smooth positioning at the pre-selected top and bottom end position.

1. **Description of the Proportional Valve:**The valve is variable between approx. 250-750 mA. 750 mA means a full deflection, at approx. 250 mA the valve main piston moves to the overlapping zone and the flow becomes zero.
2. **Zero Adjustment:** For the basic adjustment a preset current is set with the potentiometer "P8" which deflects the valve over the overlapping zone a little (approx. 250 mA). With the instruction "tamping and lowering" this full current is immediately available. The returning of the proportional valve to zero (approx. 250 mA) always takes place immediately from any position of the piston when the pre-selected theoretical value is achieved.
3. **Tamping Unit Lowering:** The "theoretical value – tamping depth" is selected with a preset-potentiometer (2f13). A voltage is applied at connection "8b" which corresponds with the required depth. This voltage is also available at output "28z" for a digital instrument.The tamping depth is specified in "mm" below DRL. The zero point is located approx. 1mm below DRL.The signal of the "actual value of the tamping depth transducer" is adjusted with potentiometer "P13" in such a way, that at the output of the amplifier "OP1B(10)" the same voltage (reversed polarity) as at the operational amplifier "OP2B(10)" depth preset (theoretical value) is apparent if the pre-selected depth is reached. 10V represents generally "425mm". The relays Re1, Re2 and Re3 on the printed circuit are always energized if the instruction "tamping unit lowering" (Q11) is received. Because the relay "Re5" is now energized, the theoretical pre-selected depth value is applied to the input of the "OP3B" via "OP2B(10)". Because the tamping unit and therefore the signal "actual value" of the depth transducer corresponds with the top position, a different signal is available at the input of the "OP3B" (R32, R34).This difference signal is transferred to "OP4B" and amplified according to the resistor wiring. By bridging the resistor "R40" the amplification can be changed to the second stage by an external activation (Connection "8d").(First stage, short of the braking reduction of approx. 110mm before 0)

(Second stage, short of the braking reduction of approx. 80 mm before 0)

Therefore a voltage of approx. "-14V" (full deflection) is available at "OP4B(10)", if the instruction "tamping unit lowering" Q11 is received, which drops linear to zero if it approximates the pre-selected depth.

Ramping in: If the proportional valve is de-energized (limit is reached or exceeded) the OP-amplifier "OP6A(12)" is at + 13V. Therefore the amplifier OP7B(10) is at +12V. Together with the instruction "tamping unit lowering" the OP6A(12) is swept back to approx. -14V. Via OP7A acting as a time delay, (time adjustment with P3) there is still a positive voltage (+12V) available at OP7B(10) which is counteracting to the "tamping unit lowering voltage" (-14V) at OP4B(10). Therefore there is no voltage available at the output of OP8A(12) if the instruction "tamping unit lowering" is given… Via OP7A delayed, the counteracting voltage at OP7B is gradually reduced to zero.

In the same way the signal at OP8A(12) is increasing (start of the ramp)

As the preset pre-conduction current, which is adjusted by P8 has already pulled the valve out of the overlapping zone, and increases the deflection of OP8B via the shorting ramp OP8A to maximum.The deflection voltage is converted into a corresponding current via the OP8B(10) and the transistor T1.For this, the current measuring resistor R76 is used. Because this resistor has 1 OHM, the measured voltage corresponds accurately with the according current 0,75V = 0,75A = 750 mA.

Via the relay contact Re2 (energized when "lowering") the current output signal is supplied to the corresponding solenoid valve via the output 28d, tamping banks down.

4. **"Tamping Unit Lowering" Cut Off:**Approaching the pre-selected theoretical depth value, the voltage at OP4B(10) is decreasing gradually and reaches "zero" if the theoretical value and the actual value are balanced. Exactly at zero the OP6A(12) sweeps to positive.
5. **Tamping Unit Lifting:** The procedure when "Lifting" is analogue to the procedure when "Lowering". Instead of the externally adjustable theoretical value (input 6b), a fixed top end theoretical value is preset with the potentiometer P9 at the operational amplifier OP3A(12). At the end of the instruction "Lowering" (="lifting" start) the relay Re5 releases again and transfers the theoretical value for "lifting" to the input of OP3B. Again, the resulting difference voltage to the actual value is amplified at OP4A and in the same way as with lowering transferred to transistor T1. Also the starting ramp is released again.

   But now the proportional valve "lifting" is supplied via the released relay Re2 and connection 28b. The diodes D16 and D17 are damping the peak voltages which occur when the proportional valve is deenergized.
6. **General Notes:** The signal at the output of the OP8(12) is transferred via P7 when lowering, but when lifting via P12. Therefore the maximum deflection during lifting and lowering can be specified individually and individually adjusted.

   Also, by bridging the resistor Re64 during lowering, a second maximum speed can be selected with switch "2b41".The amplification (specification of the start in the decreasing of the speed near the end position) is specified separately by the resistor wiring of the OP4A or OP4B respectively. (B = lowering, A= lifting)

   The adjusting sequence of the starting ramp (integration circuit OP7A) is already carried out in a basic adjustment in the E-workshop, but is also described on the corresponding functional diagram. For this adjustment the toggle switch b1 is required.

   The ramp at the start of "lifting" or "lowering" is preset generally to "200ms" with the potentiometer P3, but it can be adapted to the individual circumstances at any time on the machine. The lifting and lowering of the tamping units should take place smoothly.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/09-3X /Unimat2S&3S

Session-35: Functional Description of Tamping Unit Control PCBs EK1AP7/EK176V,

---

TAMPING UNIT CONTROL CIRCUIT OF 09-3X:CSM-3X can tamp 3-sleeper at a time. CSM-3X is equipped with four tamping units. Two for LH side, two for RH side Movement of tamping unit is controlled through electronic PCB and proportional valve for smooth lowering and lifting of tamping unit and to achieve required target depth . PCB EK1AP7 is provided for each tamping unit. It's mean there are four tamping unit control PCB EK1AP7 and four tamping depth transducer . But there is only one target depth selector which provide target depth to each PCB.Each tamping unit consists of 12 tamping tools so there are 48 Tamping tools in this machine. Tamping unit is mounted in satellite unit .In working mode the machine move continuously whereas satellite unit move in cyclic manner by way of hydraulic travel mechanism of the satellite frame axle bogie. Tamping can be done either fully automatic , semiautomatic or through an operator .When working in curves the tamping units are automatically centred over the rails .

Although there are 4 tamping unit which can tamp. 3-sleepers at a time but we can also tamp one sleeper at a time by stopping movement of two tamping units .There is also a selection for tamping cycle 1X , 2X and 3X(triple tamping in one cycle) .

PCB USED IN TAMPING UNIT CONTROL CIRCUIT.

Tamping unit control PCB - EK1AP7 - 4 nos (6u8 to 6u11)

Squeezing Pressure control PCB - EK 140V - 1no (10u12)
Power Supply PCB - EK 813 SV – 1no (6u12)

TAMPING DEPTH TRANSDUCER: Tamping depth transducer converts displacement of tamping unit to electrical signal at the rate of 11.5mv/mm. This signal will be –ve if tamping unit is above centre position and +ve if tamping unit is below centre position of this transducer **. When tamping unit is lock the output of tamping depth transducer at multicheck address should be –4 v.**

There are four tamping depth transducers one for each tamping Unit.

(i) For LH front tamping unit – 1f14 - Multicheck address **F14**
(ii) For LH rear tamping unit – 1f15 - Multicheck address **F15**
(iii) For RH front tamping unit – 1f16 - Multicheck address **F16**
(iv) For RH rear tamping unit – 1f17 - Multicheck address **F17**

.

TAMPING DEPTH SELECTOR : 2 f 10

Prior to work target tamping depth is selected which depend on rail height and sleeper height . This target depth is fed in depth selector which converts it to electrical signal at the rate of 25mv/mm(-ve).

Multicheck address of depth selector is **F13** where we can check output of depth selector.

PROPORTIONAL VALVE : There are four tamping unit in CSM-3X .One protional valve is used for one tamping unit UP and Down control. So there are four proportional valves used for tamping unit movement . One proportional valve is used for squeezing .

TAMPING UNIT CONTROL PCB IN CS-3X: In CSM-3X for tamping depth control PCB EK 1AP7 is provided. Since there are four tamping units in CSM-3X so for each tamping unit separate PCB and transducer is provided This PCB has different circuit from PCB EK16V(CSM) and EK132V(Unimat).

This PCB is used for smooth lowering and lifting of tamping units and to achieve desired target depth of tamping tools . When target depth is selected and tamping unit is lowered then top of tool blade should go 10-12mm below bottom of PRC sleeper .

Tamping Unit control PCB EK 1AP7 – 4 Nos. (6u8 to 6 u 11)

6u8 – LH Front	6u 9- LH Rear
6u 10- RH Front	6 u 11- RH Rear

FUNCTIONAL DESCRIPTION OF TAMPING UNIT CONTROL PCB EK 1AP7:

This PCB consists of different circuit s which are explain below.

INPUTS TO PCB:-

Tamping depth transducer: This PCB receive signal from tamping depth transducer at 6d terminal at the rate of 11.5mv/mm. This signal will be –ve if tamping unit is above zero position and +ve if tamping unit is below centre position. This signal goes to operational amplifier OP1-A (3) via resistance R1. OP1-A is a buffer, output of OPIA (1) will be same as input. Output of OPI-A(1) is going to OPI-B(6) via R3. OP1-B is the inverting amplifier with gain 2. It will amplify input signal two time. So out put of OP1-B(7) will be at the rate of 23mv/mm.

Output of OP1-B(7) is going to OP1-C (10), which is buffer so output will be same as input. Output of OP1-C(8) is going to OP1-D(13) via R7. OP1-D is inverting amplifier with gain one OP1-D only inverts the polarity of input signal .Output of OP1-D(14) is applied to OP2-A(2) via R10. OP2-A is inverting amplifier which amplify the input signal at the rate of 25 mv/mm**. P13** is used to adjust the gain of this amplifier by which we can adjust output of this amplifier at the rate of 25mv/mm. This is the main input amplifier which gain is adjusted to get target depth of tamping tools. **P1** is for zero adjustment by which we can adjust zero depth position. So output of OP2-A(1) will be at the rate of 25mv/mm, +ve if tamping unit is above zero position of transducer and –ve if tamping unit is below zero position .Output of OP2A(1) is going to different position circuits and to lowering and lifting control circuit of tamping unit. This output is also connected to 6z for display of depth of tamping unit.

Depth selector: Depth selector converts selected depth to electrical signal at the rate of 25mv/mm(-ve).Output of depth selector is applied at 6b terminal of EK 1AP7. From 6b terminal this signal goes to Op3-A via potentiometer **P21** and resistance R34 .OP3-A is the inverting amplifier with gain one, gain is adjusted by P21. If 300mm depth is selected in depth selector then Output of depth selector will be – 7.5V which will apply at 6b. Then output of OP3 -A (1) should be + 7.5V if it is not then it should be adjusted by P21. Output of OP3-A goes to adder OP3-D via resistance R36, relay contact 8&4 of Re8 and resistance R40.Relay Re8 operates during lowering of tamping unit.

THREE POSITIONS OF TAMPING UNIT: During lowering of tamping unit PCB sense three position of it.These three positions are explain below .

Upper working position : After tamping when tamping unit move upwards then it stops at upper working position .There are two upper working position in CSM-3X .Psition-1 and position –2 which are selected by toggle switch .Position –1 is set at 150mm and position-2

is set at 80 mm above zero position of transducer . In PCB OP3-B is used for upper working position.OP3-B is the inverting amplifier . Output of this amplifier is set **to -3.75v** for position-1 by potentiometer **P22** . **–3.75v is equivalent of 150mm at the rate of 25mv/mm**. Output of this amplifier is set to **–2v** for position-2 by potentiometer **P23**. **–2v is equivalent of 80 mm at the rate of 25mv/mm** .Normally P22 is connected to OP3-B through contact 10 &7 of relay Re9 .When toggle switch is shifted to position –2 then microprocessor generate output Q11F which ground the 24d terminal thus Re9 operates ,now contact 7 connects to 12 there for P23 is connected to OP3-B. Output of this amplifier is applied to adder OP3-D via resistance R37 ,contact 6&4 of relay Re8 and resistanceR40.

Upper position indication : Although tamping unit stops at upper working position but PCB sense upper position at 60mm above centre position of transducer .In this position PCB give input to microprocessor for upper position which means that tamping unit has reach in upper position now next tamping cycle should start. A green LED glows in this position in PCB EK1AP7 . This circuit consists of OP2-D, transistor TA-2 and green LED.OP2-D is a comparater

Summing(adder) amplifier : Operational amplifier OP3-D is summing amplifier .During lowering of tamping unit it add signal of tamping depth transducer and signal of depth selector. During lifting of tamping it add signal of transducer and output of OP3-B for upper working position .This is the inverting adder. Output of this adder is going to OP5-D which is the non– inverting amplifier .Gain of this amplifier is adjusted by **P18** for lowering speed and gain is adjusted by **P19** for lifting speed . Selection of these potentiometers is done by Re8 which operate during lowering of tamping unit in this case P18 will be connected to OP5-D through 9 &13 contact. During lifting of tamping unit Re8 will off then P19 is connected to OP5-D through 11 &13 contact .

There is five speed selection provided by selector switch on panel B2 .This switch is connected to different resistance(PCB EL-T6109 2u5) by selecting these resistance which are connected to 8d terminal of this PCB we are changing the gain of OP5-D . When tamping unit is lowered then Output of OP5-D will go to ramp circuit (OP4-A,OP4- B and OP4-C) through 12 &7 contact of Relay Re5 which operate during lowering . During lifting of tamping unit output of OP5-D goes to ramp circuit through OP3-C and contact 4 &8 of relay Re4 which operate during lifting of tamping unit .OP3-C is the inverting amplifier with gain one .

Electrical ramp circuit : For smooth lowering and lifting of tamping unit an electrical ramp generator circuit is provided in this PCB which generate electrical ramp of 200ms in starting of lowering and lifting of tamping unit .In PCB OP4-A ,OP4-B and OP4-C form the ramp circuit .OP4-B is the integrator circuit which has capacitor K14 and two zenor diode ZD1 and ZD2 in feedback. Charging and discharging of K14 form the electrical ramp .Zenor diode ZD1 and ZD2 limit the output of OP4-B(7) to ±10.6v .When tamping unit is in upper working position before starting of lowering of tamping unit , output of OP4-A(1) will be +Vsat(+14v). Integrater OP4-B will be charge it's output voltage will be –10.6v and output voltage of OP4-C(8) will be + 12.2V(set by P5).

When tamping unit lowering command is given by microprocessor then relay Re1,Re3 ,Re5, Re7 and Re8 operate which set lowering circuit in PCB .When PCB receive lowering command then output of OP5-D will be –14v which is available at input of OP4-D(13) and counteracts with the output voltage of OP4-C(8) which is +12.2V. Output of OP4-D (14) is set to zero volt with help of P6 initially when lowering command is given .Therefore initially no voltage is available at the output of OP5-A(1) and OP5-B(7) to operate the transistor T1.Same time output of OP4-A (1) is reversed to –Vsat(-14v) there for integratorOP4-B start discharging(time is set

by P3) and output of OP4-C (+12.2 v) start reducing gradually and output of OP4-D(14) start increasing in same manner . When 12.2v become zero volt then output of OP4-D(14) will be +14v . Reducing time of +12.2 v to 0v is called the ramp which time is set by P3. Output voltage of OP4-D(14) is applied to OP5-B via OP5-A(Inv. Amplifier) and contact

4&8 of Re7 ,R58,R60 and P7.Voltage to OP5-B(6) is converted to appropriate current via transistor by means of current measuring resistor R68. Sice this resistor has a value of 1 Ω ,the voltage measured across it will be equal to current . .75v =.75A =750 mA.

The current output signal is then fed to proportional valve for lowering via relay contact 13 &9 of Re3 , and to proportional for lifting via relay contact 9 & 13 of Re2 during lifting of tamping unit .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/09-3X /Unimat2S&3S

Session-36: Calibration, Testing and Troubleshooting

Calibration/Adjustment Potentiometers in PCB EK16V & EK132V

P1 → Zero depth Adjustment

P4 → Middle position adjustment

P7 → Lowering speed adjustment (Max. lowering current adjustment)

P8 → Basic current adjustment (33% = 250mA)

P9 → Upper cut off point adjustment

P10→ Lower position adjustment

P11→ Upper position adjustment

P12→ Max lifting current adjustment (Lifting speed adjustment)

P13→ Target depth adjustment

Note: P3, P5, P6 potentiometers are used in ramp generator circuit to adjust the ramp. These potentiometers should not be adjusted at site.

Adjustment Potentiometers in PCB EK1AP7 /EK176V

P1 - Zero depth adjustment potentiometer .
P4 - Middle position adjustment (Starting of lifting and lining).
P7 – Maximum current(600mA) adjustment of proportional valve for lowering (Lowering speed adjustment of tamping unit) .
P8 – Minimum current (250mA) adjustment of proportional valve for lowering of tamping unit.
P10 –Lower position adjustment (starting of Squeezing).
P11 – Upper position indication adjustment .
P12 - Maximum current(550mA) adjustment of proportional valve for lifting(Lifting speed adjustment of tamping unit) .
P13 – Target depth adjustment .
P17 - Minimum current (250mA) adjustment of proportional valve for lifting of tamping unit.
P18 – Amplification for tamping unit lowering .
P19 – Amplification for tamping unit lifting .
P21 –Target depth value adjustment .
P22 – Tamping unit upper working position –1 (150mm) adjustment .
P23 - Tamping unit upper working position –2 (80mm) adjustment .

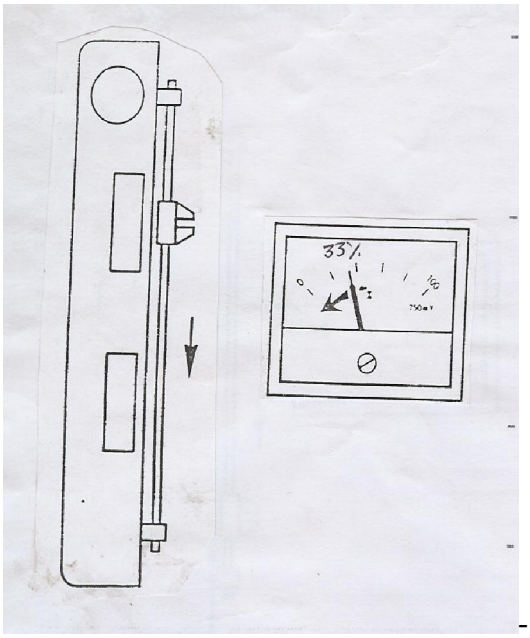
Calibration Procedure Of tamping Unit Circuit of CSM :

For calibration of tamping depth control circuit PCB EK16V. Bring machine on good track. Put machine in working mode i.e. apply Hyd. Pressure, switch on working system.

- Lower the Tamping Unit, and release hydraulic pressure let the Tamping Unit remain in lower position.
- Release the fork of transducer from Tamping Unit.

NOTE: This procedure refers to calibration of the RH Tamping Unit, for LH Tamping Unit same procedure should be adopted.

Basic Current Adjustment:



This current of proportional valve is set at 33% of full scale deflection current i.e. 250mA.

Select 200 mm depth in depth selector select the proportional valve current indicator for RH side tamping unit

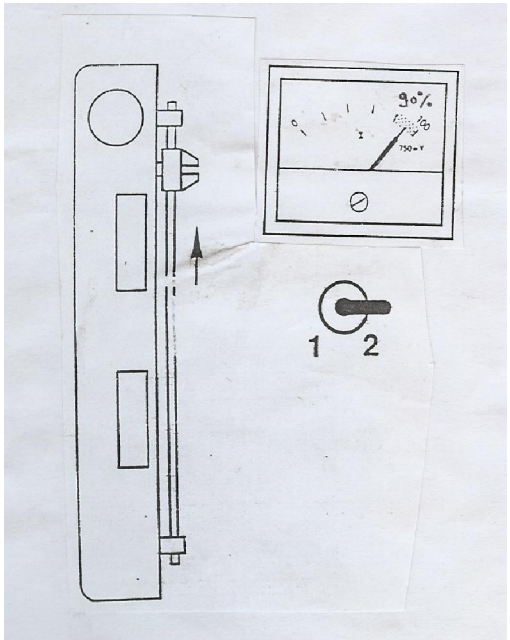
Keep the Taping Unit lowering pedal press

Move fork of Transducer top to down side and watch the deflection of pointer of current indicator. Pointer of proportional current indicator will ove fro Max. to Min. This pointer should drop suddenly at 33% of full scale deflection i.e. 250mA.

If pointer of current indicator is a not dropping suddenly at 33% then adjust P8 in EK 16V.

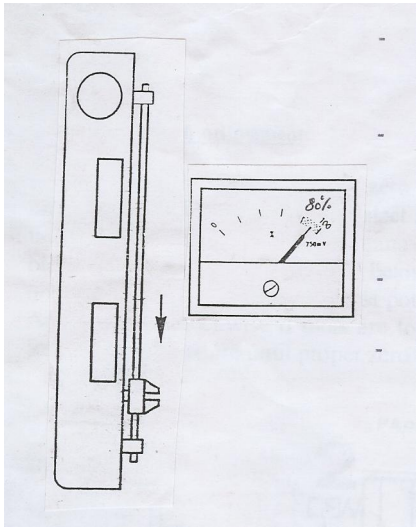
Maximum Taping Unit Lowering Current (Lowering Speed Adjustment:

Maximum current of Proportional valve for Tamping Unit Lowering is set at 67mA or 90% of full scale deflection current.



- Select depth 300mm in depth selector.
- Set toggle switch (High speed) to position.2.
- Keep fork of Tamping depth Transducer fully up.
- Keep lowering pedal press. And watch deflection of current indicator.
- Pointer of current indicator should be at 90% of full deflection.
- If pointer of current indicator is not at 90% then bring pointer at 90% (67mA) by adjusting potentiometer P7 in PCB EK 16V.
- Release Tamping Unit pedal.
- Shift toggle switch to position-I

Maximum Tamping Unit Lifting Current (Lifting Speed) Adjustment:



- Maximum current of proportional valve for Tamping Unit lifting is set at 600mAor 80% of full scale deflection current.
- Tamping pedal should be released (not pressed)
- Keep fork fully down. Watch deflection of current indicator.
- Pointer of current indicator should be at 80% (600mA) of full scale deflection.
- If pointer of current indicator is not at 80% (600mA) then adjust P12 in PCB EK16 to bring pointer at 80% of scale.

Zero Depth Adjustment: For zero depth adjustment, attach fork with tamping unit. Apply hydraulic pressure. Select zero depth in selector. Press tamping unit lowering pedal, lower the tamping unit and measure the tool depth. Top of tool blade should go 10mm to 12mm below rail head as shown in fig. If tool blade is not going at such depth then adjust potentiometer P1 to get 10mm to 12 mm depth. Adjust P1 anticlockwise if tools are too high and clockwise if tools are too low. Repeat this procedure until proper zero depth is achieved.

Target Depth Adjustment: Before tamping, target depth should be Selected. It depends upon type of sleeper and rail. Total depth is calculated by adding rail height, sleeper height and rubber packing. Suppose 60kg. Rail is used where machine is placed for calibration. Total target depth will be 392mm {rail height (176mm)+sleeper height (210mm)+rubber packing (6mm)}.

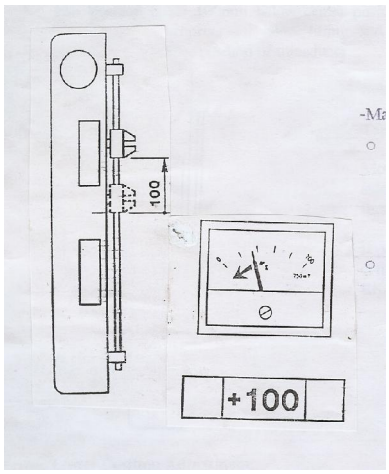
Select 392mm depth in depth selector.

Remove the ballast from sides of sleeper up to bottom.

Lower the tamping Unit by pressing the tamping pedal. Keep it press.

Measure the tool depth below bottom of sleeper. Top of tool blade should go 10mm to 12mm below sleeper bottom as shown in figure. If tool blade is not going at such depth then release the tamping pedal. Adjust potentiometer P13 in PCB EK 16V clockwise if tool blade is too high and adjust P13 anticlockwise if tool blade is too low from sleeper bottom. Again press the tamping pedal and measure the tool depth, repeat this procedure until proper depth is achieved.

Upper Position "Cut Off" Point Adjustment:



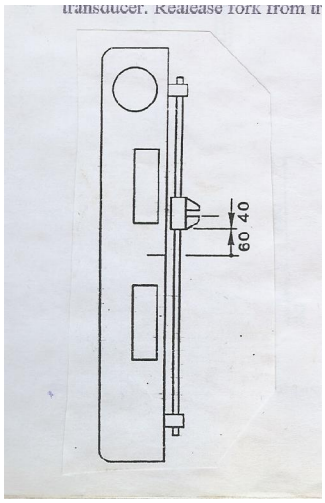
Upper "Cut Off" point is set 100mm above centre position. After Tamping when Tamping Unit comes up it should stop 100mm above centre position of Transducer.

- Mark 100mm above centre position of transducer.

o Press the tamping unit Lowering pedal, lower the tamping unit, when tamping unit Comes up after taping cycle fork should stop at 100mm mark.

o If fork does not stop at 100mm mark then adjust potentiometer P9 in EK16V.

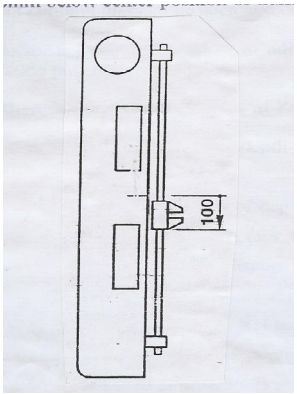
Upper Position Indication Adjustment:Although upper "Cut Off" point is set 100mm above centre position, but PCB EK16V senses upper position of Tamping Unit 60mm above centre position. In this position green LED glows in PCB EK 16V. For calibration of upper position indication, mark 60mm above centre mark of transducer. Release fork from transducer.



- Pedal should be released.

- Move fork of transducer fro centre position to up side when fork reach at 60mm, green LED in PCB EK16V should glow. If it is glowing before or after 60mm then adjust it by potentiometer P11 in PCB Ek16V.

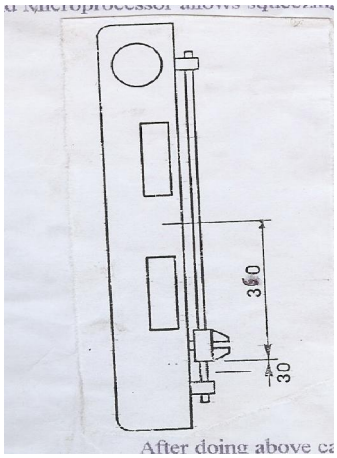
Middle Position Adjustment: This position is set 100mm below centre position. In the position yellow LED glows in PCB EK16V and microprocessor allow lifting and lining. For calibration of this position mark 100mm below centre of transducer.



- Select 300mm depth in depth selector.
- Tamping pedal should be released.
- Move fork of transducer centre position to
  down side as fork reach at 100mm below centre position then yellow LED should glow in PCB EK 16V.

- If yellow LED is glowing before or after 100mm centre position then adjust potentiometer P4 in PCB EK16V.

Lower Position Adjustment: This position is set 30mm before target depth. In this position Red LED glows in PCB EK16V and Microprocessor allows squeezing in this position.



- For calibration of this position select 390mm depth in depth selector and mark 360mm on transducer below centre position.
- Tamping pedal should be released.
- Move fork of transducer fro centre position to down side as fork reach at 360mm, red LED should glow in PCB EK 16V, if Red LED glows before or after 360mm then adjust P10 in PCB EK 16 to glow Red LED at 360mm.

fix fork of Transducer with Tamping Unit.

Calibration of Depth Display: There is a depth display in panel No. 19 in which we can see the depth achieved by Tamping Unit. This display consists of five position selector switch. Selecting 3rd position depth of left hand tamping unit can be seen and on 4th position depth of RH Tamping Unit can be seen.
Selector switch PCB consists of adjustment potentiometer by which we can adjust the display to indicate proper depth.
Adjustment of Depth Display at Zero Depth: For calibration of depth display, Apply hydraulic pressure, select zero depth in depth selector.

- Select 4th position of depth display (for RH tamping unit).
- Lower the tamping unit by pressing the tamping pedal.
- Watch the depth display.
- Display should show zero depth. If it is showing some value then adjust P7 (in depth selector PCB) for RH tamping unit.
- For calibration of depth display for LH tamping unit potentiometer P8 should be adjusted in same PCB.

Adjustment of Depth Display at Target Depth: Select 300mm depth in depth selector. Lower the tamping unit by pressing the tamping pedal and watch display. It should show 300mm. If depth display is not showing 300mm then adjust potentiometer P2 (For RH tamping unit) in depth selector PCB. Potentiometer P3 should be adjusted in same PCB for LH tamping unit.

- Release the Tamping pedal.

After Calibration:

After calibration of RH tamping unit, movement of both tamping unit should be checked during tamping (lowering and lifting of both tamping unit simultaneously). Since there are separate circuit for each tamping unit so it is very difficult that both tamping unit will behave in same manner. So we try to synchronize lowering and lifting movement of both tamping unit as near as possible.

TROUBLE SHOOTING FLOW CHART OF TAMPING UNIT CONTROL CIRCUIT OF CSM.

In starting when tamping cycle 1X is selected and pressing tamping pedal both tamping unit are not going down.

Check lowering command of tamping unit Q10 for (LH) and Q11for (RH) in programmer coming or not when pressing pedal.

Q 10 and Q11 are coming

Check hydraulic system pressure.

Select proportional valve current indicator in panel B18 for LH or RH side and press the pedal if there is no deflection in current indicator then check fuse 2A in EK16V replace it if blown . If fuse is ok then check relay Re-1, Re-2 & Re-5 and replace one by one. Relay Re 2 should be replaced first.

Check voltage +24V at coupler of proportional valve. If there is no +24V on proportional valve then check resistance 7r3 (LH) and 7r4 for RH side.

If +24V is coming on proportional valve now operate proportional valve manually then T /Unit should go down if it is not going down then prop. Valve is defective repair or replace it.

Transistor(BDW 63) in PCB may be defective If this transistor is in spare replace it other wise replace PCB EK16V.

Q10 and Q11 are not coming.

Check circuit breaker (18e3) of tamping unit circuit .check 24v. check power supply pcb EK813SV it's voltage ±15v and ±10v . If output voltage are not coming then check fuse in this pcb replace if blown . if fuse is ok , out put voltage are not coming then replace this PCB .

Check X19 should come in programmer it is tamping system "ON" input .If switch 2X19 is ON but X19 is not coming then this switch may be defective replace it switch.

Check coupler of transducer and slipping of wire replace if broken and calibrate the transducer.

Check 2kΩ resistance in transducer replace it if defective .

Check X10 while pressing the pedal, if X10 is not coming then check pedal switch replace if defective.

B

B

Check X3E should not come in programmer.

It is lining without tamping switch . 2X3E should not "ON"

↓

Check X5A and X5B should not come.These are Tamping Unit lock indication if coming then check limit switch of tamping unit lock , these should be repaired/replaced.

↓

Check X13 for LH side and X14 for RH side coming or not these are upper position indication, if not coming then calibrate upper position in PCB EK16V by potentiometer P11.If no effect of calibration then replace relay Re6 in same PCB

↓

Check X22 should not come in programmer. This is the satellite rear position indication, if it is coming even satellite in front position then repair or replace rear position limit switch.

↓

Check X1B, this is satellite middle position indication .If it is not coming then calibrate it at 340mm by potentiometer P4 in EK24V. If noeffect of calibration then replace relay Re3 in same PCB

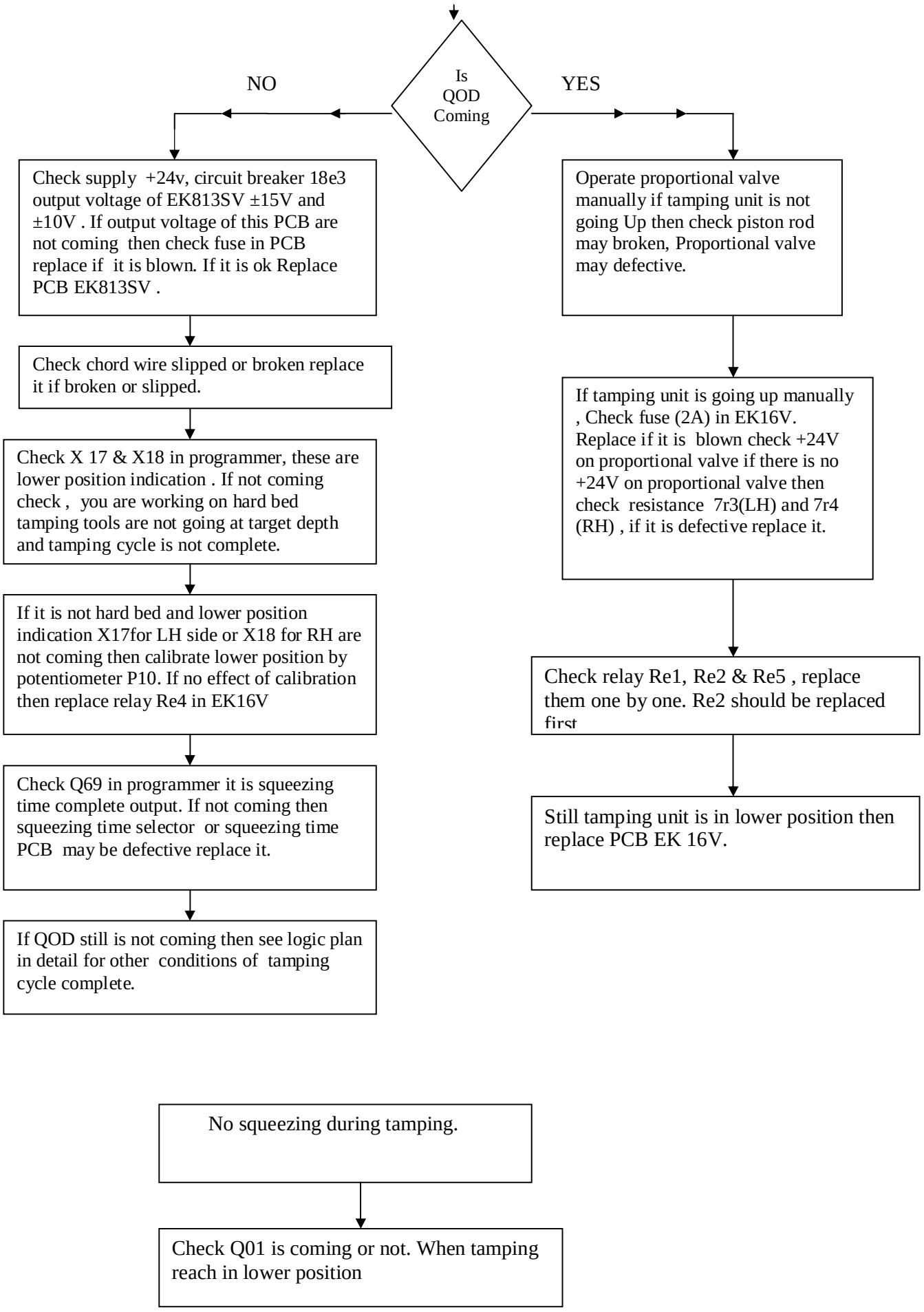
↓

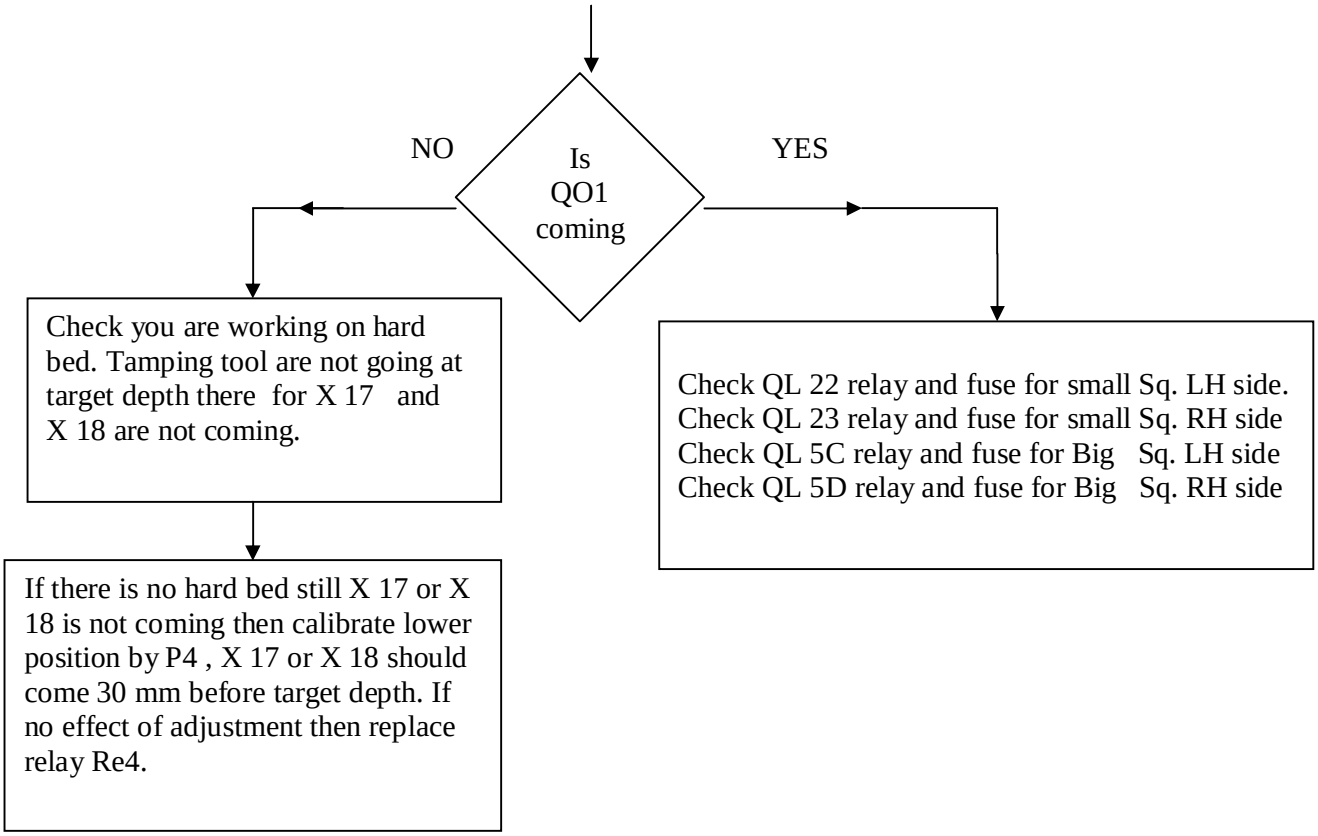
If Q10 and Q11 are still not coming then see Logic plan in detail and check all condition of lowering of tamping unit.

During Tamping , Tamping Unit remain in lower position.

↓

Check **QOD** in programmer , this is tamping cycle complete out put .


Is QOD Coming
NO
YES
Check supply +24v, circuit breaker 18e3 output voltage of EK813SV ±15V and ±10V . If output voltage of this PCB are not coming then check fuse in PCB replace if it is blown. If it is ok Replace PCB EK813SV .
Check chord wire slipped or broken replace it if broken or slipped.
Check X 17 & X18 in programmer, these are lower position indication . If not coming check , you are working on hard bed tamping tools are not going at target depth and tamping cycle is not complete.
If it is not hard bed and lower position indication X17for LH side or X18 for RH are not coming then calibrate lower position by potentiometer P10. If no effect of calibration then replace relay Re4 in EK16V
Check Q69 in programmer it is squeezing time complete output. If not coming then squeezing time selector or squeezing time PCB may be defective replace it.
If QOD still is not coming then see logic plan in detail for other conditions of tamping cycle complete.
Operate proportional valve manually if tamping unit is not going Up then check piston rod may broken, Proportional valve may defective.
If tamping unit is going up manually , Check fuse (2A) in EK16V. Replace if it is blown check +24V on proportional valve if there is no +24V on proportional valve then check resistance 7r3(LH) and 7r4 (RH) , if it is defective replace it.
Check relay Re1, Re2 & Re5 , replace them one by one. Re2 should be replaced first
Still tamping unit is in lower position then replace PCB EK 16V.
No squeezing during tamping.
Check Q01 is coming or not. When tamping reach in lower position



FAULT	CAUSES	REMIDIAL SECTION
Tamping tools are not going at proper depth.	Calibration out.	Calibrate depth transducer calibrate PCB EK16V for zero depth by P1 and for target depth by P13.
Lowering speed slow	Check current of proportional valve for lowering, it should be 650mA.	Calibrate lowering current of proportional valve by P7 in PCB EK16V.
Slow lifting speed.	Check current of proportional valve for lifting, it should be 600mA.	Calibrate lifting current of proportional valve by P12 in PCB EK 16V.

Session-37: Electronics Model Room for demonstration, testing and calibration of Tamping unit PCB

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIII: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-38: Functional Description of Lining Control Circuit and Input Potentiometer (Slew & Versine)

LINING CONTROL PCBs OF DIFFERENT MACHINES

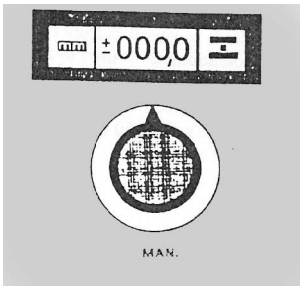
PCBs which are used in lining control circuit in different machines are given below:

CSM:			**UNIMATE 2S:**		
Lining PCB	-	EK 349 LV	Lining PCB	-	EK 2038 LV
Front Input PCB	-	EK 345 LV	Over slew	-	EK 290 LV
Over slew PCB	-	EK 290 LV	Front input	-	EK 2072LV
Power supply PCB	-	EK 813 SV	3-stage Lining	-	EK 144V
Satellite compensation PCB	-	EK348 LV	Power supply	-	EK 813 SV
CSM-3X:			**UNIMATE-3S:**		
Lining input PCB	-	EK 2361 LV	Input Lining PCB	-	EK 2173LV
Lining Output	-	EK 2140LV	Output & overslew PCB	-	EK 2140 LV
& Overslew PCB			Front input PCB	-	EK 2072 LV
Front Input PCB	-	EK 2343 LV	Power supply	-	EK 813 SV
Satellite compensation PCB	-	EK 526 MC	**UNIMAT COMPACT:**		
Power supply PCB	-	EK 816SV	Input Lining PCB	-	EK 1.1/17 LV
DUOMATIC:			Output & over slew PCB	-	EK 2140 LV
Lining PCB	-	EK 335 LV	Front input PCB	-	EK 3049 LV
Overslew PCB	-	EK 290 LV	Power supply	-	EK 813 SV
Front input	-	EK 275 LV			
3-stage Lining	-	EK 80V			
Power Supply	-	EK 813 SV			

(i)VERSINE POTENTIOMETER:

This potentiometer is provided in front cabin in panel B4 .This potentiometer is used to feed versine value in 3-pt lining and Vm value in 4-pt lining . This potentiometer converts versine value to electrical signal at the rate of 50 mv/mm, + vc for RH side, -ve for LH side.

(ii)SLEW POTENTIOMETER :



This potentiometer is also provided in front cabin in panel B4 .This potentiometer is used to feed slew value . It converts slew(Offset value in design lining) value into electrical signal at the rate of 50 mv/mm +ve for RH side and –ve for LH side.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIII: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-39: Functional Description of Lining PCB EK349LV, EK335LV, Basic concept of 3 Point Regulator / 3 Stage Regulator

---

LINING SYSTEM of CSM

Printed Circuit Boards:

4u5	.....	Front Input PCB	.....	EK-345LV-00-(02)
10u1	.....	Satellite Compensation PCB	.....	EK-348LV-00(02)
10u2	.....	Lining Control PCB	.....	EK-349LV-00(02)
10u3	.....	Overslew Control PCB	.....	EK-290LV-00 (02a)
10u4	.....	Power Supply PCB	.....	EK-813SV-002

Transducers:

1f01	.....	Lining Transducers
1f02	.....	Measuring Transducers

Potentiometers:

2f05	.....	Overslew value	.....	20k Ohms
2f24	.....	0 Point Correction	.....	20k Ohms
4f1	.....	Versine Adjustment	.....	10k Ohms
4f4	.....	Slew	.....	10k Ohms

Switches:

2b10	.....	Overslew ON-OFF
2b12	.....	2 Step Lining
2x39	.....	3 Point Lining ON
2x3B/3C	.....	Manual Lining – Left or Right.
2x4E/4F	.....	Datum Left or Rights
4b4	.....	Positive or Negative for Versine Correction.

Description of Lining Control PCB EK-349LV 02:

The inputs from the front system and the transducers on the measuring and lining trolleys are passed to the lining control board 10u2.

Inputs:

Input 1. Satellite Compensation: Due to the machine constantly moving, the relationship between the trolleys will vary and therefore a satellite compensation signal is required. The output of the compensation card at 50 mV/mm (negative for right hand adjustment) from terminal 6z, is fed to 10u2 on terminal 30z (a more detailed explanation is provided later). This signal at 50 mV/mm is passed to the summing line via R14, R18 and P2C.

Input 2. Lining Versine: Not used in 4 point lining, therefore Ov at terminal 20d.

Input 3. Zero Adjustment : In order to correct minor errors in the lining system, a potentiometer 2f24 is provided. The potentiometer is supplied with + and –10 volts from R52

and R53, the signal from the potentiometer is at 2V/mm (negative to the right) can be checked on multiplex F24. This pot is used to do a daily check before work takes place.

The signal passes to 10u2 on terminal 20z to amplifier OP1B (buffer) onto the summing line via P16, R60 and R59.

Input 4. Front Cord Displacement (3 Point): Not used in 4 point, therefore input at terminal 22z – 0v.

Input 5. Front Cord Displacement (4 Point): As previously explained, the offset in the tower by potentiometer 4f4 is fed into P.C.B. 4u5 and onto the compensation board 10u1 on terminal 28b which links to 10u2on terminal 24b. The signal at –50mV (to the right) passes to OP1D (buffer) and onto the summing line via P18 and R56.

Input 6. Curve Correction: When the machine is on a curve, the lining cord is offset downhill due to mechanical forces and therefore needs to the corrected. On a curve with 150mm difference between the high and low rail, the cord is offset by 2mm.

The rear pendulum 1f09, feeds in a signal of 25 mV/mm negative left hand high rail) to P.C.E. 6u5 on terminal 30z which is amplified by OP1D to – 50 mV/mm at terminal 30b. This signal passes to 10u2 on terminal 26d, therefore on a curve of 150mm with left hand rail high, there will be 50 mV x 150 mm = 7.5 volts = 2mm offset correction, which can be checked on multiplex F1E. The signal at 26d passes to OP2A(2) where it is inverted and attenuated by 0.035, and onto the summing line via P19 and R45.

Input 7. Measuring Transducer: The measuring transducer 1fo2 feeds in a signal at terminal 28b of 10u2 at 23.1 mV/mm (positive for movement to the right) which can be checked on multiplex F02. The signal passes to OP2B and OP3A.

With a positive at 28b, the signal passes to OP2B(5) and once the summing line via D13, R37 and P14.With a negative at 28b (movement to the left), the signal passes to OP3A and onto the summing line via 09, R16 and P13.

Input 8. Lining Transducer: The lining transducer 1f01 feeds in a signal at terminal 28d of 10u2 at 23.1mV/mm (negative for movement to the right), which can be checked on multiplex F01. be checked on multiplex F01. The signal passes to OP2D (buffer) and onto OP3C and OP3D. With a positive at terminal 28d (to the left) passes to OP3C and onto the summing line, via D6, R15 and P10. With a negative at terminal 28d, passes to OP3D, and onto the summing line via D5, R20, and P9.

Summing Line: The various signals are adjusted due to the differing value of resistors, and are added together at the summing line. The summing line forms an input to amplifier OP4C (inverting adder) on pin 9. If the track alignment is correct, no slew is required, the signals balance out and the input voltage is zero. Therefore the output voltage from amplifier OP4C is zero.Due to slight errors in the mechanical components in the system, the input signals could contain errors. Therefore two additional signals are connected to the summing line.

1) + 15 volt signal to the summing line via R6 and R7.
2) – 15-volt signal which is adjusted by a fixed resistor and a potentiometer depending on left or right hand pre-load. This is controlled by relay Re3 as follows:

Mode	**Relay Re1**	**Pre-Load**
4 Point	De-energized	Left
4 Point	De-energized	Right

Relay Re3	**Resistor/POT**
De-energized	R13/P8
Energized	R5/P7

The appropriate potentiometer is used to trim the summing line to zero in the respective direction of pre-load to balance the +15 volt signal. This is known as the Dynamic Zero.

Output of OP4C: When the machine moves onto mis-aligned track there will be an input to amplifier OP4C on pin 9 via the summing line. The output of amplifier OP4C pin 8 at 0.5 V/mm (positive for sew to the right) passes to terminal 12d and enters the over slew board 10-u3 (EK-290LV-00) on terminal 30dbz. The signal is inverted and kept at the same magnitude by amplifier OP4B, leaving 10u3 at terminal 4dbz and re-entering 10u2 on terminal 10z. (See recent modes at rear of book).The signal at –0;5 V/mm (for slew to the right), passes to earth via R9(14K) and contact earth via R9(14k) and contact Re4/2. this prevents the signal from passing to the lining servo circuit until it is required, i.e. at start lining signal.

The output of amplifier OP4C at +0.5 V/mm on pin 8, also passes to OP4D(13) which inverts the signal to- 0.5 V/mm (slew to the right) which passes to the galvo 9g2 via R26, R27 and terminal 4z, which indicates the required slew.

Daily Check: The daily check is now carried out, and adjustments made using the 0 point correction pot 2f24 until an even deflection either way on the galvonometer is obtained. The machine is ready to line the track.

Automatic Lining: To start automatic lining, an output Q0A is required which needs the following to be complete:

05^3D[(24^25)vs2F)^(4Ev4F)].

05	=	Lifting & Lining enable (20^OB)v(30^OB^15)v(30^OB^16)
3D	=	Auto Lining on, and
24^25	=	Sensors on, or
2F	=	Sensors off, and
4Ev4F	=	Pre-load to the left, or right.

If all of these inputs are made, the program will be complete for output QOA which earths terminals 28dbz and 16d on the overlsew board 10u3 (EK-290LV-02a).

With the machine selected to line every sleeper, the earth at terminal 28dbz does not affect this circuit. The earth at terminal 16d passes to terminal 18d via the closed contact Re3/1, which links to terminal 16d of the lining control card 10u2. The earth at this terminal connects to the coil of relay Re4, which has a positive supply via terminal 14z, and therefore energizes.

Contact Re4/1 reverses, completing an earth path to relay Rez, which has a positive supply via terminal 4d, causing Re7 to energies. Contact Re7/1 closes, passing the 24 volt supply from terminal 4d volt supply from terminal 4d to terminal 4b which connects to tank bypass solenoid 1s56. Solenoid 1s56 energizes moving the tank bypass valve to the blocked port position hydraulically. The second contact of relay Re4 opens, removing the earth between resistors R9 and R17, allowing the lining signal to pass to the servo valve. The lining signal at 0.5v/mm (negative for slew to the right) is inverted by amplifier OP4B (1:1) and the output passed to the servo amplifier OP4A via the combination of R39 and R32 in parallel with D11 and R33. The signal at +0.5V/mm (for slew to the right), is inverted by OP4A and amplified by approximately 7:1. The output of pin 1 is passed to a potential divider network, which consists of"- P1 (20K), R42 (16K), R52 and due to Re4 being energized R53 (Re4/2 open).

When the slew required is 4m or more, the output of OP4A will be –14 volts (i.e. saturated), which results in –3 volts at pin 2 of OP5. The output of OP5 at pin 5 is approximately – 6 volts which results in a current of 15mA's flowing through the circuit of R44 (100µ), 1s15 (100µ) and returning through R68 (200µ). With 15 mA flowing through the servo valve, the valve allows maximum flow of oil to the lining cylinders which moves the track to the right. As the track moves, the lining trolley which is pre-loaded to the rail, moves with it, reducing the input from the lining transducer. The signal at the summing line reduces and when under 4mm of track movement is required, amplifier OP4A comes out of

saturation. Therefore the current through the servo valve 1s15 reduces.Due to the current reducing in the servo valve, the oil to the lining rams is reduced, slowing down the movement of the track.

When the track has been slewed to the correct position, the summing line will be balanced, resulting in no current flowing through the servo valve. The valve is now, in the null position, i.e. blocked, trapping oil between the servo valve and the lining rams. This maintains the track in the correct position as seen on the lining galvo 9g2, which shows zero slew.

When squeeze has finished, output QOD breaks the program of QOE which in turn breaks the program of QOE which in turn breaks the program of QOB. The loss of output QOB results in breaking the program of QOA. Due to the loss of output QOA, the earth is removed from 10u3, terminals 16d and 28dbz. Therefore removing the earth at terminal 18d, which connects to 10u2.

The loss of the earth at terminal 16d, causes relay Re4 to de-energies, causing relay Re7 to de-energize, ad the tank valve solenoid to de-energize, moving the valve to the parallel port position. With Re4/2 returning to the de-energized position, an earth is placed again between R9 and R17, blocking any signal from passing to the servo circuit.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIII: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-40: Functional Description of EK2038, EK2173 and Over-slew PCB EK290LV

08-275 POINTs AND CROSSING TAMPING MACHINE

LINING SYSTEM:PCBs:

10u1	Power Supply	EK-813SV-002
10u2	Analogue Circuit	EK-2039LV-00(02)
10u3	Overslew Circuit	EK-290LV-00a(02a)
10u4	Rear Cord Follow Up	K-719A-00(02)
4u5	Front Input Interface	EK-2039-LV-00(02)
4u7	Laser Lining Control	EK-715A-00(02)

Switches:

22b1	Overslew On-Iff
22x10	Lining System on & Automatic Start
23x2F	Manual lining to left
23x30	Manual lining to right
22x4B	2 step lining on
22x11	3 point lining on
4b4	Lining versine director

INPUTS:

1f21	Lining versine transducer
1f22	Measuring versine transducer
1f1	Rear cord follow up transducer
22f4	O-correction potentiometer (±5mm)
4f1	Lining adjusting value
4f4	Front cord displacement
22f05	Overslew value

Circuit Description: When the working main switch is turned on terminal 2 is fed at 24 volts. Via circuit breaker 18e2 and terminal R2 printed circuit 10u1 is fed with 24 volts at terminal 4db. The output terminals of 10u1 will be at the following voltages:

8db(R52)	+ 10 volts
20db(R53)	– 10 volts
2d	+ 15 volts
2z	- 15 volts
32db OA earth	

From these five terminals the printed circuits 10u2, 10u3 & 10u4, transducers 1f1, 1f21 & 1f22 and potentiometer 22f24 are fed with the correct voltage.

Six analogue inputs are fed into the analogue control circuit 10u2:

1. Lining Versine: The signal from the lining transducer 1f21 is fed in via terminal 28d at 23mV/mm of displacement, the signal is negative when the transducer is deflected to the right. The voltage can be checked using Multi check F01. From terminal 28d the signal is taken to OP2D(12) via R51, OP2D is wired as a high impedance buffer of gain 1, the signal leaves the output OP2D(14) and passes to amplifiers OP3C(10) and OP3D(12). Due to the use of diodes D5 & D6 OP3C will only accept positive signals and OP3D negative signals. The output from OP3C(10) passes via R5 and P10 to the summing line. The output from OP3D(14) passes via R20 and P9 to the summing line. P9 is used to calibrate the signal to the summing line when the transducer is deflected to the right and P10 when deflected to the lift.

The output from OP2D(14) via terminal 23z is taken to printed circuit 10u4 to control the automatic follow up of the lining cord.

Switch S2 on printed circuit 1pu3 can be used to connect terminal 30b to earth effectively feeding a “zero” into OP2D for calibration purposes.

2. Measuring Versine: The signal from the measuring transducer 1f22 is fed in via terminal 28b at 23mV/mm of displacement, the signal is positive when the transducer is deflected to the right. The voltage can be checked using Multi check F02. From terminal 28b the signal is fed via R49 to OP2B(5) and OP3A(3). Due to the use of diodes D7 & D10 OP2B will only accept negative signals and OP3A positive signals. The output from OP2B(7) passes via R37 and P14 to the summing line. The output from OP3A(1) passes via R16 and P13 to the summing line.When the 4 lining trolleys are in perfect alignment on either straight or curved track and all other inputs are at zero the signals from OP2B and OP3D or OP3A and OP3C balance each other out at the summing line. However, due to the relationship of the trolleys the signal from the measuring trolley will always be smaller than the signal from the measuring trolley will always be smaller than the signal from the lining trolley. Therefore P13 is used to calibrate the correct ratio when the transducers are deflated to the left and P14 when they are deflected to the right.

3. Compensation Input: In order to keep the lining cord in the centre of the machine (see cord follow up) a compensation transducer is fitted to the rear lightening trolley to compensate for the reduced input signal from the lining transducer when the cord has been displaced at the rear.The signal from the compensation transducer 1f1 is fed in via terminal 26z at 23mVm/mm (negative when displaced to right). The voltage can be checked using multicheck F03. The terminal 26z the signal is fed via R50 to OP2C(10) and OP3B(5). Due to the use of diodes D7 & D10 OP2C will only accept positive signals and OP3B negative signals.The output OP2C(8) passes to the summing line via R8 and P12 whilst the output OP3B(7) passes via R19 & P11. P11 is used to calibrate the signal whilst deflected to the right and P12 when deflected to the left.When 3 point lining is selected Re2 will be energized and the inputs to OP2C and OP3B earthed.

4. Zero Correction: Due to the possibility of slight inaccuracies in the lining system a zero correction potentiometer 22f4 is fitted. This can adjust the input signals by upto ±5mm.

The signal from the potentiometer is fed into printed circuit 10u2 at terminal 20z. The signal then goes via R71 to OP1B(5). The output OP1B(7) is fed into the summing line via P16, R60 and R59.Potentiometer P16 is used to calibrate the signal to the summing line.

5. Digital Versine Value: When the machine is sued in the 3 points Lining mode the inputs from the measuring transducer and compensation transducer are grounded by connecting OP2B(5) and OP2C(10) to earth via contacts Re2/1 and Re2/2 which are now closed. The signal from the lining transducer is compared directly with required versine, set by potentiometer 4f1 (see description of front tower).

The signal is fed into printed circuit 102 at terminal 20d at 50mV/mm and can be measured using multicheck F00.From terminal 20d the signal passes to OP1A(3) via R70. The output OP1A(1) goes to the summing line via R63.

6. **Front Card Displacement:**Unlike previous machines the front end of the lining cord is fixed. Fixed point slews are still made in the same manner but the signal is fed into printed circuit 10u2 directly.For4-point lining the displacement signal at terminal E48 is fed into the printed circuit at terminal 24b via the normally closed contact of relay 7u1/B. From terminal 24b the signal passes through R58 to OP1D(12). The output OP1D(14) goes via P18 & R56 to the summing line.

Due to a difference reduction factor for 3 point lining the signal from terminal E48 is fed into printed circuit 10u2 at terminal 22z via the normally open contact of relay 7u1/B (which is energized when 3 point lining is selected).The output OP1C(8) passes via P17 and R55 to the summing line.The values of P18 & R56 (4 point lining) and P17 and R55 (3 point lining) are difference and alter the input of 50mV/m to 311. 5mV/mm (4 point lining) and 159 mV/mm (3 point lining) at the summing line.

Summing Line: The six inputs previously described are connected together at the summing line which forms the input to OP4C(9) which is wired as an "inverting adder".If the track is correctly aligned and no slew is required the inputs balance out and the input voltage is zero. Therefore the output voltage OP4C(8) will be zero.The system can be worked in 3 point or 4 point modes with the trollies preloaded to left or right. Slight errors in the mechanical system will mean that input signals could contain slight errors. Therefore an additional input is fed into the summing line via the contact of Relay Re1. Relay Re1 is energized from program output Q18 when 3 point lining is selected. When right hand preload is selected relay Re3 is energized.

A-15 volt signal is fed to the summing line via the resistors shown in the table below.

Mode	Relay Re1	Preload	Relay Re3	Resistors
3 Point	Energized	Left	De-energized	P6, R3
4 Point	De-energized	Right	Energized	P7, R5
3 Point	Energized	Right	De-energized	P5, R4
4 Point	De-energized	Left	De-energized	P8, E13

The potentiometers are used to trim the summing line to zero in the respective mode. The signal is balanced by a +15 volt signal via R6 & R7.

Output Stage: The output OP4C(8) is taken to terminal 12d and OP4D(13). The signal is now 0.5V/mm (set with P21). The output of oP4D(14) passes through resistors R26 & R2 to terminal 4z and finally to the lining indicators. This signal is negative for a slew to the right.

From terminal 12d the output signal at 0.5mV/mm (slew to right positive) enters the overslew printed circuit 10u3 at terminal 30d. From terminal 30d the signal passes via R33 to OP4B(7). The overslew value enters 10u3 at terminal 6d and via R31 to OP4B(7). If overslew is not selected terminal 6d is connected to earth via switch 22b2. The signal is inverted and the output OP4B(10) is connected to terminal 4d. This terminal is connected to terminal 10z on printed circuit 10u2. This terminal is connected to terminal 10z on printed circuit 10u2. The signal (now negative for slew to right) passes to E9. Unless automatic lining has been selected and the machine is in the correct stage of the working cycle Re4 will be de-energized and the junction of R9 and R17 connected to earth via Re4/2.

If automatic lining has been selected and the machine is in the correct stage of the working cycle program output QOA will be fed to terminals 28d and 16d of 10u3. For normal slew every cycle QPA at terminal 16d passes via the normally contact of Re3 to terminal 18d. This terminal is connected to terminal 16d of 10u2, thus providing an earth path for relay Re4 which no energies contact Re4/2 opens removing the earth from R9/R17.

The signal now passes to OP4B(6) where the signal is inverted again (1:1 ratio slew to right positive). The output OP4B(7) goes via R38 to R39, R32 to OP4A(2). Each side of R38 is connected to terminals 10d & 10b and can be shorted out by switch 22b/1 in order to increase the gain of OP4A. The output OP4A(1) is taken via P1 & R42 to OP5 which is the output amplifier The servo value Is15 is connected in the feed back loop via terminals 6z and 8z. Terminal 6z is negative for a slew to the right.Contact Re4/1 changes over and switches R53 into circuit to increase the servo value current for automatic lining.

Manual Slew to Left: Switch 2x30 is closed, connecting terminal 14d to earth. Relay Re5 now energizes and its contacts reverse. Re5/2 connects a-15 volt signal via Re34 to OP4B(6). The output path from OP4B(7) is the same as for automatic slew.

Lining By Pass Value: The lining by pass value is operated directly from the programme output QL20 which is available providing the conditions for track slew are met.

Over Slew PCB EK290LV: The input to the overslew printed circuit 10u3 at terminal 30d additional charges capacitor K8 via normally closed contact Re5/4. The voltage on K8 is equal to the input voltage (including polarity).

The output voltage at terminal 4d is also used as an input voltage for the two comparators OP3A & OP3B. The reference voltage is determined by R21, R22, R25 and R26 and is approximately – 0.65v for OP3A and + 0.65v for OP3B (approx 1mm of slew required). Should the output from OP4B(10) lie outside – 0.65v and + 0.65v either OP3A or OP3B will switch to an output of +15 volts and in turn will switch TI on.When the automatic lining signal QOA is received at terminal 28d the earth to Re6 will be completed and Re6 will energize and its contact close.

A 24 volt feed is now passed to Re4 coil and contact Re4/1. Due to capacitor K11 Re4 does not energize immediately and Re4/1 stays closed long enough for Re5 to energize – contact Re5/1 closes and retains Re5.The charge on K8 is now connected to OP4A(2) via Re5/3. The output OP4A(12) is connected to terminal 8d. If the overslew is switched on terminal 8d is switched on terminal 8d is connected to terminal 6d via 22f05 and 22b2. When the lining indicator shows zero the overslew value from K8 and OP4A is still present at OP4B(7) . The track is therefore slewed past the zero point until the new signal at 30db cancels the overslew value at 6d and output OP4B(10) is zero.

When the output OP4B(10) approaches zero the comparator OP3A or OP3B switches to –15 volts. Therefore T1 is switched off and Re5 deenergises. OP4A(2) is now fed at zero voltage and hence the input is now zero. Because the track has been overslewed the input 30d is reversed polarity. This causes OP4B(10) to be reversed polarity and the track is slewed back to the zero point.

Two step Lining: The machine has the facility for lining every second working cycle. To enable the machine to line every second cycle switch 22 x 4B must be turned on. The output from the programmer Q19 is made every cycle. When Q19 is on terminal 20d is earthed and relays Re2 & Re3 are energized. At each automatic start signal “Q19” relay Re6 energises (see overslew) and the 24V is also taken to Re1 (1 & 6) and SB1(3). SB1 operates as a flip flap on the first pulse Re1 coil (1 & 12) energises and all contacts reverse. The signal Q19 passes via Re1/3 to terminal 18b. Automatic lining now takes place. As the state of SB1 has now changed the next signal QOA allows Re1 coil (6 & 7) to energise which reverts all contacts to the original state. As Re1/3 is now open QOA signal cannot pass to terminal 22d and automatic lining does not take place. On the next cycle Re1 coil (1 & 12) energises again.

Front Tower Lining:

Digital Input: The direction switch 4b4 has to be correctly set for the direction of the curve. For right hand curves 4b4 connects the digital potentiometer 4f1 to the +10 volt supply and the –10 volt supply for left hand curves. A signal of 50mV/mm (positive for right hand curves) is taken from 4f1 to terminal 8b of 4u5. The signal passes via R72 to OP6C(10). The output OP6C(8) is taken via R31 to OP4D(13) where the inverted signal from OP4D(14) passes to terminal 30d. This terminal is connected to the lining display (4u2) to show the set versine and 10u2 terminal 20d to feed the desired versine into the lining control board.

If the GVA computer is used the output versine from the computer is fed to terminal 20z of 4u5 and via R22 to OP3A(3). The output OP3A(1) passes via R23 to inverter OP3B(6). The zero point of this inverter is set by P7 and the gain by P8. The output OP3B(7) passes via R73 and P21 to OP4D(13) where it is added to the signal from 4f1.

Front Cord Displacement: The front cord displacement is carried out electrically on these machines either by the manual potentiometer 4f4 or the laser potentiometer 1f27. (Laser equipment is not completely fitted but the machine are wired for laser equipment.

The manual signal from 4f4 (50mV/mm positive for displacement to right) is fed into printed circuit 4u5 at terminal 6b via R54 the signal goes to OP5A(3). The output OP5A(1) is taken to terminal 8, and display 4u2(1) to show manual displacement and via R55 to OP5B(6). The laser input from, 1f27 (23, 1mV/mm, negative for displacement to right) is fed into terminal 10d and via R64 to OP6A(3). The output OP6A(1) is taken via R65 to OP6B(6) where the signal is amplified and inverted to 50mV/mm positive for displacement to right. The gain is set by P16 and the zero point by P15. If the laser lining is switched on a 24 volt feed via 4b1 is connected to terminal 2b and energizes Re3. The contact Re3/1 closes and connects output OP6B(7) to input OP5B(6) via R56 thus adding the manual and laser

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIII: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-41: Calibration of Servo Valve, Transducers & Input Potentiometer.

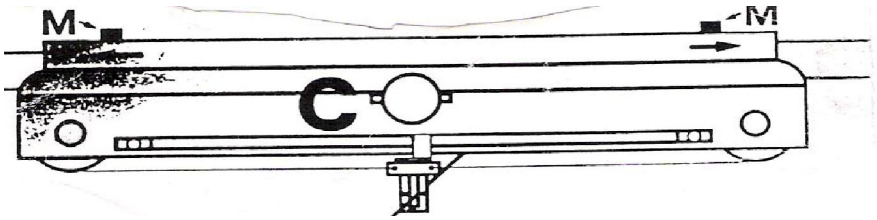
Calibration of Servo Valve: Put machine in working mode.For null adjustment of servo valve remove coupler of servo valve used in lining circuit . Then operate manual lining switch to LH side. In this condition there should be no movement in lining cylinder i.e. lining cylinder should not operate if there is any movement in lining cylinder it's mean null of servo valve is disturb.

To calibrate the servo adjust Allen bolt of servo until movement of cylinder stops.

Now operate the manual lining switch RH side and watch movement of lining cylinder and there should be no movement if there is movement then adjust Allen bolt of servo valve until movement stops.
After null adjustment fit the coupler of servo valve.

Electrical Null adjustment of Servovalve: Put machine in working mode and keep deflection of lining galvanometer on zero keeping fork of lining transducer and measuring transducer at zero lining potentiometer and slew potentiometer should be at zero now operate lining without tamping by pedal switch and watch movement of lining cylinder there should be no movement if there is any movement then adjust P3 in EK349LV until movement stop.

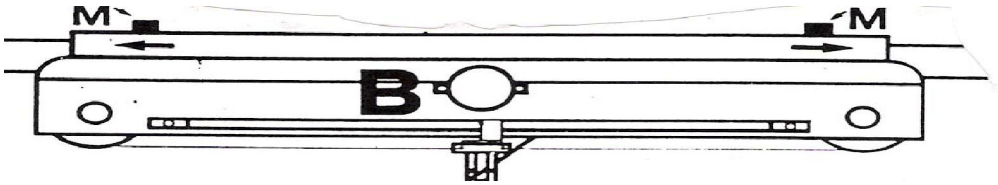
Calibration of Lining Transducer: Lining transducer converts actual versine H1 of track to electrical signal at the rate of 23.1 mv/mm –ve if cord is deflected to RH side and +ve for LH side.



For calibration of lining transducer keep fork of lining transducer at zero lock select **F01** in multicheck then display of multicheck should show 0v, if it is not showing zero volt then loosen the screw of potentiometer and rotate potentiometer to get zero volt . After adjustment tightened the screws of potentiometer.
Before calibration of transducer voltage applied to potentiometer should be checked .It should be +10V and –10V. If there is any variation, then adjust +10v and –10v in EK813SV.

Calibration of Measuring Transducer: Measuring transducer converts **H2** value of versine to electrical signal at the rate of **23.1 mv/mm +ve for RH side and –ve for LH side.**

Calibration procedure of measuring transducer is same as lining transducer but for checking of signal of measuring transducer, multicheck address F02 should be selected and 4 Pt. lining should be ON.



Calibration of Versine Potentiometer(4f1): This potentiometer converts versine value to electrical signal at the rate of 50mv/mm +ve for RH side and –ve for LH side.
For calibration of versine potentiometer select Multicheck address **F00**. Select "0" value in versine potentiometer then output voltage of versine potentiometer should be zero on display. If not , loose the screw of digital counter and take out the counter and now rotate shaft of potentiometer to get zero volt on display. Now set all digits to zero of counter then fit counter on shaft of potentiometer.When voltage of versine potentiometer is checked at multicheck address F00 then polarity will be –ve for RH and +ve for LH side.
Before starting calibration +10V & -10V to this potentiometer should be checked and adjusted by potentiometer P1 & P2 in EK 813SV of front input .

Calibration of Slew Potentiometer(4f4): This potentiometer is provided in front cabin on panel B4.This potentiometer converts slew value to electrical signal at the rate of **50mv/mm** +ve for RH side and –ve for LH side. For calibration of this potentiometer , keep slew potentiometer at zero position then output voltage should be zero, if not then take out the knob of potentiometer then rotate the shaft of potentiometer to get zero volt. Then by matching the knob at zero position fit on shaft of potentiometer. When voltage of slew potentiometer is checked at multichecked address **F06** then polarity will be –ve for RH and +ve for LH side.
Before starting calibration +10V and –10V should be checked . If there is any variation then adjust by P1 & P2 in EK813SV of front input .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIII: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-42: Calibration of Lining PCB, Troubleshooting & Fault finding

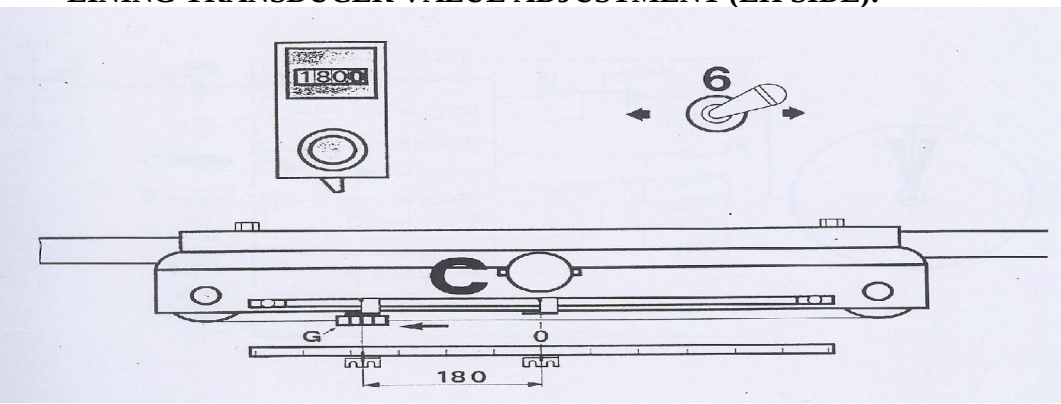
---

CALIBRATION OF LINING PCB EK349LV:

The calibration procedure of EK349LV is explained below:

- Before starting calibration inputs in front cabin slew and versine potentiometer should be kept on zero.
- Zero adjustment potentiometer should keep on zero.
- Satellite should be locked at front zero position.
- Datum potentiometers P5 to P8 should keep at center.

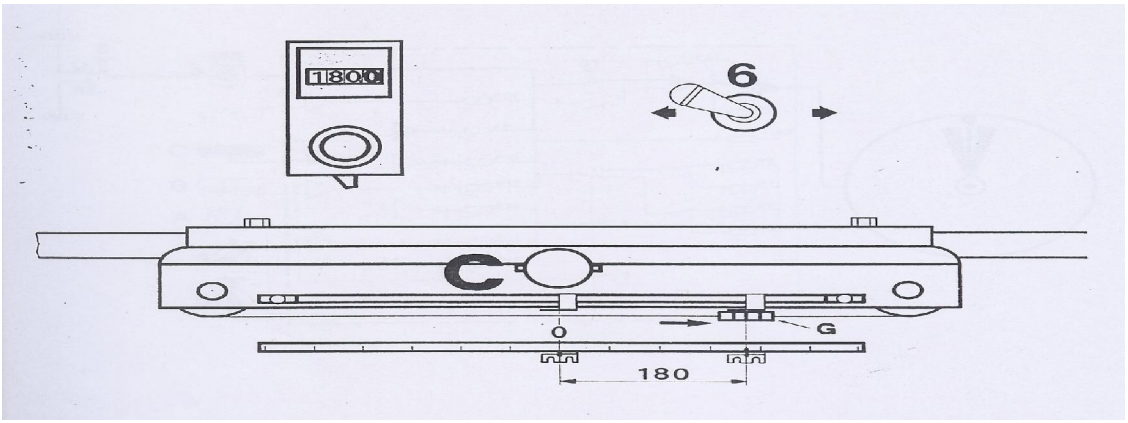
1. LINING TRANSDUCER VALUE ADJUSTMENT (LH SIDE):



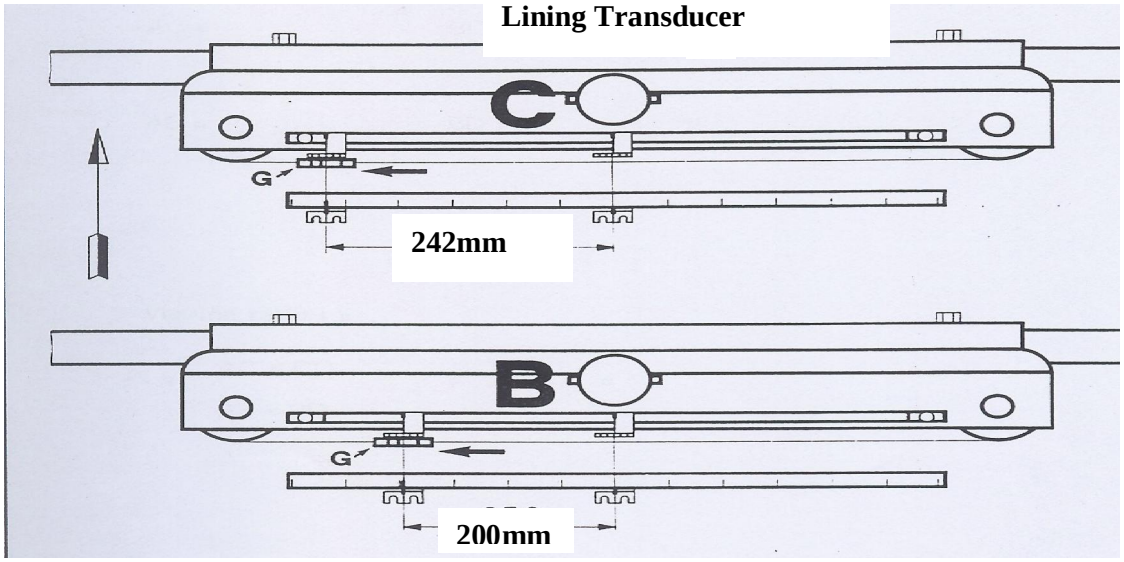
3-point lining should be ON.Set 180 mm Value in versine potentiometer and turn toggle switch to RH side in front cabin.Now keep the fork of lining transducer at 180mm in LH direction. Deflection of lining galvanometer should be zero if not then adjust potentiometer P10 to get pointer of galvanometer at center(zero).

2. LINING TRANSDUCER VALUE ADJUSTMENT (RH SIDE):

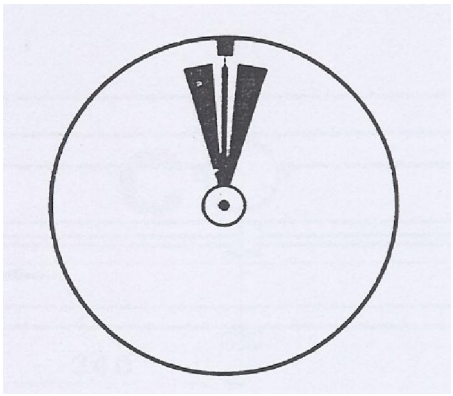
Now turn direction of toggle switch of versine potentiometer towards LH side. Keep fork at 180mm in RH direction then deflection of pointer should be zero if pointer is not at zero then adjust by P9 to get deflection of pointer at center(zero)



3. VERSINE RATIO ADJUSTMENT (LH SIDE):



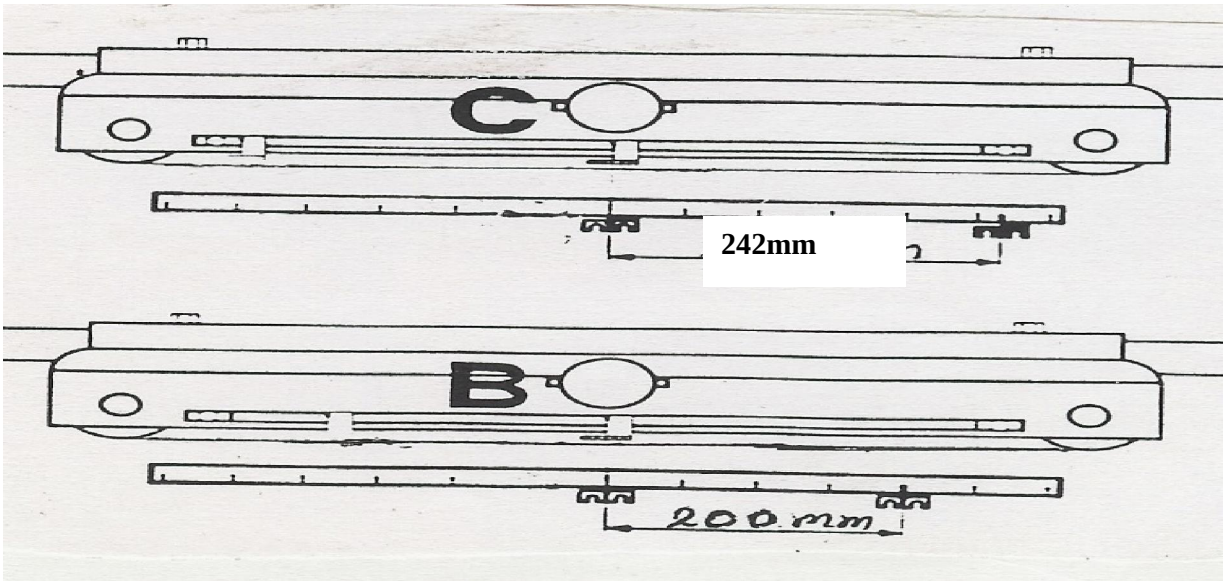
Meas



VERSINE RATIO ADJUSTMENT (RH SIDE):

Select 4- point lining.

- Move fork of measuring transducer LH side and keep at 200mm
- (H_2 = 200mm)
- Now keep fork of lining transducer at 242mm in same direction .
- (H1 = ixH2)
- (H_1 = 1,21 x 200 = 242mm)

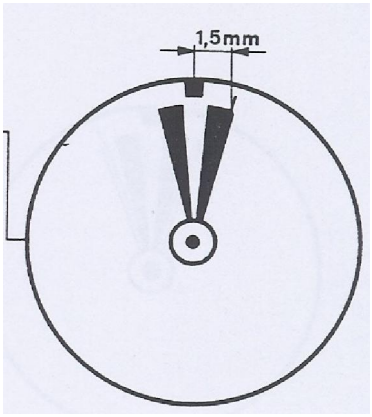


- Move fork of measuring transducer RH side and keep at 200mm.
- Now move fork of lining transducer and keep at 242mm in same direction.
- In this condition deflection of galvanometer should be at center, if not adjust P14 to get deflection at center.

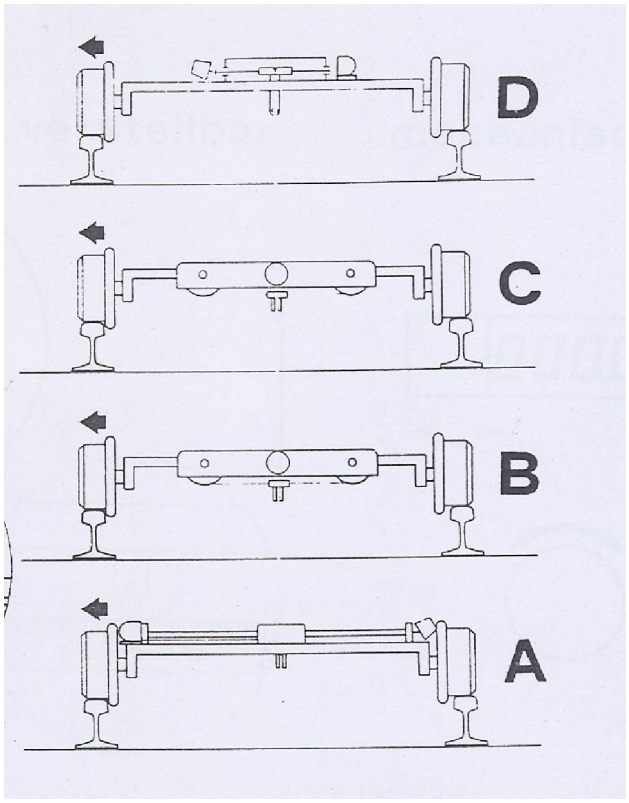
ZERO ADJUSTMENT POTENTIOMETER CALIBRATION: For calibration of zero adjustment potentiometer (2f24) turn it anti clock wise (Red zone) upto 5mm. Now feed 5mm in versine potentiometer and turn toggle switch to left side. Lining galvanometer should indicate zero. If pointer is not at center then adjust **P16**. Untill galvanometer indicate zero.

LINING GALVANOMETER POINTER DEFLECTION ADJUSTMENT:

Feed 1.5mm in versine digital potentiometer and turn toggle switch to LH direction. Now adjust potentiometer **P4** to move pointer to the end of the right side red zone.

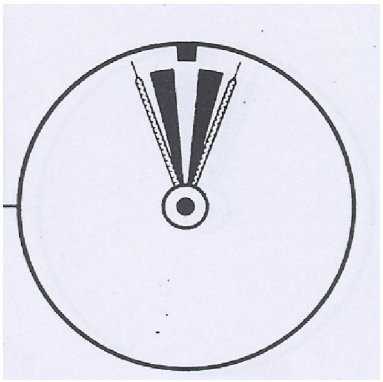


DATUM ADJUSTMENT:



After above all calibration datum adjustment should be done. In which we compensate the small error due to wear & tear of wheels of different trolleys, i.e. lining trolley measuring trolley etc.

During working datum has to be applied LH side or RH side. So both side datum adjustment should be done one by one in 3- point and 4 -point lining.



LH DATUM ADJUSTMENT: For datum adjustment machine should be bring on good track put machine in working mode in 4- point lining and apply LH side datum and move machine forward and watch deflection of lining galvanometers. Pointer of galvanometer should be deflect around zero. If there is only one side deflection then potentiometer **P8** in PCB EK 349LV should be adjusted to get proper deflection of pointer around zero.

Now select 3- point lining in same datum and move machine then in this case pointer should deflect around zero if it is one side deflection then adjust **P6** to get proper deflection of pointer around zero.

RH DATUM ADJUSTMENT: Now apply RH datum and select 4 point lining. Now move machine and watch deflection of pointer. It should deflect l around zero if not adjust **P7** to get proper deflection around zero.Now select 3-point lining. Now move machine and watch deflection of pointer. It should deflect around zero if not adjust **P5** to get proper deflection around zero.

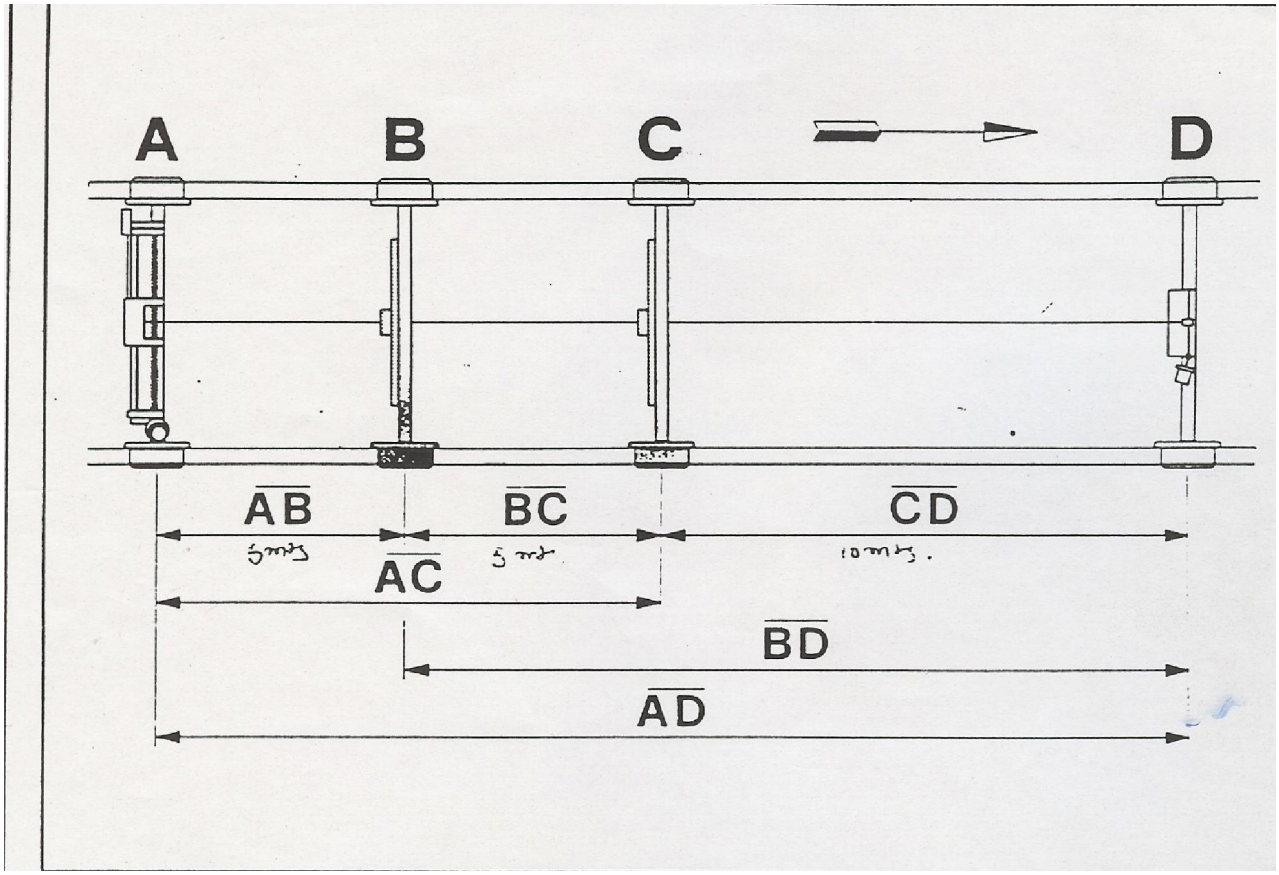
CURVE CORRECTION: For curve correction adjustment machine should be bring on high cant curve i.e. 150mm. (LH high) select-3-point lining. Apply Datum accordingly and feed value in versine potentiometer to get zero deflection of lining galvanometer . Now feed 2mm in zero adjustment potentiometer anti clock wise (Red zero) in this case pointer of lining galvanometer will deflect. Now bring it to zero by adjusting potentiometer **P19** in EK349LV.

MECHANICAL ADJUSTMENT OF BOGIES:

08-series and 09-series Machines are equipped with single cord lining system. Machine can work in 3-point mode and 4 point mode.

In CSM and 08-series machines in 3-point lining. three trolleys are used and in 4 -point lining 4 trolleys are used.

DISTANCE BETWEEN DIFFERENT TROLLIES OF CSM:



CSM:

AD	=	$20.75M_1$	CD	=	10.15M
AC	=	10.5M	BC	=	4M
AB	=	6M	BD	=	14.75M

$$H_1 = \frac{AC \times CD}{2R}$$

$$H_2 = \frac{AB \times BD}{2R}$$

$$\text{Versine Ratio } i = \frac{H_1}{H_2} = \frac{AC \times CD}{AB \times BD} = \frac{10.6 \times 10.15}{6 \times 14.75}$$

i = 1.2157

Versine ratio depends upon distance between bogies since these.

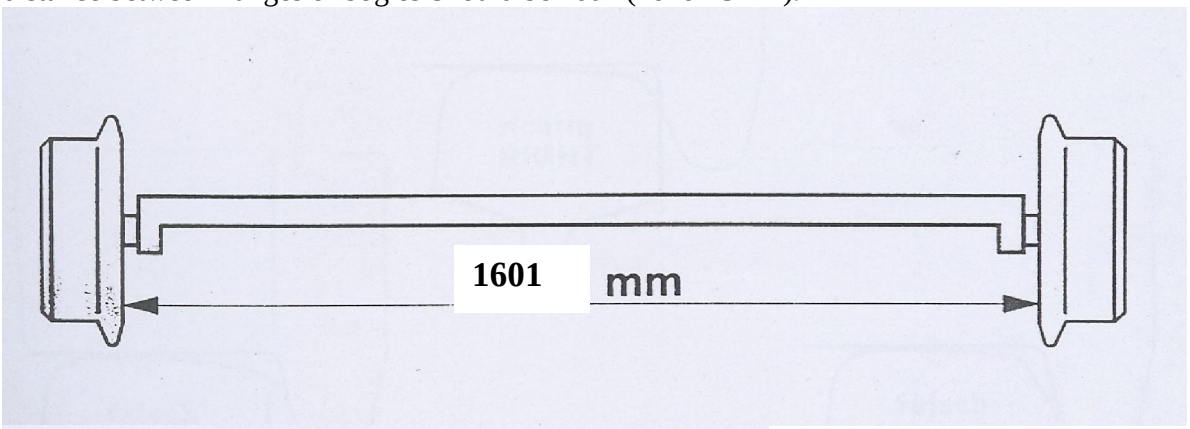
Distance are different for different machine therefore versine ratio is also different for different machines.

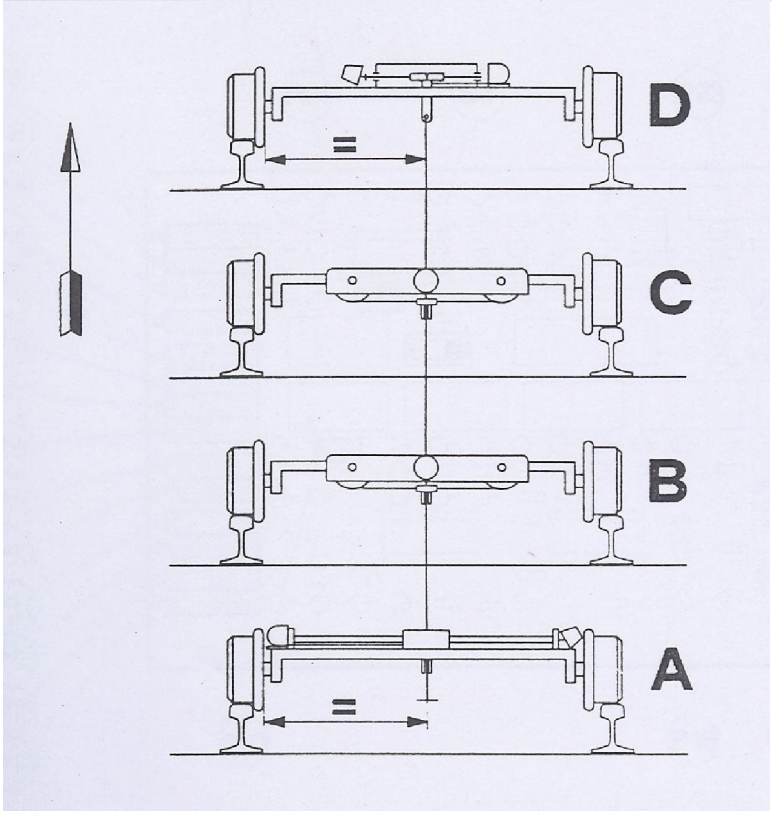
UNOMATIC/DUOMATIC: i = 1.33

UNIMAT 2S: i = 1.33
UNIMAT – 3S : i = 1.6
CSM-3X: i = 1.49

DISTANCE BETWEEN FLANGES OF WHEELS OF BOGIES:

Distance between flanges should be gauge-75mm since broad gauge is 1676mm. Therefore distance between flanges of bogies Should be 1601 (1676-75mm).





Since distance between flanges of bogies Should is1601 (So Centre of these bogies should be at 800.5mm .

So in front bogie and rear bogie lining chord should be fix at 800.1mm from flange . Centre position of lining transducer and measuring transducer should be at 800.5mm from flange of bogies .

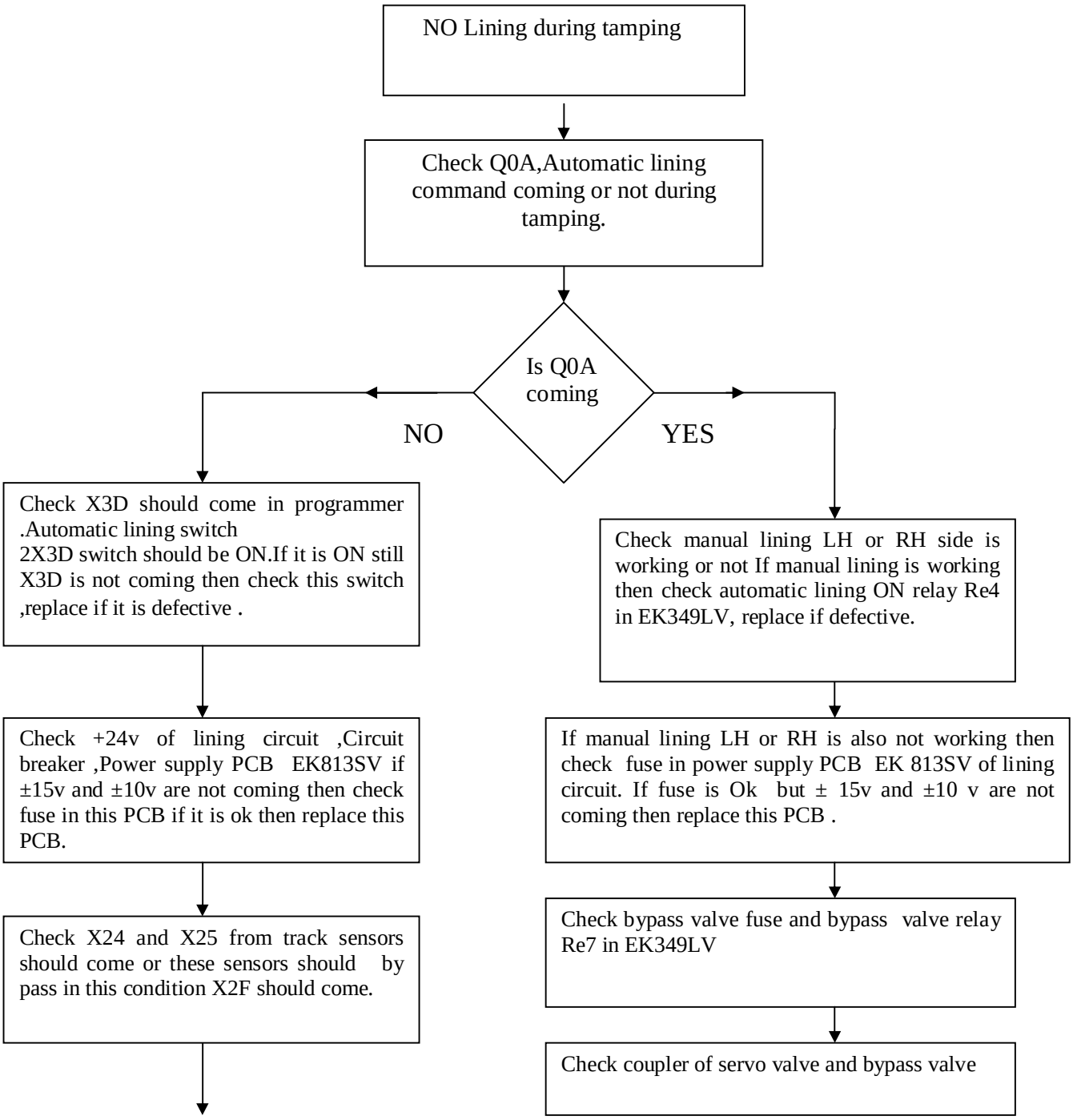
If there is variation in distance (1601)mm between flange of wheels then shim should be provided in wheels two maintain this distance.

This distance should be maintain in all bogies.

.

MECHANICAL ADJUSTMENT OF LINING TRANSDUCER AND MEASURING TRANSDUCER: Transducers should be mounted in such way that centre position clamp of transducer should be at centre(800.5mm). There is a scale in mm mounted on lining transducer and measuring transducer which has range 400mm-0-400mm. This scale should be fitted in such a way that it's 0-mark should be at centre of distance between flange of wheel i.e at (800.5mm). If transducer is not at centre then loose the mounting bolts of transducers and shift until correct distance is achieved from flange, tighten the screw after adjustment. If scale also is not at centre then loose the bolt of scale and shift to achieve correct centre position.

TROUBLE SHOOTING FLOW CHART OF LINING CONTROL CIRCUIT OF CSM



Check X30 should come. This is from switch 2X30 which enable lining and leveling in middle position of tamping unit.

Check X4E or X4F left side datum or right side datum should applied.

1. Manual lining Lh side is not working

Check X3B in programmer when operating manual lining switch, if not coming then replace this switch

Check manual lining LH relay Re5 in Ek349LV replace if defective

2. Manual lining RH side is not working

Check X3C in programmer when operating manual lining switch, if not coming then replace this switch

Check manual lining LH relay Re6 in Ek349LV replace if defective

3 . Left side datum not working .

Check X4E in programmer if not coming then check datum switch , replace if defective .

If X4E is coming then check Relay QL38 and fuse ,replace which is defective

If Relay QL38(7002/S4) and fuse is OK then check coupler of datum pneumatic solenoid (1s270), if coupler is ok then check solenoid , repair/replace if defective .

Check deflection in servo indicator if pointer is not deflecting during tamping then PCB EK349LV may be defective replace it. If pointer is deflecting but no lining then servo valve may be defective replace it.

4 . Right side datum not working .

Check X4F in programmer if not coming then check datum switch , replace if defective .

If X4F is coming then check Relay QL39 and fuse ,replace which is defective

If Relay QL39(7002/S4) and fuse is OK then check coupler of datum pneumatic solenoid (1s271), if coupler is ok then check solenoid , repair/replace if defective .

5. No deflection in lining galvanometer when switch

ON the lining system and giving deflection to lining

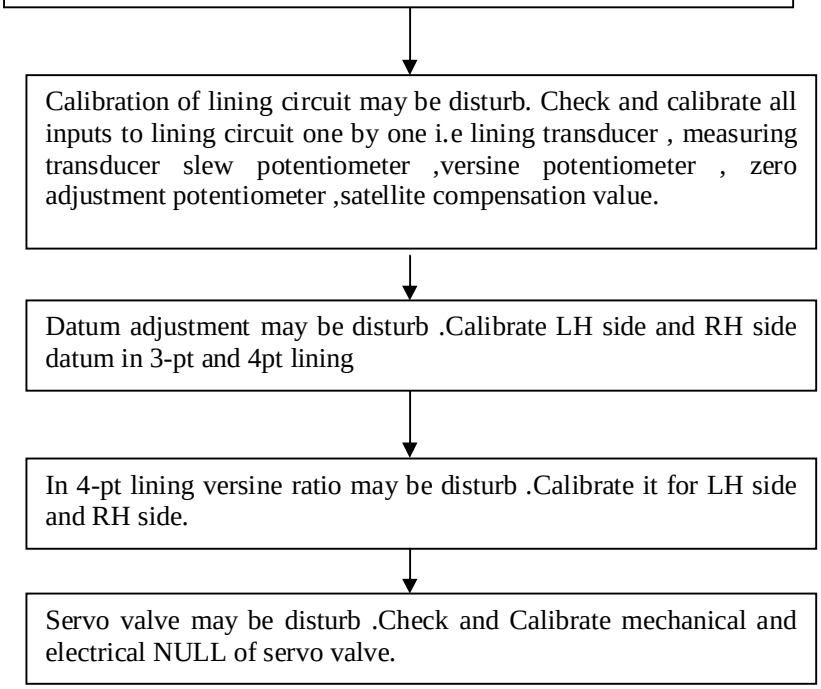
Check +24v of lining circuit ,Circuit breaker Power supply PCB EK813SV if ±15v and ±10v
are not coming then check fuse in this PCB if it is ok then replace this PCB.

Check somebody has shifted the position of switch S1in the PCB EK349LV which is used to isolate the output circuit from input .

Check somebody has shifted position of switch S1 in over slew PCB EK290LV, which is used to ground the signal of lining transducer .

Check connection of lining galvanometer if it is OK then lining galvanometer may be defective replace it.

6. In 3-pt. and 4pt. Lining machine is not doing lining



SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIV: Front Input Circuit: UNO/DUO/ CSM/3X /Unimat

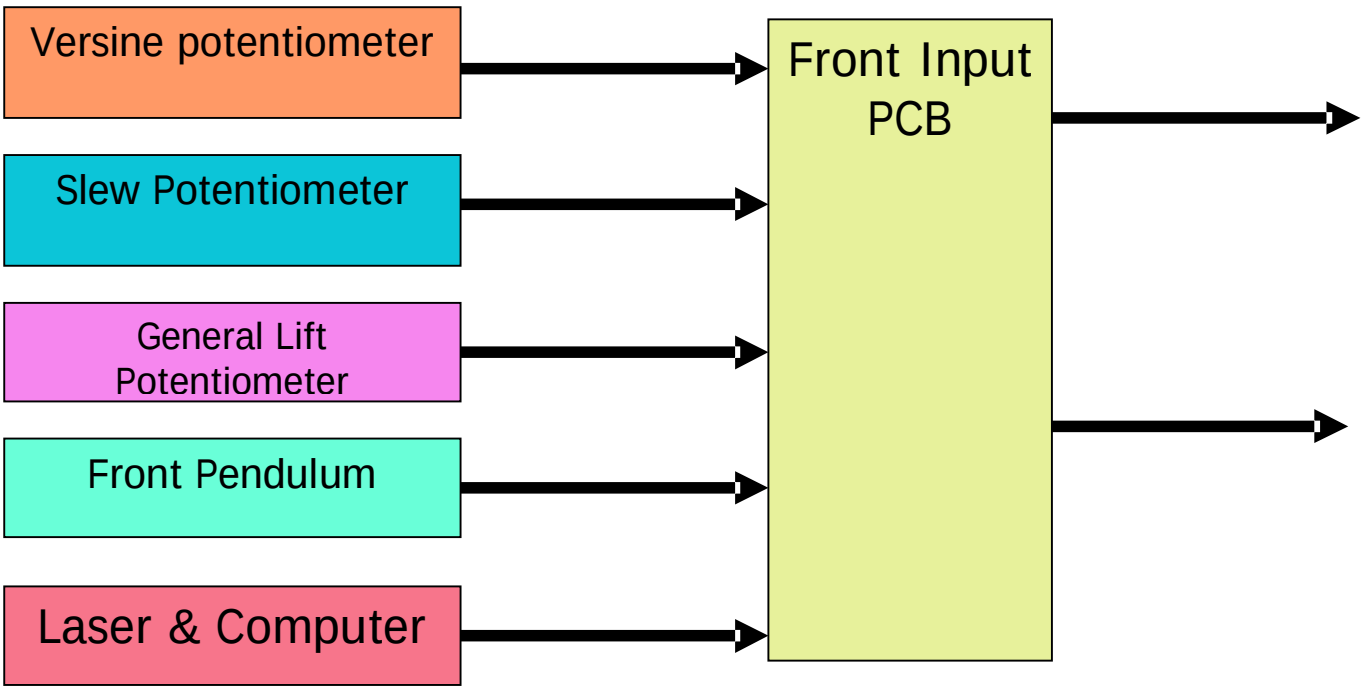
Session-43: Functional Description of Front Input Circuit, Front Input Potentiometer, Slew, Versine, General Lift etc.

Front Input Circuit :-This circuit receive inputs from front cabin and transmits to lining & levelling circuit.The parts of front input circuits are as under:-

- Input potentiometers :-Versine,Slew,General lift potentiometers.
- Front Pendulum.
- Front Input PCB.
- Laser lining.
- Computer(ALC, GVA)

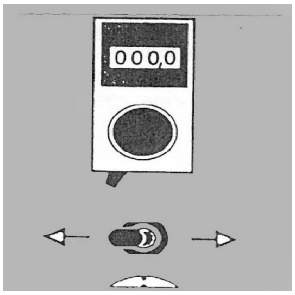
Front-input PCBs :

- UNO/DUO/ :-EK 17/255/275LV00
- CSM :-EK 345LV00.
- UNIMAT2S/3S :-EK 2072LV00
- 09-3X :-EK 2343LV00



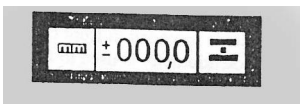
INPUT POTENTIOMETERS IN FRONT INPUT CIRCUIT:

(i)VERSINE POTENTIOMETER:



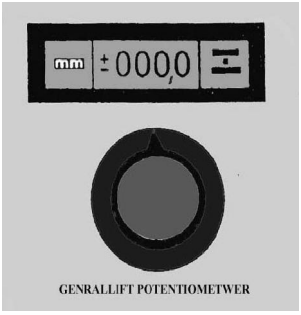
This potentiometer is provided in front cabin in panel B4 .This potentiometer is used to feed versine value in 3-pt lining and Vm value in 4-pt lining . This potentiometer converts versine value to electrical signal at the rate of 50 mv/mm, + vc for RH side, -ve for LH side.

(ii)SLEW POTENTIOMETER :



This potentiometer is also provided in front cabin in panel B4 .This potentiometer is used to feed slew value . It converts slew(Offset value in design lining) value into electrical signal at the rate of 50 mv/mm +ve for RH side and –ve for LH side.

(iii) GENERAL LIFT POTENTIOMETER:



GENRALLIFT POTENTIOMETWER

This potentiometer is provided in front cabin in panel B4. It is used to feed genral lift value. It converts general lift value to electrical signal at the rate of 50 mv/mm +ve for lifting.

Lesson-XIV: Front Input Circuit: UNO/DUO/ CSM/3X /Unimat

Session-44: Basic idea of ALC, GVA and Laser Lining

ALC:INTRODUCTION:-

Win ALC is the next generation of the well proven Plasser "ALC" track alignment computers. Since the first Plasser PC MSDOS based "ALC" was introduced in 1992 approximately 300 units have been fitted to machines world wide. The program is not tailor made for one specific country but contains all the main elements for world wide applications. The program for the "ALC" has constantly been updated from the first edition with new features being added as an ongoing situation. The PC based "ALC" program had been taken to the limit of the MASDOS operating system so it is a natural progression to change the operating environment to WINDOWS 95, this removing the restrictions of the MSDOS memory limitations and enabling a multi tasking environment that will be already familiar to the majority of people today.

The "Win ALC" system is designed as an addition to enhance and improve the existing PLASSER tamping machines lining and lifting systems. It can be fitted as a bolt on to an older machine or normally is fitted when the machine is built.

TECHNICAL DESCRIPTION OF SYSTEM:

The WIN-ALC system comprises of 4 distinct main parts:

1. The Computer or PC
2. The Display or Monitor
3. The keyboard (also fitted with the pointing device, the mouse)
4. The distance measuring wheel or encoder

Technical data:

System unit
PLASSER Built Dedicated PC :Intel Pentium 100 MHZ
16 Mbytes Memory
70 Ns Starting time
3 ½'1.44MB Floppy Disc drive
959 MB IDE-BUS

WORKING IN GEOMETRY, MEASURING RUN.

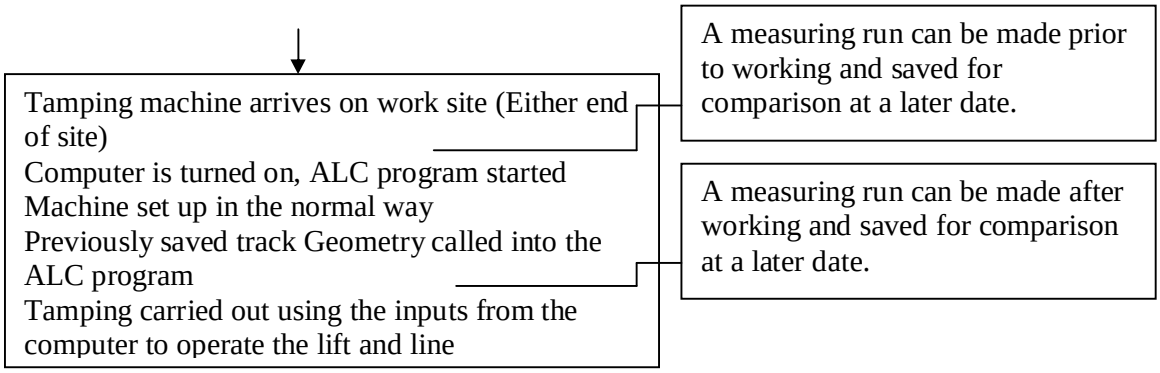
The "ALC" has two methods of enhancing the tampers track alignment systems. "Geometry" method and the "Measuring and compensation" method. In the geometry method the target track geometry is entered into the computer along with design data. For this method of working the exact design and geometry information must be known. A measuring run is not carried out as the computer will automatically input the correct lining and lift information calculated from the data entered.

The "Measuring" method is used where the track data is not known.The data for the track is obtained via a measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radii, etc. After computation by the "ALC" computer the tamper is set to work with the "ALC" automatically entering the computed lift and line data.

ALC Geometry Method: The geometry method of operating the "ALC" is used when all of the target data for a section of track is known. The data is loaded into the computer at any time prior to work. A measuring run is not used in calculations as all data has been entered, although measuring runs can be made before and after work as a benchmark.

Sequence of Operation

BEFORE ARRIVING AT WORK SITE
(preferable)
Obtain site details, geometry, location etc.
Enter site geometry into a computer running the
Win ALC program



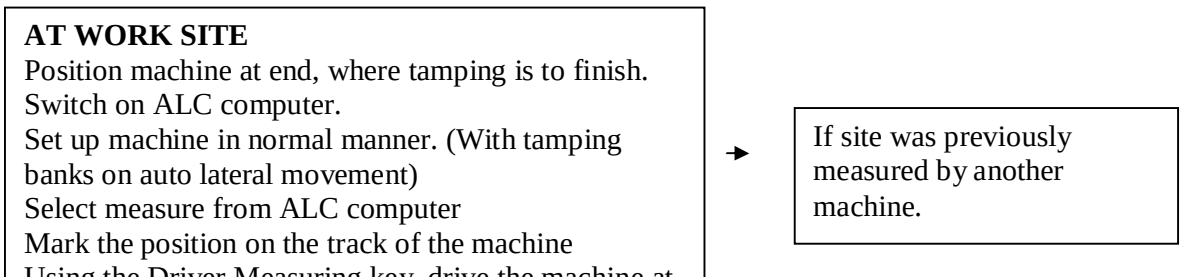
THE "MEASURING" METHOD : The measuring method is used where the track data is not known. The data for the track is obtained via measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radius, etc. After computation by the "ALC" the tamper is set to work with the "ALC" automatically entering the computed lift and line data.

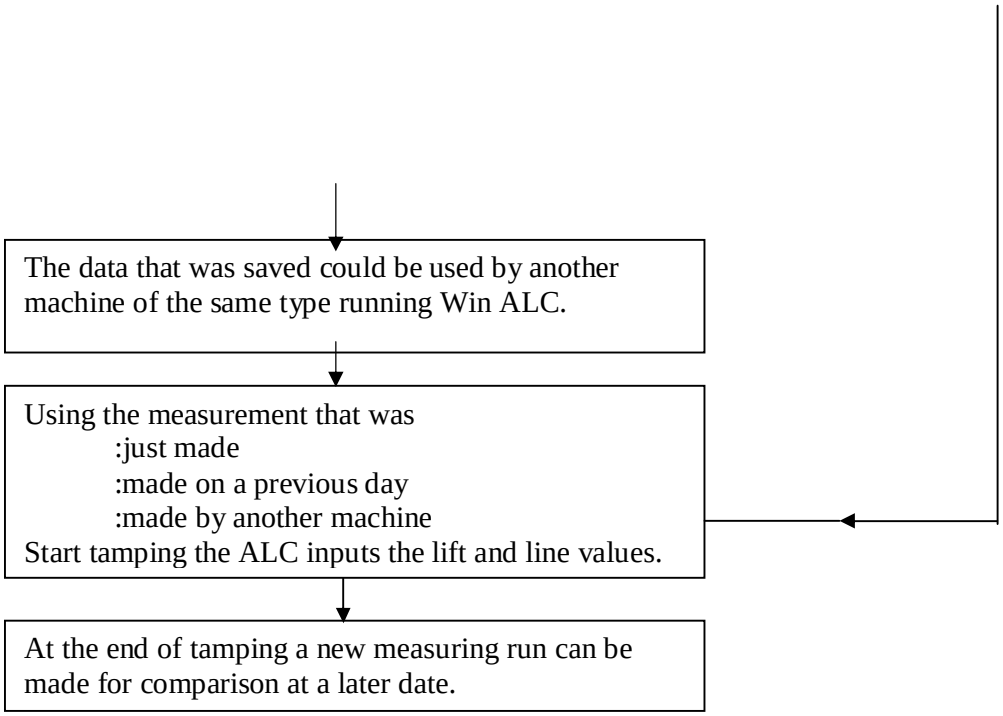
Sequence of Operation: The machine can either measure in the working direction or in the reverse. If the track is measured in the working direction, the tamping machine must reverse back to the start of the work site before commencing tamping. There is a "fast measuring drive" key switch on the front and rear driving desks. These enable the machine to use the second gear of the main drive to make the measuring run.

Performing a Measuring Run: The machine is set up for normal working, although this is not necessary to have the tamping banks running. The tamping banks slew switch on the B2 panel should be set to automatic. If it is on manual the fast measuring function will be disabled. It is advisable to drive the machine for a short distance using the normal working drive. Thus checking that the lifting and lining system is in working order before the start of the measuring run by avoiding errors at the start of the measuring run, due to poor bogie alignment or incorrect pre-loading. It is important to select the correct float rail. If the wrong rail is selected, the design for the lift will not be correct. It is also a good idea to mark the position of the machine on the rail before the start of the measuring run, so that the machine can be repositioned accurately at the start position after the measuring run has been completed (Forward measuring run). The lining system has to be set to 3-point. Use the can switch to select the datum rail for the longitudinal height recording. The reference rail for the versine recording is selected by turning on the lining system and selecting the required pre-load.

End of Measuring Run: At the end of the measuring run return the key switch to the normal position. The computer will automatically produce a "run in from" the old track geometry to the new target geometry at the beginning and end of the measuring run. The measuring run should therefore only cover the length of rail on which the work has to be carried out.

Sequence of Operation





Laser Lining System in CSM & 09-3X:

09-3X machine is provided with a laser lining system that can be used to extend the measuring system on straight track. Laser lining is used on straight track in 3-Pt mode to remove long misalignment or false curve. The laser system consists of laser gun and laser receiver. The laser trolley which consists of laser gun is placed in front of the machine up to 300 meter(200m in CSM) away. The receiver on the machine is adjustable so that it follows the laser beam and the position is detected by a transducer that provides an input to the lining system equivalent to the off set of the front end of the cord. As the machine is working it moves up to the laser trolley until the distance is a minimum of 20 meters away

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIV: Front Input Circuit: UNO/DUO/ CSM/3X /Unimat

Session-45: Functional description of Front Input PCB EK345LV, EK2072LV etc. Calibration, Troubleshooting & Fault finding

---

PCB EK345LV: Lining Cord Displacement: The lining cord on this machine is fixed at the front and rear tightening trolleys. To simulate the movement of the cord, a potentiometer 4f4 (IOK) is fitted, which is operated by a knob mounted on a disc. The potentiometer is supplied with + 10 volts (E52) on terminal 1. Turning 4f4 to the right, simulates movement of the

cord to the right feeding in a signal of +50 mV/mm (-50 mV/mm for the left) into P.C.B. 4u5 on terminal 6b. The input is buffered by amplifier OP5A, and is passed to terminal 8z at +50 mV/mm (for the right) which passes to P.C.B. 4u2 on terminal B. Moving the switch to position 4, passes the signal to gauge 4g2 where it is displayed. The output of OP5A also passes to OP5B (inverter), the output of which at – 50 mV/mm (to the right) passes to the input of OP5C(9). The output of OP5C(8) at + 50 mV/mm is fed to OP5D(13) which inverts the signal to –50 mV/mm (to the right) which connects to terminal 8b. Terminal 8b connects two ways:

1) To terminal E of 4u5, which is displayed on 4g2 with the switch in position 1.
2) To terminal E48, which can be seen on the multiplex F06, From E48, the signal at – 50 V/mm (to the right) passes to the satellite compensation card 10u1 (EK-3.48-LV-00) on terminal 28b which passes to terminal 28z via Re3/1 contact. Terminal 28z of 10u1 is connected to the lining analogue control P.C.B. 10u2 on terminal 24b.

Cross Level and General lift Setting: Terminal E26 connects to the front analogue input interface 4u5 on terminal 16z (EK-345LV-02) which passes the +50 mV/mm signal to OP8B which inverts it to –50 mV/mm. The output of OP8B(7) passes to terminal 28d, and onto E23 which connects to PCB 33u1; by turning the switch to position 2, the signal is passed to display 33g5 which shows the theoretical cross level.The output of OP8B(7) at –50 mV/mm also passes to OP8C(9) and to the contact of Re5. As switch 2b32 is set to the left hand high rail position, the 24 supply at N13 connects to terminal 18z of 4u5; relays Re5 and Re4 are energized. Therefore the contact Re5/2 contact is closed and Re5/1 is open, and so the –50 mV/mm output of OP8D(7) passes to OP8D(13) via Re5/2 contact.The front pendulum 1f13 feed in a signal of –25 mV/mm (left hand high rail) to PCB 4u5 on terminal 12b, which is inverted by OP6D and amplified, to +50 mV/mm. The signal passes to OP8D(13) where it joins the signal from the cross level digital, which is –50 mV/mm. Therefore if the theoretical cross level set by the digital is the same as the cross level under the tower, the two inputs cancel each other out.The output of OP8D(14) will depend on the input; if the inputs cancel each other out the output is 0 volts, which passes to the display via terminal 16d, -E28 – 33u1 position 1 – to 33g5.The output of OP8D(14) also passes to pin 4 of relay Re4, which is energized, and therefore passes through Re4/2 to OP4B, which is negative if the rail is too high. OP4B inverts the signal and passes it to amplifier OP4A which inverts it again. The output of OP4A(1) connects to terminal 28z, and then onto the left hand levelling PCB 6u2 via terminal E47.As the machine is set up, terminal 28z is negative, i.e. in the no lift position as shown on the lift gauge 19g3 and 33g2, ready to run in the lift for the left hand side (floating rail).The basic lift is set using potentiometer 4f3 which feeds in a signal of 50mv/mm into PCB 4u5 (EK-345LV-02). This signal is positive for lift, and as the previous shift the lift would have been run out, to bring the lift gauge towards the centre, the potentiometer is turned passing a more positive signal into the PCB.This signal passes to OP1A (buffer) and to OP13, where it is inverted and passed to OP1C where it is inverted back to 50 mV/mm. The output of OP1C(8) connects to terminal 22b which connects to terminal E55; this terminal connects to both lifting PCB i.. 6u2 for the left (floating rail) and 6u3 for the right (datum rail).

The tower end is now set, with the lift gauges just past the centre in the no lift position ready to run in the lift.

PCB EK2072 LV-02: Cross Level:

Pendulum:

The cross level at the front tower is measured by the pendulum 1f13 and the signal at 25mV/mm of cross level (negative for left hand high rail) is fed into printed circuit 4u5 at terminal 12b and is taken via R42 to OP6D(13) and added to the offset from P25 (used for zero calibration) and R41. The output OP6D(14) is inverted and the signal increased to 50mV/mm of cross level (left hand high rail now positive). The output OP6D(14) is taken via terminal 12z to the display 33u1 and via R45 to OP8D(13).

Required Cross Level: The required cross level is set with potentiometer 4f5 and the signal of 50mV/mm (positive for positive cant) is fed into 4u5 at terminal 14b and viaR53 to OP8A(3). The output OP8A(1) signal passes via P22 and R52 to OP8B(6) where it is added to the signal from the GVA output via terminal 16z, R51 and P24 (normally only one is used). The input OP8B(6) can be zeroed using P23.The output OP8B(7) is inverted and fed to display 33u1 via terminal 28d, R35/2 and OP8C(9) via R48.If switch 23b3 is set to left hand high rail terminal 18z will be connected to 24V and Re5 energized. Therefore Re5/2 is closed and the output from OP8B is taken directly to OP8D(13) via R46 (signal strength 50mV/mm negative for position cant).

Cross Level Error: At OP8D the signals from the pendulum and required cross level are added together.If the actual cant and required cant are equal the two signals will be of the same voltage but of different polarity. Therefore the output will be zero.

Should the actual cant and required cant be different (cross level error) there will be an output at OP8D(14) of signal strength 50mV/mm (negative if the left rail is too high) and this is displayed on 33u1 via terminal 16d.The output also passes to Re4/1 and Re4/2.

Basic Lift Setting: Unlike previous machines the front end of the front end of the card is fixed and basic lift is applied proportionally to the lift transducer.The basic lift set on potentiometer 4f3 is fed into 4u5 at terminal 20d (50mV/mm, positive for lift) and via R1 to OP1A(3) the output OP1A(1) is taken to display 4u1 via terminal 20b (where the manual lift can be displayed) and OP1B(7) is inverted and is taken to display 4u1 via terminal 22d to display manual and laser lift, at a strength of 50mV/mm negative for lift, and via R6 to OP1C(9).

At this point the GVA lift from terminal 24d R5 and P2 is added to the output of OP1B. P1 can be used to zero the input of OP1C. The output OP1C(8) is inverted (now 50mV/mm positive for lift) and is taken via terminal 22b to 4u1 to indicate complete lift and via R10 to OP1D(13). Output OP1D(14) is again inverted and the signal taken to terminal 22z, which is connected to terminals 28b and 32z.From terminal 28b this signal passes via R30 to OP4A(2). If left hand high rail is selected Re4 will be energized and the cross level error signal from OP8D(14) will pass via Re4/2, and Re5 to OP4B where the signal is inverted. The output passes via R33 to OP4A(2) where it is added to the basic lift signal. The inverted output OP4A(1) is taken via terminal 28z to the left hand lift circuit 10u6 at 50mV/mm positive for lift.

The signal from terminal 32z is taken via R36 to OP4C(9). The output OP4C(8) is inverted. Because Re4/1 is open the cross level error does not affect this signal. The output passes via terminal 30z to the right hand lift circuit10u7. Basic lift is therefore put onto the opposite rail to that selected as the high rail and the cross level error appears on the high rail.

If right hand high rail is selected Re4 will be de-energized and the cross level error is taken via Re4/1 and R39 to OP4C and is added to the basic lift. The output is taken to the right hand lift circuit. The signal to the left hand lift circuit is not affected by the cross level error.

Front Tower Lining:Digital Input:

The direction switch 4b4 has to be correctly set for the direction of the curve. For right hand curves 4b4 connects the digital potentiometer 4f1 to the +10 volt supply and the –10 volt supply for left hand curves. A signal of 50mV/mm (positive for right hand curves) is taken from 4f1 to terminal 8b of 4u5. The signal passes via R72 to OP6C(10). The output OP6C(8) is taken via R31 to OP4D(13) where the inverted signal from OP4D(14) passes to terminal 30d. This terminal is connected to the lining display (4u2) to show the set versine and 10u2 terminal 20d to feed the desired versine into the lining control board.

If the GVA computer is used the output versine from the computer is fed to terminal 20z of 4u5 and via R22 to OP3A(3). The output OP3A(1) passes via R23 to inverter OP3B(6). The zero point of this inverter is set by P7 and the gain by P8. The output OP3B(7) passes via R73 and P21 to OP4D(13) where it is added to the signal from 4f1.

Front Cord Displacement: The front cord displacement is carried out electrically on these machines either by the manual potentiometer 4f4 or the laser potentiometer 1f27. (Laser equipment is not completely fitted but the machine are wired for laser equipment.

The manual signal from 4f4 (50mV/mm positive for displacement to right) is fed into printed circuit 4u5 at terminal 6b via R54 the signal goes to OP5A(3). The output OP5A(1) is taken to terminal 8, and display 4u2(1) to show manual displacement and via R55 to OP5B(6).

The laser input from, 1f27 (23, 1mV/mm, negative for displacement to right) is fed into terminal 10d and via R64 to OP6A(3). The output OP6A(1) is taken via R65 to OP6B(6) where the signal is amplified and inverted to 50mV/mm positive for displacement to right. The gain is set by P16 and the zero point by P15. If the laser lining is switched on a 24 volt feed via 4b1 is connected to terminal 2b and energizes Re3. The contact Re3/1 closes and connects output OP6B(7) to input OP5B(6) via R56 thus adding the manual and laser inputs together

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XV :Leveling & Lifting Control Circuit of UNO/DUO/ CSM/3X /Unimat

Session-46: Functional Description of Leveling Control Circuit, Transducers and Input Potentiometers

---

LEVELLING SYSTEM

PCBs which are used in leveling circuit of different machine are given below:

CSM:			**UNIMAT – 2S:**		
Lifting PCB	-	EK 347 LV	Lifting PCB	-	EK 2041 LV
Front input PCB	-	EK 345 LV	Front input PCB	-	EK 2072 LV
Pendulum Control PCB	-	EK 346 LV	Pendulum Control PCB	-	EK 2042 LV
Satellite compensation PCB	-	EK 348 LV	3-Stage Lifting	-	EK 144 V
Power supply PCB	-	EK 813 SV	Power supply PCB	-	EK 813 SV
CSM-3X:			**UNIMAT – 3S:**		
Lifting PCB	-	EK 3069 LV	Lifting PCB	-	EK 2041 LV
Front input PCB	-	EK 2343 LV	Pendulum Control PCB	-	EK 2042 LV
Pendulum Control PCB	-	EK 2351 LV	Front input PCB	-	EK 2072 LV
Satellite compensation PCB	-	EK 526 MC	Power supply PCB	-	EK 813 SV
Power supply PCB	-	EK 816SV	**UNIMAT COMPACT:**		
DUOMATIC:			Lifting PCB	-	EK 2041 LV
Lifting PCB	-	EK 229 LV	Front input PCB	-	EK 3049 LV
Front input PCB	-	EK 255 LV	Pendulum Control PCB	-	EK 2042 LV
Front pendulum PCB	-	EK 217 LV	Power supply PCB	-	EK 813 SV
Middle pendulum PCB	-	EK 277 LV			
3-Stage lifting PCB	-	EK 79 V			
Power supply PCB	-	EK 813 SV			

Transducers used in leveling control circuit:

PENDULUM: Pendulum is a transducer which converts cross level error to electrical signal at the rate of 25 mv/mm –ve for LH rail high and +ve for RH rail high **.**There are three pendulums are used in CSM ,unimat 2Sand 09-3X.In other tampingmachines only two pendulums are used

Front Pendulum: This pendulum is mounted on front trolley . It measures cross level of front area before tamping.

Middle Pendulum: This pendulum is mounted on middle feeler rod . It measures cross level of tamping area .

Rear Pendulum: This pendulum is mounted on measuring trolley . It measures cross level after tamping .This pendulum participates in twist correction.

GENERAL LIFT POTENTIOMETER (4F3): This potentiometer is provided in panel no. B4 in front cabin. This potentiometer converts given general lift value to electrical signal at the rate of 50MV/MM output of this potentiometer can be checked at multicheck address F.

For calibration of this potentiometer keep general lift potentiometer on zero and check output of this potentiometer with the help of multi meter it should be OV. If there is some signal on zero position first take out knob of potentiometer now rotate shaft of potentiometer to get zero volt. Now fit knob on shaft by matching zero position.

Now feed 100mm general lift now output of this potentiometer should be +5V if it is more than +SV then supply voltage to this potentiometer should be checked it should be +10V if it is not +10V (less or more) than adjust P1 potentiometer in EK 813 in panel No. B4.

SUPER ELEVATION POTENTIOMETER: This potentiometer is provided in B2 panel in working cabin this potentiometer is used do provide SE. Values on curves. This converts cant values to electrical signal at the rate of 50MV/mm.output of this potentiometer can be checked at multicheck address F08.

Leveling & Lifting Control Circuit of CSM:

PRINTED CIRCUIT BOARDS:

1u48	-	Distance Measuring – Encoder	-	EL–T5034.002
4u1	-	Board for Lift Indication (To 4g1)	-	EL–T5103.00(02)
4u4	-	Power Supply for the Tower	-	EK-813SV-002
4u5	-	Front Analogue Input Interface	-	EK-345LV-00(02)
6u2	-	L.H. Levelling Control	-	EK-347LV-00(02)a
6u3	-	R.H. Levelling Control	-	EK-347LV-00(02)a
6u4	-	Power Supply, Main cab	-	EK-813SV-002
6u5	-	Pendulum Control	-	EK-346LV-(02)b
6u6	-	Distance Shift	-	EK-110V-00(02)a
10u1	-	Compensation Card	-	EK-348V-00(02)
19u2	-	Encoder Power Supply	-	EK-851SV-002
19u3	-	Distance Measuring	-	EK-99V-002
33u1	-	Board for Cross Level Indication (33g5)	-	EL-T5105.00(02)a

TRANSDUCERS:

1fOD	-	Levelling Transducer L.H.S.	-	5 k ohms
1fOE	-	Levelling Transducer R.H.S.	-	5 k ohms

POTENTIOMETERS:

1f07	-	Middle Pendulum
1f09	-	Rear Pendulum
1f13	-	Front Pendulum
4f3	-	Basic Lift Setting
4f5	-	Cross Level Adjustment – Tower
19f31	-	Settlement Compensation
88f1	-	Cross Level Digital

Levelling Control Board 6u2 or 6u3 (EK-347LV-02a)

On the levelling control boards 6u2 and 6u3 are seven inputs to a summing line. The following description is for the left hand side (6u2).

Input-1. Proportional Levelling Transducer: The levelling transducer 1FOD is supplied with + and –10 volts on terminals N52 and N53 (see power supply circuits 6u4). The signal from the transducer at 90 mV/mm is fed into 6u2 on terminal 26b (positive for lift), and can be checked using multiplex 7OD. The signal is passed to the summing line via amplifier OP1A (buffer), P1 and R7, remaining positive.

Input-2. Lift Correction: The 11 position switch on 51u1 (ED-T)= 5140.022) can be used to correct cross level errors, but only on one side (floating rail) at a time. This switch can be used to apply up to 5mm of lift in 1m steps, which connects to 6u2 on terminal 30b. This signal of 2 v/mm can be checked on multiplex F11. The signal passes to the summing line via amplifier OP13 (buffer), P3 and R8, remaining positive.

Input-3. Cross Level Error: Any difference between the pendulum at the tower, and the cross level digital, produces a signal from 4u5 terminal 28z (E47) which connects to 6u2 on terminal 26d which can be checked on multiplex F21. This will be positive for lift, which passes to amplifier OP2A and onto the summing line via f5 and R9.

Input-4. Satellite Displacement Compensation: On the 09 machine, the centre reference point is attached to the satellite; as this is the only part of the machine that stops during the tamping cycle, the relationship between the front, rear and centre reference point varies dependent on the satellite position. Therefore errors will occur in the longitudinal level.

To compensate for the satellite position, PCB 10u1 (EK-348LV-03) is fitted. The satellite length transducer1f1D feeds in a signal to 10u1 on terminal 20d, which is –10.2 volts in the 0 position, which passes to OP1A (buffer) The output of OP1B(7) is zero. This passes

through OP2A and OP2D so that the input to the multiplier MUL4 on pin 7= 0. Therefore the output at terminal 22z is 0 volts. Terminal 22z connects to PCB 6u2 and 6u3 on terminal 24z which can be checked on multiplex FOC.With the machine moving and the satellite stationary, the input from the length transducer becomes less negative so that pin 6 of OP13 becomes more positive. Therefore the output of OP1B(7) is negative at a maximum of –1.5 volts/m. This is inverted by OP2A to +1.6 volts/m and amplified to +8 volts, i.e. gain = 1 + R36/R35 x V in 5 x 1.5 = 8 volts.

With +8 volts on pin 7 of MUL4 and 10 volts on pin 13 (200mm max. lift x 50 mV = 10 volts)] the output of MUL4 on pins 1 and 2 = Input 13 x Input 7/10. This equals 10 x 8/10 = 8 volts, which connects to terminal 22z. Terminal 22z connects to terminal 24z of levelling PCB's 6u2 and 6u3 to compensate for the satellite position at –187 mV/mm of lift, which passes to the summing, line via o2B, P4 and R10.

Note:200mm = max lift and 1 metre max distance of satellite therefore 1.6 v/m and –3.12 volts are maximum values.

Input 5. Cross Level Error Rear: The input of the digital 88f1 and the input of the rear pendulum 1f09 are compared by pendulum PCB 6u5 [EK-346LV-(02)] and with the left hand rail as the high rail, the error signal is passed to terminal 24z. This terminal connects to terminal 8z on levelling board 6u2; the signal at 200 mV/mm (negative for L.H. rail too low) is passed onto the summing line via the inverter OP3A P6 and R11. Therefore this signal is now positive.

Note: This will only occur if the rear automatic cross level correction switch 19b1 is in the "outer position, i.e. not lit (site operator's manual page 41, item7). If this switch is in the 24 volt supply to terminal 26d of 6u5 is removed, de-energizing Re4 and Re5, connecting 24z and 24b to earth. This prevents any cross level correction.

Input 6. Settlement Compensation: The lifting value for the L.H.S. from 6u2 and the lifting valve for the R.H.S. from 6u3 are compared and displayed. A potentiometer is fitted to select a percentage of the difference from 0 to 100% and a signal is passed to the side requiring the most lift, i.e. to 6u2 or 6u3.The signal at terminal 6z at 6u2 is 2V/mm, negative for lift, is inverted by OP3B and passes to the summing line via P7 and R12. (This will be explained further under settlement compensation).

Input 7. Basic Lift Setting: The basic lift is set by 4f3 which produces a signal from 4u5 at terminal 22b to terminal E55 (tower end). This connects to 6u2 and 6u3 on terminal 4z; the signal at 50mV/mm is positive for lift, and passes onto the summing line via P11 and R13.

Summing Line: At the summing line, the various signals are added together, and adjusted due to their differing value of resistors. The final signal is passed to amplifier OP4A (inverting adder), the output will be negative for lift. At this time as the machine is ready to run in the lift, the output will be negative for lift. At this time as the machine is ready to run in the lift, the output will be positive.

Lift Indication: Amplifier OP4A(12) feeds the positive signal to OP5A and OP4B. At OP5A, the positive signal of 1 v/m is inverted and doubled by OP5A which connects to terminal 10b, and passes to the lift gauges 19g3 and 33g2 (19g4 and 33g3 for R.H.S.) This causes the gauges to deflect to the right i.e. no lift.At OP4B (Comparator), the output is low, therefore Re1 remains de-energized.

Starting to Work: Before work takes place the rear cross level circuit has to be reset, as the machine's memory circuit provides incorrect indication on the rear galvo 19g2. To correct the indication, press the green start button 19b13, (see operator's manual page 40, item 1), press and hold the yellow simulation button 19b15, untill the display 19g2 reads ub excess if 80. The red stop button is then depressed, 19b14. (This will be explained under rear cross level, distance measuring)

The lifting method is now selected using either the "lining down" switch 2x20 or the "lining and levelling start with tamping units middle position" 2x30. In this case 2x20 is operated.

Automatic Lift:

To obtain automatic lift, an output Q06 for the left hand side and Q07 for the right hand side.To achieve an output for the left hand side Q06, the program needs to be complete, i.e. 2E^05^6E^32^48^49^(24v2F)^02^93^94.

2E = Auto levelling on using switch 2x2E.
05 = 20^OB, e.g. 2x20 made and tamping down signal.
6E = Right hand bank not latched.
32 = Left hand over lift transistor not on.
48 = Front trolley not in the upper position.
49 = Rear trolley not in the upper position.
24v2F = Track sensor L.H.S. made, or track sensors switched off.
02 = Left clamp lift and stop not made.
93 = Levelling transducer not in the upper position.
94 = Satellite not in the travel position.

With the tamping system on (19) and the drive (11) and tamping pedals (10) depressed the machine now drives, and due to the output QOB the tamping banks descend. Output QOB completes the program of QO5 (20^OB), which in turn completes the program of QO6 and QO7.

Outputs Q06 or Q07 complete the program of Q4C which connects to PCB 1-0u1 on terminal 24z energizing relay Re5. Relay R energizing results in 1 contact changing over removing the input from terminal 10z which is the value from the cross level digital theoretical value) via terminal 4z of 5u5. With the contacts of Re5 having changed over, connects the capacitor K20, which had been charged to the value set by the digital, to amplifier OP5B. The capacitor discharges via OP5B and OP5D, ensuring that the value at terminal 14b remains the same as before tamping. Terminal 14b links to terminal 6b of PCB 6u5 ensuring the cross level indication remains a true reflection at that point, even though the machine has continued to move.Output Q06 and Q07 complete the programs of QL2E(06) and QL2F (07) and due their positive outputs, energize 1s3 and 1s4 which are the lifting solenoids, moving the C.S.V's into the lift position.Output Q06 completes an earth path to terminal 16b of 5u2 and Q07 completes an earth path to terminal 16b of 6u3. The earth at 1sb passes to the coil of Re2 (automatic lift relay) via Re4/1 contact, Re3/2 contact and DIL. As terminal 14d is connected to PR (+24 volts), relay Re2 energizes reversing its two contacts. Re2/1 contact changing over doesn't affect the over lift of T1 circuit due to the link between earth and R33, i.e. shorting out Re2/1 contact. By changing over, however, the earth is removed between R40 and R41 which had previously blocked the output from OP4A(12) passing to the servo circuit.

Servo Circuit: As the machine has started to work, the basic lift has been increased by 4f3 in the tower to run in the lift. Therefore terminal 4z of 6u2 and 6u3, each mm of lift applied increases the signal by +180 mV. The summing line now becomes positive resulting in the output of OP4A turning negative at –1 V/mm of lift. This output signal is inverted and doubled to 2 v/mm by OP5A which connects 10b, indicating lift, i.e. deflecting to the left.The output of OP4A passes to OP6A where it is inverted to +1 V/mm and passes on to amplifier OP6B where it is inverted and amplified 5:1 up to a maximum of 14 volts, (negative for lift). The output of OP6B passes to terminal 22b which links to terminal 20b. As R63 is now in circuit, with –14 volts at terminal 20b, there will be –3 volts a pin 6 of OP7, which results in an output of approximately –4.5 volts at pin 10 of OP7.Connected in the feedback loop is the servo valve, which form a potential divider circuit with R65(200Ω). If the servo valve resistance is taken as a nominal figure of 100Ω, the voltage across it = 100/300 vin = 1/3 of –4.5 volts, i.e. –1.5 volts. By Ohms Law, the current through the servo valve = 1.5 V/100Ω = 15 mA.

The servo gauge 18g2 is connected to terminal 22d, with switch 18b2 in position 1 for 6u2 (L.H.S.) and earth (see drawing E1-09-1.929-0). Therefore the gauge will read 100% due to measuring the –3volts across R65, i.e. –4.5 volts – the volt drop across the servo valve (-1.5 volts) = -3 volts (15 mAs). With 15 mAs flowing through the servo valves, oil is passed

to the clamp frame lift/lower cylinders via the C.S.V.'s and lift takes place both sides. As the rail lifts, the centre feeler rods lift with it, changing the input from the levelling transducer towards the zero position. Therefore the lifting signal on the summing line becomes less positive, resulting in the output of OP4A(12) becoming less negative.When the lifting signal is less than 3mm, amplifier OP6B comes out of saturation, reducing the voltage at terminal 22b to below –14 volts and therefore the current through the servo valve coils drops below 15 mA. The flow of oil to the lift/lower cylinder decreases, reducing the speed of lift.When the inputs on the summing line are balanced, the output of OP4A being zero, results in the servo valve moving to the null position trapping the oil between it and the cylinder, i.e. maintaining the lift.

As the output of OP4A is zero the input and output of OP5A has reduced to O which can be seen on the lift gauges which are connected to terminal 10b. The gauges having been in the lift position (to the left) move towards the centre of the gauge, and when the output is zero from OP5A, the pointer of the gauge will be in the centre, i.e. lift achieved position.

Lift Light: When the output of OP4A is negative (for lift to take place) by 0.5 volt, the output of comparator OP4B swaps to + 14 volts. Therefore relay Re1 energizes, reversing its contact, which passes the 24 volt supply at terminal R6 to 12z. Terminal 12z connects to the lift light 19h4 (19h5 for the right), which illuminates, showing lift is required.

When lift is achieved, the output of OP4A is below 0.5v, therefore comparator OP4B switches to low (-14 volts) de-energizing Re1. Therefore the lift light goes out.

Lift Correction: As explained on the levelling board write up, the lift correction switch mounted on panel 51 (left hand armrest) can correct errors in the lifting circuit. The switch can be used to increase the lift by 5mm in 1 mm steps on the floating rail only. Therefore in this example of L.H. high rail (floating), if the working cross level gauge pointer does not reach the centre position and hangs to the left, more lift is required on the left hand rail. Therefore the switch is used to correct the lift by feeding in a signal of +2/MA volts which increases the summing line voltage and therefore the output signal.To check the input from the switch on 51u1, the multiplex F11 for the L.H.S. ad F12 for the R.H.S. can be used.

Overlift: Should a fault cause the track to be overliefted by 4mm, the summing line turns negative, resulting in the output OP4A turning positive. The output of OP4A passes to OP5A which inverts and doubles the signal to –2V/mm which passes to the lift gauges via terminal 10b, and comparator OP5B. This reduces the input at pin 7 of OP5B below pin 6 and therefore the output switches high (+15 volts), turning "On" the base of transistor T1. The transistor connects the earth at terminal 6db to terminal 8d which connects an input to the PLC x 32 for the L.H.S. and x 33 for the R.H.S.Input X32 breaks the program of Q06, which removes, the lifting circuit for the L.H.S. and makes the lowering circuit, i.e. Q16 and QL2B. Input x33 breaks the program of Q07 , removing the lifting circuit for the R.H.S. end completes the program for lowering i.e. Q17 and QL2C.

Lift and Hold: With the machine set for double tamping, i.e. 2 x position (2x28) and the lift and hold switch 2x31 made, the tamping banks descend when foot pedal 1 x10 is pressed. When the bank reach the middle position (15-16), output Q05 is latched by (31^15v16)^OF, and geld on by 04v(28^CC)^OF. Therefore when the banks raise for the first time, even though OB is lost, Q05 output remaining ensures Q06 & Q07 are retained, i.e. machine still lifting.

When the banks are lowered for the second time, output Q00 is removed (see tamping section, and the hold program of Q0C is lost when the banks raise for the second time. The loss of Q0C results in the loss of Q05 which breaks the lifting cycle.

Cross Level Correction & Display Tower End: The cross level at the tamping position is also displayed in the power on gauge 33g4 (see modification No. 17) which is fed on terminal N45 from terminal 8d of PCB 6u5. Therefore the operator at the tower can see if the cross level is correct after lift has taken place.If correction is required, there used to be a + or – 10mm adjustment potentiometer 4f5 fitted, which has since been modified to 100mm. This is

achieved by operating a switch to either connect +10 volts (E52) or –10 volts (E53) to the potentiometer, which is also connected to earth. By moving the digital, a signal at 100 mV/mm is fed into PCB 4u5 on terminal 14b, which is buffered by OP8A. The output from OP8A(1) at 1`00 mV/mm is passed to the summing line of OP8B via P22 and R52.Potentiometer P22 and R52 originally were 47k and 255k respectively, but were reduced to 4.7 k and 24.9 k. This was carried out because the input signal was reduced from 1 V/mm to 100 mV/mm due to the mod, i.e. $1/10^{th}$ of the original signal. Therefore the resistors were reduced by approximately $1/10^{th}$.

At the input of OP8B, the signal from the main cab digital, and the cross level correction digital are added together, increasing the output of OP8B at –50 mV/mm. The output from OP6D (pendulum 1f13) at +50 mV/mm no longer balances the signal from from OP8D (the two digitals) at pin 13 of OP8D and therefore the input to OP8D is negative.

The output of OP8D at +50 mV/mm, passes to OP4B via Re4/2 where it is inverted to –50 mV/mm. Which is again inverted to +50 mV/mm by OP4A. OP4A's output at pin 1 is connected to terminal 28z, which passes to terminal E47 and then onto PCB 6u2 on terminal 26d, and can be checked on multiplex F21. This positive input to the levelling board results in the summing line increasing positively, resulting in a stronger negative output of OP4A, which increases the servo current. Therefore the lift is increased on the L.H.S. correcting the cross level fault.

PCB EK-346LV(Cross Level – Working Area):

The middle pendulum 1f07feeds in a signal of 25 mV/mm into PCB 6u5 (EK-346LV-02B) on terminal 22b, which is negative for the L.H. high rail selection. The signal is passed to OP4C where it is doubled in strength to –50 mV/mm which is inverted by OP3B. The output of OP3B is passed to a sub actor OP3C(9) at +50 mV/mm, where it is compared with the +50 mV/mm signal from the cross level digital (terminal 6b) at pin 10 of OP3C, which is held due to the memory from 10u1 terminal 14b.The input from the pendulum is taken away from the input from the digital and the output is passed to Re2/1 contact. With the left hand rail as the high rail, switch 2b32 is turned to the left closing contacts 2b32/1, 2b32/3 and 2b32/5. Contact 2b32/3 closed, connects an earth to terminal 6d and 28d, energizing relays Re1 and Re2 on 6u5. Therefore the output of OP3C passes through Re2/1 contact at 200 mV/mm (positive if the left hand rail is too low).The 200 mV/mm signal is inverted by OP6D and passed to terminal 8d via P13, R71 and R72 and onto the display 9g2. When tamping takes place, if the correct amount of lift has been applied, due to the rail lifting, the pendulum input should balance the input from the digital. Therefore the output of OP3C is) volts, and the galvo 9g2 shows no cross level error.

Settlement Compensation: If large cross level, errors exist, there is a problem with the settlement of the ballast, which can be overcome if required by the 09-32. The output of the left hand levelling board 6u2 on terminal 22z is passed to the pendulum board 6u5 on terminal 18z and can be checked on the multiplex F16. The output of the fight hand levelling board 6u3 on terminal 22z is also passed to the pendulum board 6u5 on terminal 20d and can be checked on multiplex F17. The two lifting signals at –1V/mm of lift are compared by amplifier OP4B on 6u5 (EK346LV-02B). If the left hand side requires the greater lift, the output of OP4B(7) will be positive.

The output of OP4B (+5 Volts) charges capacitor K15 via Re /2 contact. When the machine start lifting output is given, i.e. Q06 or Q07, there is an output Q4C which earths terminal 18b, resulting in relay Re3 energizing. Therefore both contacts reverse; Re3/2 passes the +5 volts from the capacitor K15 to Re3/2 contact which passes the signal to OP4A(3). The output of OP4A(1) at 5 v (i.e. 1 v/mm of lift = 5 mm of lift) passes to the lift difference gauge 19g8, showing which side requires the most lift. The output of OP4A(1) also passes to the settlement compensation potentiometer 19f31 which can select from 0% (system off) to 100% (all of the signal). With the potentiometer 19g8 set to 20%, the reduced value is connected to terminal 12b of 6u5 (positive for left hand rail low), which in this case is 20% of 5 = + 1 v *1mm of lift). This signal is inverted to – 1 v/mm of lift by OP6A; as the output is negative, this results in the comparator OP6C's output being low, therefore Re6 remains in the de-energized state.The – 1 v signal from the output of OP6A(1) therefore passes to

terminal 16z of 6u5 via Re6/1 contact. This signal passes to PCB 6u2 (levelling board for the L.H.S.) which at –1 v is inverted by OP3B (on 6u2) to 1 v which is passed onto the summing line to give 1 mm of extra lift. As relay Re6 remained de-energized on PCB 6u5, Re5/2 contact maintains an earth at terminal 16b, which passes to PCB 6u3 (levelling board R.H.S.). Therefore no extra lift signal is passed to the R.H.S. With this system the total lift on the left hand side equals 7 mm and the right hand side equals 1 mm of lift (figures only used as an example). This results in an over lift on the L.H.S. of 1 mm to compensate for the ballast settling after tamping has taken place. If the circuit remained as explained, the 1 mm of overlift would cause the middle cross level galvo 9g1 to pass the centre point (0 cross level error) and finish to the right of centre due to the pendulum's new level. This could cause problems as the operator might try to correct this indication.

Leveling & Lifting Control Circuit of Unimat2S

Levelling System:

Printed Circuit:

10u5	Levelling System Power Supply	EK-813SV-002
10u6	Levelling Control Left	EK-2041LV-00(02)
10u7	Levelling Control Right	EK-2041LV-00(02)
10u8	Pendulum Control Rear	EK-2042LV-00(02)
4u4	Power Supply Tower	EK-813SV-002
4u5	Front Analogue Interface	EK-2039LV-00(02)

Transducers:

1f00 Levelling Transducer Left.
1f0E Levelling Transducer Right
1f07 Pendulum Rear
1f13 Pendulum Tower
1f25 Laser (Lift right) not fitted at present
1f26 Laser Lift left
232f11 Zero adjuster left
22f12 Zero adjuster right
23f08 Required cross level rear
22f09 Settlement Compensation value
23f0B Zero correction left (plain line)
52f0B Zero correction left (S & C)
51f0C Zero correction right
4f3 Lift Setting Tower
4f5 Required cross level tower

Switches:

23b3 High Rail selector rear
22b6 Gain control right
22b7 Gain control left
23b4 Cross level direction rear
4b7 Cross level direction front

Front Tower:Cross Level:

Pendulum: The cross level at the front tower is measured by the pendulum 1f13 and the signal at 25mV/mm of cross level (negative for left hand high rail) is fed into printed circuit 4u5 at terminal 12b and is taken via R42 to OP6D(13) and added to the offset from P25 (used for zero calibration) and R41. The output OP6D(14) is inverted and the signal increased to 50mV/mm of cross level (left hand high rail now positive). The output OP6D(14) is taken via terminal 12z to the display 33u1 and via R45 to OP8D(13).

Required Cross Level: The required cross level is set with potentiometer 4f5 and the signal of 50mV/mm (positive for positive cant) is fed into 4u5 at terminal 14b and viaR53 to OP8A(3). The output OP8A(1) signal passes via P22 and R52 to OP8B(6) where it is added to the signal from the GVA output via terminal 16z, R51 and P24 (normally only one is used). The input OP8B(6) can be zeroed using P23.
The output OP8B(7) is inverted and fed to display 33u1 via terminal 28d, R35/2 and OP8C(9) via R48.

If switch 23b3 is set to left hand high rail terminal 18z will be connected to 24V and Re5 energized. Therefore Re5/2 is closed and the output from OP8B is taken directly to OP8D(13) via R46 (signal strength 50mV/mm negative for position cant).

Cross Level Error: At OP8D the signals from the pendulum and required cross level are added together.If the actual cant and required cant are equal the two signals will be of the same voltage but of different polarity. Therefore the output will be zero.Should the actual cant and required cant be different (cross level error) there will be an output at OP8D(14) of signal strength 50mV/mm (negative if the left rail is too high) and this is displayed on 33u1 via terminal 16d.
The output also passes to Re4/1 and Re4/2.
Basic Lift Setting: Unlike previous machines the front end of the front end of the card is fixed and basic lift is applied proportionally to the lift transducer.
The basic lift set on potentiometer 4f3 is fed into 4u5 at terminal 20d (50mV/mm, positive for lift) and via R1 to OP1A(3) the output OP1A(1) is taken to display 4u1 via terminal 20b (where the manual lift can be displayed) and OP1B(7) is inverted and is taken to display 4u1 via terminal 22d to display manual and laser lift, at a strength of 50mV/mm negative for lift, and via R6 to OP1C(9).
At this point the GVA lift from terminal 24d R5 and P2 is added to the output of OP1B. P1 can be used to zero the input of OP1C. The output OP1C(8) is inverted (now 50mV/mm positive for lift) and is taken via terminal 22b to 4u1 to indicate complete lift and via R10 to OP1D(13). Output OP1D(14) is again inverted and the signal taken to terminal 22z, which is connected to terminals 28b and 32z.
From terminal 28b this signal passes via R30 to OP4A(2). If left hand high rail is selected Re4 will be energized and the cross level error signal from OP8D(14) will pass via Re4/2, and Re5 to OP4B where the signal is inverted. The output passes via R33 to OP4A(2) where it is added to the basic lift signal. The inverted output OP4A(1) is taken via terminal 28z to the left hand lift circuit 10u6 at 50mV/mm positive for lift.
The signal from terminal 32z is taken via R36 to OP4C(9). The output OP4C(8) is inverted. Because Re4/1 is open the cross level error does not affect this signal. The output passes via terminal 30z to the right hand lift circuit10u7. Basic lift is therefore put onto the opposite rail to that selected as the high rail and the cross level error appears on the high rail.
If right hand high rail is selected Re4 will be de-energized and the cross level error is taken via Re4/1 and R39 to OP4C and is added to the basic lift. The output is taken to the right hand lift circuit. The signal to the left hand lift circuit is not affected by the cross level error.
Rear Pendulum: The rear pendulum is used purely as an indicator circuit. The required cross level is set with 23f08. The signal of 50mV/m (positive for positive cant) is fed into 10u8 at terminal 28z and passes via R22 to OP1A(3). P4 is used to adjust the zero point. The output OP4C(1) is amplified by 1.33, set with P16. The signal passes via R27 and R28 to OP2C(9). When the GVA is used the required cross level enters at terminal 6z and passes via P5 and R30 to OP2C(9).When the GVA is used the required cross level enters at terminal 6z and passes via P5 and R30 to OP2C(9).
The gain of OP2C is 0.7 and the signal is reduced and inverted to 50mV/mm (negative for positive cant). The signal then passes R32 to OP2D(13). The output OP2D(14) is again inverted and passes to terminal 4z and the display 23g5. Terminal 4z is connected to terminal 6b and is taken via R44 to OP3C(10) and R47 to OP3D(13).
The pendulum, input 1f07 is taken to terminal 22b at 25mV/mm (negative for left hand rail high) and via R35 to OP4C(10).)7 is used to set the zero point. The output OP4C(8) is amplified 2:1 and the signal is now t0mV/mm and passes via R39 to OP3B(6). The output OP3B(7) is inverted and P8 can be used to accurately calibrate the signal. The output OP4C(8) also passes via R40 to OP3A(3). The output OP3A(1) is not inverted and P9 can be used to calibrate the output. This output passes vua R46 to OP3D(12) where it is compared with the signal from 23f0B via terminal 6b and amplified. The resultant output OP3D(14) passes to Re2/2 at 200mV/mm (negative if the lift hand rail is high).

The output OP3B(7) via R45 to OP3C(9) where it is compared with the signal from 23f08. The output OP3C(8) is also amplified to 200mV/mm (negative if the left hand rail is high) and passes to R32/1.If left hand high rail is selected switch 23b3 will connect terminal 6d to earth and Re2 will energize. Therefore R32/1 will close and the signal from OPP3C(8) will

pass via R68 to OP6D(13). The output OP6D(14) is inverted but still at 200mV/mm (now positive for left hand rail high) and passes via P13, R71 and R72 to terminal 8d and the cross level indicators.
If right hand high rail is selected Re2 is de-energized and Re2/2 is closed. Therefore the signal from OP3D(14) passes via R68 to OP6D(13). The output is the same as for left hand high rail.

Track Lift (Only left side described):Inputs:

Proportional Levelling Transducer: The signal from the levelling transducer IfOD t 90m/V/mm (positive for lift) is fed into printed circuit 10u6 at terminal 26z and passes via R1 to OP1A(2). The output OP1A(12) is the same as the input and passes via P1 and R7 to the summing line.
Front Tower (Lift Value): The output from the front tower 4u5 terminal 28z is fed into 10u6 at terminal 24z at 50mV/mm (positive for lift). From terminal 26z the signal passes via R4 to OP2B(6). The output OP2B(10) is the same as the input and passes via P4 and R10 to the summing line.
Cross Level Correction: In order to correct minor cross level errors additional lift can be made by using 23fOB in plain line mode or 52fOB in switch mode. A signal of 600mV/mm (positive for lift) is fed into 10u6 at terminal 26d and passes via R3 to OP2A(2). The output OP2A(12) is the same as the input and passes via P5 and R9 to the summing line. A maximum of 3mm of lift can be applied.
Zero Correction: Minor errors in the levelling system (±5mm) can be made using 22f11. The signal is fed into 10u6 at terminal 30b and passes via R2 to OP1B(6). The output OP1B(10) is the same as the input (2V/mm positive for lift) and passes via R8 to the summing lien
Lift Reduction: In curves it is necessary to reduce lift and if the machine is fitted with GVA this is carried out automatically. The signal from the GVA at 100mV/mm (negative for lift) is fed into 10u6 at terminal 8z and passes via R5 to OP3A(1). The output OP3A(12), be amplified and inverted to 200mC/mm (positive for lift), passes via P6 and R10 to the summing line.

Summing Line: At the summing line the various signals from the inputs are added together. Due to differing values of resistors the signals at the summing line are adjusted e.g. the lift value from the front tower of 50mV/mm passes via P4 and R10 (= 19k) whereas the value from the levelling transducer of 90m/V/mm passes via P1 and R7 (= 9.5k). Therefore only half of the lift value is used compared with the error value. As they are in the ratio 1:1.8 only a small part of the lift value is ued (1:3.6).From the summing line the total signal passes to OP4A(1). P2 can be used to trim any minor errors when all inputs are zero.

The output OP4A(12) is now 1V/mm and is inverted (negative for lift) and passes:

1) via R40 and R41 to OP6A(1)
2) via R22 to OP4B(7)
3) via R27 to OP5A(1)
4) to terminal 16d

Output Stage:OP4B is used as a comparator and if the input OP4B(7) is negative the output OP4B(10) will be +15 volts ands relay Re1 will be energized. Re1/1 will close and connect the 24 volt feed at terminal 12b to terminal 12z and the lift indicator lamp 23h5 which will illuminate for positive inputs the output OP4B(10) will be –15 volts and Re1 will be de-energized.

OP5A is used to invert the signal via R27 and increase it by a factor of 2.5:1. The output OP5A(12) is positive for lift, passes via R29 to terminal 10b and the lift indicator 23g3. The output also passes via R30 to the over lift protection circuit.
OP6A is used to invert the signal via R40 and R41 and the output OP6A(12), now positive for lift, passes via R51 and R44 to OP6B(7). The output OP6B(10) is inverted and increased by approx 7:1. An input of 2mm will saturate the amplifier to an output of 14v (= 15mA

servo value current) which is fed into OP7 via terminals 22b and R62. The servo valve is connected in the feedback loop of OP7 via terminals 22d and 20z. The current will be 15mA when more than 2mm of lift is required. (Cut off point set with P8).
When automatic lift is required and the machine is in the correct part of the working cycle the processor output for automatic lift will be made, connecting terminal 16b to earth. If Re4 and Re3 are de-energized terminal 16b is connected to Re2 via Re4/1, Re3/2 and D11. The Re2 will now energize as the other side of the coil is connected to 24 Volts via terminal 14d Re2/1 will open removing the earth from R41 and allow signal from OP4B to pass to OP6A and give the servo valve a signal as described above.
Lift Unit Lowering: Under normal working conditions the lift unit is in the lowering condition unless lift is required. To lower the unit the processor give an output connecting terminal 18d to earth allowing Re4 to energize. As Re4/1 is open Re2 cannot energize and Re2/1 connects R41 to earth. A positive 15 volt signal via R47 is connected to OP6A(1). The output OP6A(12) is negative and gives the servo valve a lowering signal via OP6B and OP7.
Manual Lift: Under certain circumstances it is necessary to apply track lift manually. Push button 23X7A is depressed and if the program is complete the processor output Q1C connects terminal 4b to earth allowing Re3 to energize. The lowering signal is cancelled and as Re3/2 is open Re2 is de-energized. As Re2/1 is closed R41 is earth. Re3/1 closes and gives OP6A(1) a negative 15 volt signal via R46. OP6A(12) is positive and gives the servo valve a lift signal.
Over lift Protection: Should a fault occur in the lift system and cause the track to be over lifted the proportional transducer will give a lowering input and OP4A will have a positive output. Therefore OP5A will have a negative output. When the output reaches negative 10v (= 4mm) the comparator output OP5B(10) will change to positive 15 volts which will switch T1 on connecting terminal 8d to the earth at terminal 6db. Terminal 8d gives an input to the processor and prevents further track lift.
Settlement Compensation: The output at terminal 16d of 10u6 (L.H. Levelling) and 10u7 (R.H. Levelling) at 1V/mm, negative for lift are fed into the pendulum printed circuit at terminals 18z and 20d respectively. The inputs are taken via R53 and R55 to OP4B(6) and OP4B(5). The output OP4B(7) is the difference in the total lift value for each side (positive if L.H. side larger lift) and through V5, R33/2 and R57 charges K15.
When the processor gives a start lifting signal terminal 18b is earthed and Re3 energizes. Re3/1 changes over and removes the earth from R58. Re3/2 also changes over and connects K15 to OP4A(3) via R57, R3/2 and R58. This is to ensure that the lift difference does not change as track lift takes place. The output OP4A(1) goes to terminal 20b at 1V/mm of lift difference positive if L.H. side has larger lift) is taken to 22f09 and 22g2. 22f09 is used to set the percentage of lift difference used and this value is fed into 10u8 at terminal 12b. The signal passes via R78 to OP6A(2). The output OP6A(1) is now negative if the left side has the larger lift (too low) and passes to Re6/2, to comparator OP6C and via R79 to OP6B(6), the output OP6B(7) is inverted (positive for more lift L.H. side) and is taken to Re6/1 and terminal 12z which is connected to terminal 20z..
If the output OP6A(1) is positive (R.H. side has larger lift) the comparator output OP6C(8) will be +15 volts and Re6 will energize. Both contacts will change over, Re6/2 will earth terminal 16z and in turn earth terminal 6z of 10u6 (L.H. side). The negative signal from OP6B(7) will pass via Re6/1 to terminal 16b and in turn to terminal 6z of 10u7 (R.H. side).

From terminal 6z (10u6) the signal will pass via R6 to OP3B(7). The output OP13B(10) will be inverted and will pass to the summing line via R12 increasing lift on this side. At the same time the negative signal at terminal 12z (10u8) will pass to OP6D(13) via terminal 10z, R70 and P14 (10u8) to modify the cross level error signal from Re2 i.e. an extra lift of 2mm on the right hand side will cause this side to be over lift by 2mm. The resultant cross level error will be adjusted to zero.
If the larger lift is on the left side OP6C(8) will be –15 volts and Re6 will be de-energized. Re6/1 will earth terminal 16b and therefore terminal 6z of 10u7. The output OP6AZ(1) will give a negative signal to terminal 16z via Re6/2. Therefore a negative signal will be fed to

terminal 6z (10u6) which will be fed as a positive signal to the summing line of 10u6 via OP3B. At the same time a positive signal via terminals 12z and 10z will be fed to OP6D(13) again modifying the cross level error signal.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XV :Leveling & Lifting Control Circuit of UNO/DUO/ CSM/3X /Unimat

Session-49: Calibration of Lifting PCB, Troubleshooting & Fault finding.

CALIBRATION OF INPUT POTENTIOMETERS IN LEVELLING CIRCUIT:

CALIBRATION OF GENERAL LIFT POTENTIOMETER (4f3): This potentiometer is provided in panel no. B4 in front cabin. This potentiometer converts given general lift value to electrical signal at the rate of 50MV/MM output of this potentiometer can be checked by multimeter.For calibration of this potentiometer keep general lift potentiometer on zero and check output of this potentiometer with the help of multi meter it should be OV. If there is some signal on zero position first take out knob of potentiometer now rotate shaft of potentiometer to get zero volt. Now fit knob on shaft by matching zero position.
Now feed 100mm general lift now output of this potentiometer should be +5V if it is more than +SV then supply voltage to this potentiometer should be checked it should be +10V if it is not +10V (less or more) than adjust P1 potentiometer in EK 813 in panel No. B4.

CALIBRATION OF SUPER ELEVATION POTENTIOMETER: This potentiometer is provided in B2 panel in working cabin this potentiometer is used do provide SE. Values on curves. This converts cant values to electrical signal at the rate of 50MV/mm.output of this potentiometer can be checked at multicheck address F08.For calibration of this potentiometer. Set zero value in this potentiometer. Set zero value in this potentiometer. Select multicheck address F08 then check voltage on display. It should be OV if there is some value then remove digital counter set it to zero and also set shaft of potentiometer to get zero volt on display then refit digital counter on shaft.
Feed 180mm in S.E. potentiometer and select multi check address F08 keeping selector switch on position 2 display should show +9v. If this voltage in less or more then check +10V supply of EK813SV (6U4) if it is not exact +10V then adjust by potentiometer P1 (-10V by P2).
Now feed 5mm in S.E. potentiometer. Select LH rail high with cant selector. Measure voltage at 24Z it should be –1 volt if not adjust P11 in EK 346QV. Now select RH rail high with the help of cant selector. Now measure voltage at 24b it should be –1V if not adjust P12 in EK 346LV.

CALIBRATION OF FRONT INPUT PCB EK345LV:

For calibration of this PCB:

- Front bogie should be on zero cross level track.
- Measure voltage with the help of multimeter
- Measure voltage with the help of multimeter between terminals 12Z and 32 dbz. It should be zero volt if it is not zero then adjust P2S potentiometer in EK 345 LV. Front input PCB 4U5 to get zero volt.
- Place 100mm shim under LH wheel of front bogie. Measure voltage between 12Z and 32dbz it should be 5V if not adjust potentiometer P26 in EK345LV.
- Select LH rail high with the help of cant selector in working cabin measure voltage between 282 and 32 dbz of EK 345LV it should be –SV if not adjust P11 in EK 345LV.

- Place 100mm shim under RH wheel of front bogie and select RH rail high cant selector. Now measure voltage between 30z and 32 dbz of multimeter it should be – SV if not adjust P12 in EK 345 LV.

CALIBRATION OF MIDDLE PENDULUM IN EK 346LV:

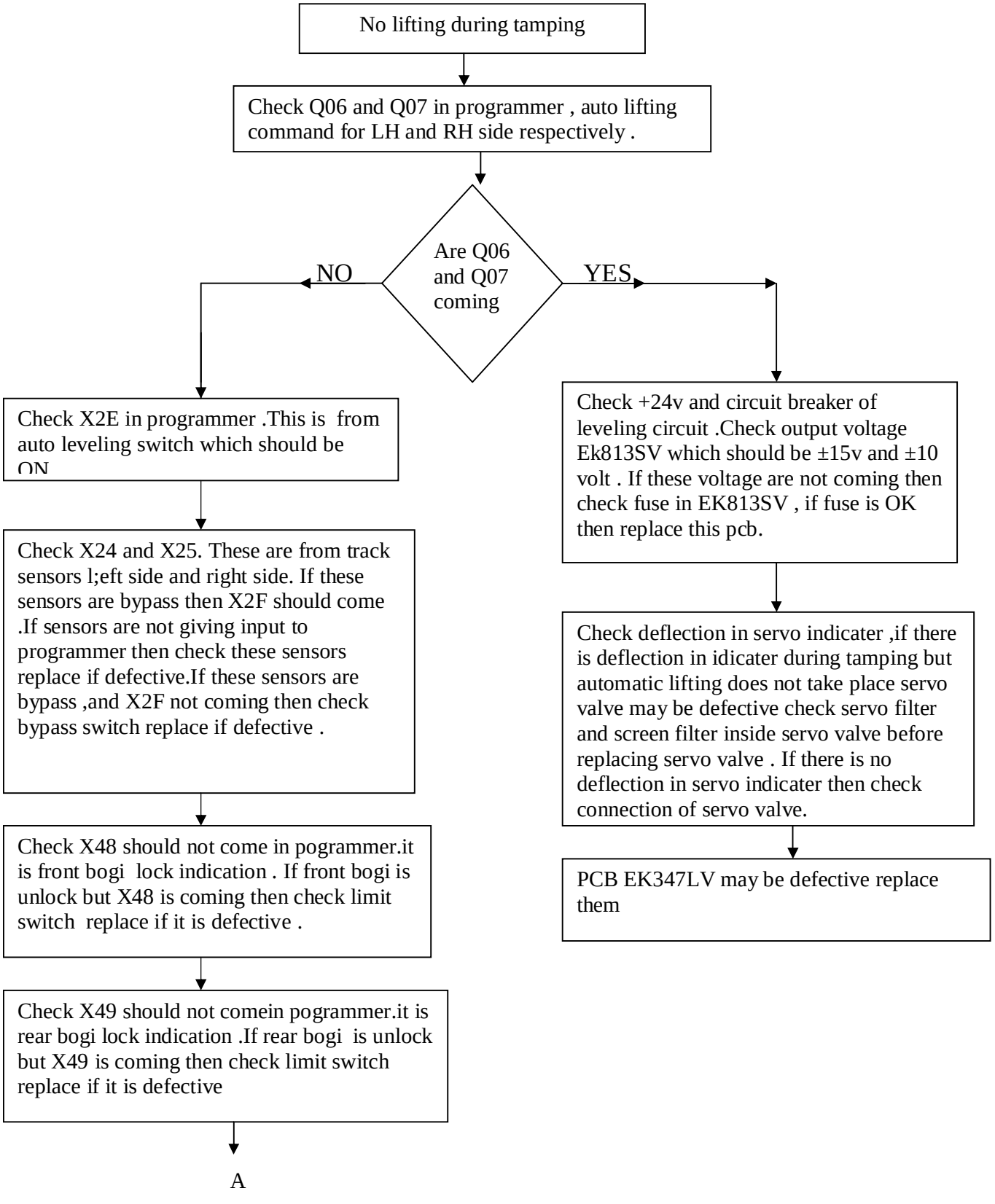
- Place 100mm shim under LH feeler rod of middle pendulum. Select LH rail high by cant selector.
- Feed 100mm in S.E. potentiometer cross level galvanometer should be at centre if it is not on centre then adjust P9 in PCB EK 346LV.
- Now place 100mm shim under RH feeler rod and feed 100mm in S.E. potentiometer. Select RH rail high. Galvanometer working area) should be at centre if not adjust P9 in EK 346LV to bring deflection.

- Select multicheck address F1E. Display should show OV if not zero then adjust pot P1 in EK 346LV.

CALIBRATION OF EK 346 FOR REAR PENDULUM:

- When rear pendulum on zero track then select F1E and check signal on zero it should be 0V if not then adjust P1 in EK346LV.
- Place 100mm shim under LH wheel. Select LH rail high with cant selector and feed 100mm in super elevation potentiometer. Now measure voltage at 26b terminal with the help of voltmeter (display) keeping selector switch on Ist position or with the help of multimeter. Voltage at 26b should be zero if it is not zero then adjust P2 in EK 346LV.
- Place 100mm shim under RH wheel of rear pendulum select RH rail with cant selector. Now feed 100mm in S.E. potentiometer. Now measure voltage at 26b with the help of voltmeter or multimeter it should be zero volt if not adjust P3 in EK 346LV to get zero volt.

TROUBLE SHOOTING OF LEVELLING CIRCUIT OF CSM



SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVI : Satellite Control Circuit:

Session-50: Functional Description of Satellite Control Circuit, Description of different positions of Satellite, Satellite Transducer, PCBs.

SATELLITE CONTROL CIRCUIT:

- Satellite Control circuit controls movement of Satellite This circuit is used only in CSM & CSM-3X for control of satellite movement. PCB EK 24V in CSM,& EK 202V in CSM-3X. are used for satellite movement control .

SATELLITE TRANSDUCER: Satellite transducer converts displacement of satellite to electrical signal at the rate of **11mv/mm.**This transducer is used in CSM and CSM-3X .Output of this transducer goes to satellite control PCB EK24V**(in CSM)** and EK202V(09-3X) at **6d** terminal of these PCBs.

CALIBRATION OF SATELLITE TRANSDUCER: For calibration of Satellite Transducer. Put Machine in working mode, lock the satellite unit in front zero position. Measure output voltage of transducer or at 6d terminal of EK24V, it should be +8.2V.If it is not +8.2v, then open the cover of transducer and loose three screws of potentiometer and adjust it to get +8.2V . After adjustment tight the screws and fit the cover of transducer and release the satellite from front zero position.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVI : Satellite Control Circuit:

Session-51: Functional Description of Satellite Control PCBs EK24V & EK202V

Explation of Satellite Control PCBs PCBs EK24V & EK202V

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVI : Satellite Control Circuit:

Session-52: Calibration of Satellite Control PCB Troubleshooting & Fault finding.

CALIBRATION OF SATELLITE CONTROL PCB EK24V:

For calibration of EK24V (10U8) Put machine in working mode select multicheck address F1D. and keep selector switch (18b4) on 2nd position. Now move satellite forward until display (18g4) indicate zero. If necessary adjust P1 in EK24V to get zero on display.

Mark position of Satellite wheel on rail. Now move satellite 300mm forward. Now check. Voltage on display (F1D) it should be **–6.9V,** if it is not –6.9v then adjust **P13** in EK24V to get –6.9V.

ZERO POSITION OF SATELLITE: Now move satellite forward by Joy stic (2X12) until satellite stops lower the lock for of satellite and lock satellite in zero position.

Now selector switch 18b4 on position 1 and check voltage at 6d terminal of EK24V it should be +8.2V if it is not adjust potentiometer of transducer . Select address F1D keep selector switch 18b4 on position 2. Voltage on display should be –10.2V if necessary adjust **P1** in EK24V.

Now turn 24 position switch 18b4 to position 1`and check voltage at out put of OP3 (10) it should be 0V if it is not 0V then adjust P9 to get zero volt on display.

ADJUSTMENT OF SATELLITE DISPLACEMENT DISPLAY: 19g6:

Displacement of satellite can be seen on display 19g6 . Keeping 5-position selector switch 19b6 on position-5th, when satellite is locked in zero position it should show 0mmif it is not showing 0mm then adjust potentiometer **P6** in display PCB to get zero display.

FRONT POSITION ADJUSTMENT: Select multicheck address F1D and keep multi position switch 18b4 to position 2. Check displacement of satellite on display 19g6, Keeping multi position switch 19b6 on 5th position. Now move satellite forward until display 19g6 indicate 120mm in this position Red LED in EK24V should glow and input to microprocessor **X1C** should go for **2 bar** brake of satellite. If red LED is glowing before or after 120mm then adjust **P10** to glow Red LED at 120mm.

MIDDLE POSITION ADJUSTMENT:
Move satellite backward until 19g6 display indicating 340mm in this position yellow LED in EK24V should glow and input to Microprocessor **X1B** should go for 5 bar satellite brake. If yellow LED is glowing before or after 340mm then adjust **P4** in EK24V.

BASIC CURRENT ADJUSTMENT OF PROPORTIONAL VALVE:
Select satellite proportional valve current Indicator using multi position switch 18b3 on position 3. Now move satellite front side when satellite stops in front then needle of current indicator should drop at **33%** of scale of current indicator (**250mA**) if this current is not 250mAthen adjust **P8** in EK24V to set minimum current or basic current at 250mA.

MAXIMUM FORWARD CURRENT: Bring satellite in rear position and release Hydraulic pressure. Now operate joy stick to drive satellite forward and watch deflection of satellite proportional valve current indicator it should be at **650mA (90%)** if it is not at 650mA then adjust **P7** in EK24V to get deflection of indicator at 650mA.

SATELITE CONTROL CIRCUIT OF CSM-3X: In CSM-3X satellite movement is controlled by PCB EK 202 V (10U11). Power supply PCB EK813SV is used.

SATELLITE TRANSDUCER: Satellite transducer converts displacement of satellite to electrical signal at the rate of 1.5 mv/mm. Signal of satellite can be checked at 6d terminal of EK202V.For calibration of satellite transducer lock satellite in rear lock position then measure the output of satellite transducer at 6d terminal of EK202V. It should be –8.6V. If it is not –8.6V then loose the screw of potentiometer and adjust it to get –8.6V.After adjustment tightened the screw of potentiometer. Now move satellite full forward output of satellite transducer should be +8.6V.

- Position the satellite in such position where output of satellite transducer at 6d terminal is 0v.

  In this condition output of Op-IB(7) should be OV. If not adjust P2 in EK202V to get OV. Now check voltage at 6Z it should be OV. If not adjust pot. P1 in such a way to get OV at 6Z.

- Mark this position and move satellite towards rear around 1000MM. Now check output of OP-1B(7). It should be +8V. because gain of OP1B(7) is set at the rate of 8mv/mm. If output of Op-1B(7).

  In some position check voltage at 6Z. It should be +10V because gain of OP2A is set at the rate of 10mv/mm. If voltage at 6z is not +10V then adjust pot.P13 to get +10V at 6z.

- Now move satellite in rear position and lock it satellite should be in such position that damper cylinder should press satellite in front position.

- Voltage at 6z or at (F11) should be +10V if not adjust P1 to get +10V at 6Z.

- Now move satellite in front position, keep the gap 30 to 50mm between damping cylinder and main chassis frame press the paddle and measure

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVII Work Drive Control Circuit:

Session-53: Functional Description of Work Drive Control Circuit, Encoder, PCB ELT-5034.

Work drive of CSM machine is controlled through PCB EK319LV.

There is a variable pump in driving circuit which is operated by proportional valve. Proportional valve is operated by PCB VT3005. VT 3005 receives signal from EK319LV it controls current to proportional valve of variable pump which is responsible for increase or decrease of speed of machine.

Working drive speed is synchronized with the satellite by a distance measuring wheel. This distance measuring wheel converts distance traveled by machine to pulses at the rate of 1000 imp/meter which frequency is 277.7 Hzs at 1 Km/hrs speed and EK319LV converts it to voltage (1km/hr = 1v.).Speed can be seen on bar type display. Maximum working speed can be set at 2km/hr.

PCB USED IN DRIVING CIRCUIT:

(1) Driving PCB-EK 319LV (6U8)

(2) Power supply PCB-EK813SV (6U7)

(3) Encoder PCB ELT-5034

(4) Variable pump proportional valve amplifier-VT 3005

ENCODER:

This transducer is used in CSM ,09-3X and DGS. This transducer converts displacement of machine to Digital signal at the rate of 1000 Pulse/meter. This is mounted on front trolley.out of this transducer is used for speed display.

Encoder PCB ELT-5034:-This PCB is mounted on Front trolley which receives inputs from encoder and sends to Workdrive PCB EK319LV and EK99V.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVII Work Drive Control Circuit:

Session-54: Functional Description of Work Drive PCB EK319LV& VT-3005

Functional Description of Work Drive PCB EK319LV):-

For the drive control of 09-machines the frequency/voltage transformation, the OP amplifier IC3Aand IC3B and the servo amplifier IC4 are used from this board.

1. Frequency – voltage transformation
   This stage is used by supplying a speed indicator.
   To input”12” the frequency signal is supplided(it is generated by the
   Distance measuring wheel withan incremental transducer-1000imp/m)
   The ICI is an integrated frequency/voltage transformer(VFC42) which
   Supplies at its output +10 V if the input frequency is 10Khz. With 1000
   Imp/m a voltage of 277,7Mv is generated by 1Kmph.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVII Work Drive Control Circuit:

Session-55: Calibration of Work Drive PCB, Troubleshooting & Fault finding .

CALIBRATION OF WORK DRIVE CIRCUIT OF CSM MACHINE:

Speed Adjustment Potentiometer:

There are two potentiometer for speed adjustment 19f40 and 19f40A.Selection of second potentiometer is done by toggle switch in B19 panel , by which we can reduce the speed to half .

Calibration procedure of work drive circuit:

Bring the machine on track. Where there should be sufficient space to drive machine at 1 Km/hr. speed in working mode.

- Now put machine in working mode for working drive. Lower the front trolley and front measuring wheel.

- Remove EK319LV PCB from it's slot and fit it again with extension card. When removing and inserting PCB supply of driving circuit should be off.

- Keep multi position selector switch 18b4 on position 1(displ)

- Now set machine for working drive and move the machine. Increase the speed with the help of speed adjustment potentiometer. Now measure voltage in PCB EK319LV on pin no1 of IC1 and increase speed until display shows .277V.

- ICI is the frequency to voltage converter IC. Pulses from distance measuring wheel encoder is applied at 12db terminal which frequency is 277.7Hz. ICI convert it to 277mV or . 277V at 1 Km/hr. speed.

- Now let the machine move at 1Km/hr. speed.

- Now select multicheck address F1B. Keep multi position selector switch on 2nd position. Display should show +1V. If display is not showing +1v then adjust potentiometer P1 in EK319LV.

- Now keep multi position selector switch on position 1 and measure voltage at 26db terminal of EK 319LV with the help of test prob it should be .62V , if not adjust P3 in same PCB.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVIII Hook Control circuit

Session-56: Functional Description of Hook Control Circuit and Transducer

Hook Control Circuit

Hook Control Circuit: Hooks are used only in Unimat machines to lift the track on switch & crossings where rollers clamp can not be used**.**Hook Control Circuit is used only in point and crossing tamping machines to control depth of Hook.. Two different depths may be selected by a theoretical value potentiometer. The actual value is monitored by Hook control PCB with the help of Hook depth transducer , There are two positions where Hook can be applied PosI (Rail Head) and PosII (Rail Foot)

Printed Circuit Board PCB: In Unimat 2S, PCB 144V and in Unimat 3S PCB EK 120V is used for Hook Control.

Transducers:

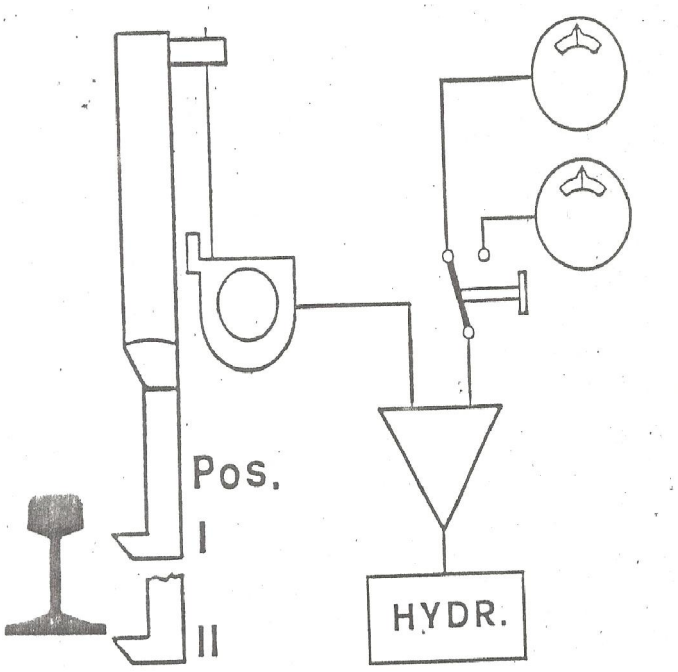
1f50 Hook depth Transducer Left

1f51 Hook depth Transducer Right

23f1 Required Depth L.H. side Rail head
23f2 Required Depth L.H. side Rail foot
23f3 Required Depth R.H. side Rail head
23f4 Required Depth R.H. side Rail foot

Switches:

23b1 Rail head/Rail foot L.H. side
23b2 Rail head/Rail foot R.H. side



Hook depth Transducer 1f50(Left) ,1f51 (Right) :

This transducer converts displacement of hook to electrical signal at the rate of 23mv/mm .Multicheck address of hook Transducers are F18(Left) and F19(Right).

Calibration :-For calibration of hook transducer hook should be in up position ,select multicheck address of hook transducer **F18 or F19**, in this position output voltage of hook transducer should be **-2.2 Volt**. If output is not -2.2 V then open the cover of transducer and loose three screws of potentiometer and adjust it to get -2.2 V.

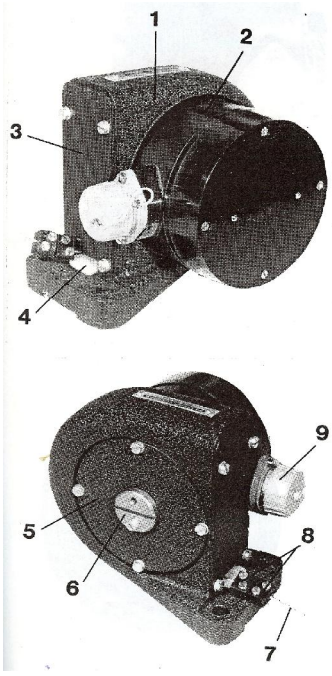


Fig. 1
1 = Housing
2 = Transmission
3 = Assembly Cover
4 = Chord Guide Strips
5 = Cover
6 = Spring Fixing Bolt
7 = Potentiometer Chord
8 = Chord Clamps
9 = Socket

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVIII Hook Control circuit

Session-57: Functional Description of Hook Control PCB EK120V & EK144V

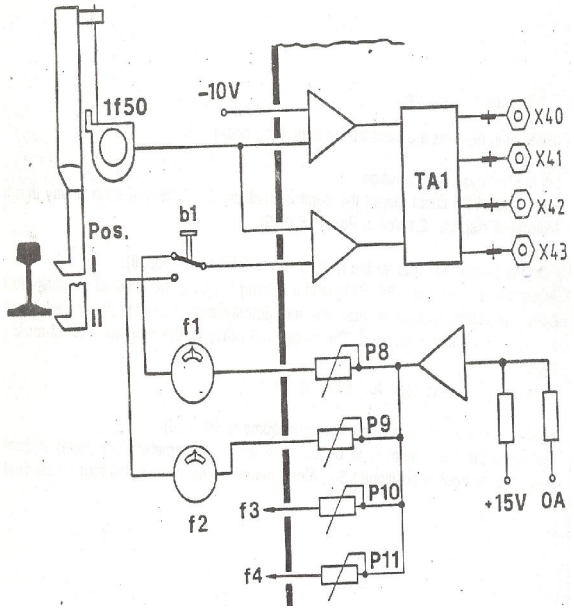
Circuit Description of PCB EK-120V-00(6U5) in Unimat 3S

Lowering of Hook:

The hook can be lowered to either rail head or rail foot, selected with 23b1(LH)and 23b2(RH).

The theoretical depth is set with potentiometer 23f1 (for rail head). This is supplied with **+3 volts** set from 6u5 terminal 30b and adjusted using **P8.**

The required depth is set and the resulting voltage (between 1.5V and 3V) is fed into 6u5 at terminal 32z and via R40 to OP2C(10). The output OP2C(8) is identical to the input and provides a reference voltage for the comparator OP2B(5). The actual depth is fed in at terminal 26b and passes via R41 to OP2B(6).



If the voltage at OP2B(6) is less than OP2B(5) the output OP2B(7) will be +14 volts. This is fed into the transistor array TA1 pin 1 and connects terminal 18b to earth, This becomes an input to the processor. If the program to lower the hook is complete the processor will effectively earth erminal 10z and through R50 and D11 switch on the LED 3/4 of OC1. This will switch on the transistor 5/6 which will turn on T2, connecting terminal 4z to terminal 6z (earth). The lowering solenoid will now energies and the hook will lower. The actual depth voltage will become more positive and when equal to the theoretical voltage OP2B(7) will switch to –14 volts switching off TA1 1/18 and removing the input to the processor and therefore to terminal 10z . OC1 3/4 will now switch off and T2 will rapidly de-energies the lowering solenoid, stopping and hook in the required position.

If the hook is required to apply at rail foot switch 23b1 is changed to the rail foot position and 23f2 will feed in the reference voltage (between 2.5 & 5 volts) to terminal 32z. A higher voltage therefore a greater depth. The hook will now lower until the actual depth voltage equals this greater reference voltage.

Lifting of Hook: A -10 volt signal is fed in at terminal 24d and passes via R30 to OP3D(12). R61 connects this terminal to earth and set the voltage at –2 volts. The output OP3D(14) will –2 volts. This forms the reference voltage for the comparator OP3A. Terminal 20b is connected to terminal 26b and the actual depth signal is fed to OP3A.

If the hook is lowered the voltage at terminal 20b will be more positive than the reference voltage and OP3A(1) will be –15 volts switching off TA1 5/24 and ensuring that the processor input via terminal 18z is not made.To lift the hook the processor output connects terminal 12d to earth which switches on LED ½ of OC1 and therefore transistor 7/8. This will turn on T1 connecting terminal 8z to earth and energizing the lifting solenoid.As the hook raises the actual depth voltage decreases and when equal to –2 volts OP3A(10) switches to +15 volts TA1 5/14 is switched on connecting terminal 18z to earth giving an input to the processor for the drive safe routine. The hook is stopped in its upper position physically.

Circuit Description of PCB EK-144V-00 in Unimat 2S

In Unimat-2S EK144V-00 PCB is used in hook control circuit .Theoretical depth value (+ polarity) is applied at connection “32z” which is fed to Operational Amplifier “OP2C” via resistor ”R40” and capacitor “K12”. K12 represent a low pass filter to avoid eventual high interfering frequency. Operational Amplifier “OP2C” is a buffer which output is applied to “OP2B (5)” via resistor “R 32”. OP2B is a comparator which compare signals applied at pin no 5 and 6 .At the pin no 6 of the OP2B via “R41” the left depth-actual value of the hook depth transducer is available (+ polarity).

As long as the theoretical signal at pin no 5 of OP2B is more positive than the actual value signal at pin no6, the output at pin no 7 will be on full level (approx + 14 volts) which is applied at base of transistor in transistor array T A1 at pin no1 via diode D4.Transistor supplies an earth signal via pin no 18 of TA1 to the output connector 18b of PCB. This signal is used as input X40 (left hook lowering) by processor for the further control .In the same way the other four theoretical-actual-comparison circuits are operating with “OP2A”,”OP3A”, and “OP3B”.

With the OP1D a voltage of +7.5 V is generated at output pin no 1 by means of the potentiometers P8, P9,P10 and P11 this voltage can be set at 3V by P8 & P10 for rail head and at 5.5V by P9 & P11 for rail foot.

Four FET(Field effect transistor)-power transistors are also used in this PCB. These field effect transistors can operate solenoid directly. The output signal is an earth signal and therefore at the other end of the coil of solenoid +24V is applied.

The parallel diodes “D18” to “D 21” serve as transistor protection in case of negative back voltages by solenoids. The terminals of FET are: S (SOURCE), D(DRAIN) and G (GATE).

Via the gate ”G” the control voltage which connects the connection from “S” to “D” is supplied .Via a dropping resistor R49 with diode D10 an earth signal supplied by the programmer energizes an optical coupler OC1.In OC1 the internal LED illuminates which light energizes photo transistor. The photo transistor transfers then a plus-signal applied at collector to emitter then to the gate “G”of the corresponding FET transistors(T1) through OC1(8) and resistor R45.Because FET transistors have a very high gate resistance ,a leak resistor R53 is provided against earth .

For protection against voltage peaks when the solenoid of valves cut off a protection combination is provided which consists of a resistor R60 and a free wheeling diode D14

The + 24V power supply for the Solenoids of hook DC valves should be supplied via the fuse Si1(6,3A).

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XVIII Hook Control circuit

Session-58: Calibration of Hook Control PCB, Troubleshooting & Fault finding

Calibration potentiometers in Hook Control PCB:-

P8 :- Required Depth LH Side Rail head.
P9 :- Required Depth LH Side Rail foot.
P10:- Required Depth RH Side Rail head.
P11:- Required Depth LH Side Rail foot.

S.No.	Faults	Causes and Remedial Actions
1.	L.H. hook is not getting lower	i) Switch for LH hook down should be in ON position and signal should come on multi check or subroutine Q00→X00 should come on multi check and following conditions should also be fulfilled.
		a) Preselector switch for LH hook should be in ON position
		b) Switch for LH lining unit unlock should be in ON position and indication should come on multi check.
		c) Switch for LH hook always down should be in ON position and indication should come on multi check.
		d) If indication for all above conditions are not coming on multi check then check the lifting circuit.
2	R.H. hook is not getting lower	If hydraulic circuit is found Ok then problem is in electrical circuit. Check it as follows. i) Switch for RH hook down should be in ON position and signal should come on multi check or subroutine Q01→X01 should come on multi check and following conditions should also be fulfilled. a) Preselector switch for RH hook should be in ON position b) Switch for RH lining unit unlock should be in ON position and indication should come on multi check. c) Switch for RH hook always down should be in ON position and indication should come on multi check. d) If indication for all above conditions are not coming on multi check then check electrical circuit.
3	R.H. hook is not going outward	If hydraulic circuit is found Ok then problem is in electrical circuit. Check it as follows. i) Condition Q63→X63 should be fulfilled and indication should come on multi check. ii) Condition Q06→X06 should not come on multi check. iii) Condition Q07→X07 should not come on multi check. iv) Preselector switch for RH hook should be in ON position and indication should come on multi check. v) RH lining unit should be in unlock condition and indication should come on multi check. vi) If any one of the above condition is not fulfilling, the relay QL72 may be defective. Check and do the needful. vii) Fuse for QL72 may also be blown. Check and do the needful.
4	L.H. hook is not going outward	If hydraulic circuit is found Ok then problem is in electrical circuit. Check it as follows. i) Condition Q63→X63 should be fulfilled and indication should come on

		multi check. ii) Condition Q06→X06 should not come on multi check. iii) Condition Q07→X07 should not come on multi check. iv) Preselector switch for LH hook should be in ON position and indication should come on multi check. v) LH lining unit should be in unlock condition and indication should come on multi check. vi) If any one of the above condition is not fulfilling, the relay QL74 may be defective. Check and do the needful. vii) Fuse for QL74 may also be blown. Check and do the needful.
5.	R.H. hook is not coming inward	If hydraulic circuit is found Ok then problem is in electrical circuit. Check it as follows. i) Check the signal X43 on multi check .If not coming then check output at terminal no. 12 of Transistor TA 1 of PCB EK144V-02. If it is not found there then transistor may be defective. Replace it. ii) Switch for lifting unit fully up should be in ON position. iii) Signal for QL73 should come on multi check. If not coming then relay may be defective. iv) Fuse for QL73 may also be blown. Check and do the needful.
6.	L.H. hook is not coming inward	If hydraulic circuit is found Ok then problem is in electrical circuit. Check it as follows. i) Check the signal X42 on multi check .If not coming then check output at terminal no. 14 of Transistor TA 1 of PCB EK144V-02. If it is not found there then transistor may be defective replace it. ii) Switch for lifting unit fully up should be in ON position. iii) Signal for QL75 should come on multi check. If not c coming then relay may be defective. iv) Fuse for QL75 may also be blown. Check and do the needful.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:19 SESSIONS:59)

Lesson-XIX Panel Boxes & Cable List

Session-59: Main Panel Boxes i.e Working & Engine Panel boxes, Cable List

---

Panel Boxes :-In the machines switches, relays , PCBs and wiring connectors are fitted in Panel Boxes provided in cabins and machines chasis.list of panel boxes is as under.

Panel Boxes in Unomatic & Duomatic

S.No.	Panel Box No.	Description
1.	B2	Working control panel R.H.S.in working cabin.
2.	B4	Front inputs panel in front cabin.
3.	B5	Engine control panel in working cabin.
4.	B7	Levelling and lining control Panel
5.	B11	Engine control panel in front cabin
6.	B13	Engine electrical circuit junction box
7.	B19	Galvanometers box
8.	B33	Galvanometer (cross level and lining)Box in front cabin.
9.	B50	Electrical terminals box outside on machine chassis for solenoids.
10.	B51	Manual cross level correction on working chair handrest LHS
11.	B52	Manual cross level correction on working chair handrest RHS

Panel Boxes in CSM

S.No.	Panel Box No.	Description
1.	B2	Working control panel R.H.S.in working cabin.
2.	B4	Front inputs panel in front cabin.
3.	B5	Engine control panel in working cabin.
4.	B6	PCBs slide module
5.	B7	Base plate for logistic cabinet
6.	B9	Galvanometer (cross level and lining)Box outside machine chassis
7.	B10	PCBs slide module
8.	B11	Engine control panel in front cabin
9.	B13	Engine electrical circuit junction box
10.	B18	Measuring and multicheck Panel
11.	B19	Working control panel L.H.S.in working cabin.
12.	B20	Programmer PCBs slide module
13.	B26	Electrical terminals box outside on machine chassis.
14.	B28	ZF gearbox electrical circuit junction box
15.	B29	Fault indication box
16.	B33	Galvanometer (cross level and lining)Box in front cabin.
17.	B40	Intercom Box
18.	B45	Electrical terminals box outside on machine chassis.
19.	B47	Electrical terminals box outside on machine chassis.
20.	B48	Electrical terminals box outside on machine chassis.
21.	B50	Electrical terminals box outside on machine chassis.
22.	B51	Manual control box on working chair handrest LHS
23.	B52	Manual control box on working chair handrest RHS
24.	B53	Working light electrical terminals box outside on machine chassis.
25.	B55	Fault indicater electrical terminals box outside on machine chassis.
26.	B77	Laser battery charger box

27.	B79	Engine throttle control box front cabin
28.	B80	Engine throttle control box working cabin
29.	B81	Engine throttle control box

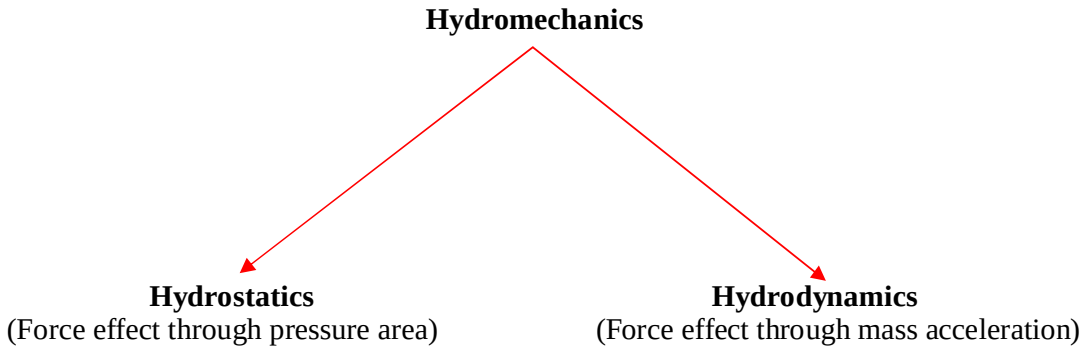
Panel Boxes in Unimat 2S & 3S

S.No.	Panel Box No.	Description
1.	B4	Front inputs panel in front cabin.
2.	B5	Engine control panel in rear cabin.
3.	B6	PCBs slide module
4.	B7	Base plate for logistic cabinet
5.	B10	PCBs slide module
6.	B11	Engine control panel in front cabin
7.	B13	Engine electrical circuit junction box
8.	B18	Measuring and multicheck Panel
9.	B20	Programmer PCBs slide module
10.	B22	Working control panel R.H.S.in working cabin.
11.	B23	Working control panel middle.in working cabin.
12.	B24	Working control panel L.H.S.in working cabin.
13.	B26	Electrical terminals box outside on machine chassis.
14.	B28	ZF gearbox electrical circuit junction box
15.	B29	Fault indication box
16.	B33	Galvanometer (cross level and lining)Box in front cabin.
17.	B40	Intercom Box
18.	B51	Lifting correction and tamping tool slew , outside R.H.S.
19.	B52	Lifting correction and tamping tool slew , outside LH.S.
20.	B53	Working light electrical terminals box outside on machine chassis.
21.	B55	Limit switch connector box.
22.	B69	Terminal box clamp.
23.	B94	Recorder panel box rear

SUB: HYDRAULICS, PNEUMATICS & MECHANICAL
Duration: 74 Sessions = 148 Periods
Sub-discipline: Hydraulics (Lessons: 20 Sessions: 42)
Lesson-I: Fundamentals Session–1: Introduction, Pascal's Law, Bernoulli's Theorem, Advantages of Hydraulic System.

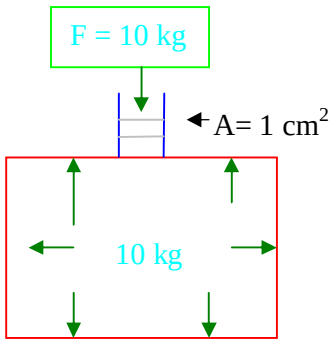
INTRODUCTION:

The word hydraulics originates from the Greek. This is made of two words-hydor and aulos. Hydor means water and aulos means pipe i.e. flow of water through pipes. Today the term hydraulic commonly refers to "Power hydraulics" in which fluid is used under controlled pressure to do work. Hydraulic power is used in every branch of industry in a machine tool, missiles, man made satellite, boat, planes, cranes, lifts, track machines etc. So fluid is most versatile means of transmitting power & modifying motions. A fluid is infinitely flexible. It can easily change its shape, it can be divided into parts to do work in different locations, it can move rapidly in one place and slowly in another place. No other medium has the same accuracy, positiveness & power in minimum of volume & weight. It is the science of forces and movements transmitted by means of liquids i.e. generation of forces and motion using hydraulic fluid. It is a part of hydromechanics.

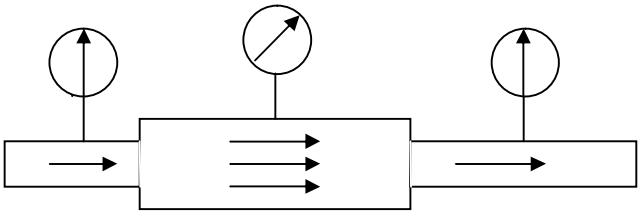


Hydraulic fluid contains two energy: (1) Kinetic energy (2) Potential energy.
Basically hydraulic fluid obeys:

PASCAL'S LAW: It states that when pressure is applied on a confined fluid, it is transmitted undiminished in all directions, and acts with equal force on equal areas, and at right angles to them.



BERNOULLI'S PRINCIPLE: "It states that in a system with constant flow rate, energy is transformed from one part to other, each time the pipe cross-section changes"



CHARACTERISTICS OF HYDRAULICS:

- Ø **Multiplication of Forces:** If a small force on small area would create a proportionally larger force on a larger area, the only limit to the force, a machine can exert, is the area to which the pressure is applied.
- Ø **Incompressibility:** Hydraulic fluid is incompressible that is why tremendous pressure is achieved.
- Ø **Acceptance of Shape:** The hydraulic fluid accepts the container's shape in which that is contained.
- Ø **Non Diffusion:** Hydraulic fluid can be easily poured from one container to another without diffusing in atmosphere.

ADVANTAGES OF HYDRAULICS:

1. **Variable Speed:** The actuator of a hydraulic system can be driven at variable speeds by varying the pump delivery or using a flow control valve.

2. **Reversibility:** An actuator can be reversed instantly while in full motion without damage. A four way directional valve or a reversible pump provides the reversing control.

3. **Overload Protection:** The pressure relief valve in hydraulic system protects it from overload damage. When the load exceeds the valve setting, pump delivery is directed to tank.

4. **Self Lubrication:** In most hydraulic components internal lubrication is provided by the fluid**.** Pump elements and other wearing parts slide against each other on a film of fluid.

5. **Cooling:** Circulation of the fluid through lines and around the walls of the reservoir allow the fluid to give up the heat that has been generated in the system.

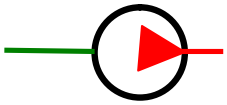
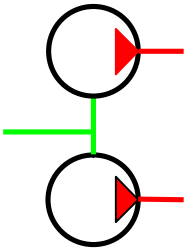
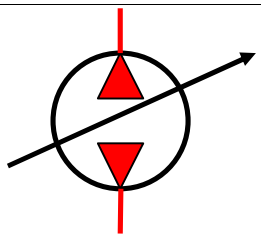
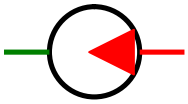
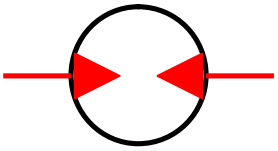
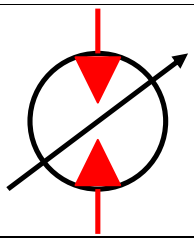
6. **Sealing:** In many instances the fluid is the only seal against pressure inside the hydraulic component. In DC valve there is no seal between the valves spool and the body to minimize leakage. The close mechanical fit and the viscosity of the oil determine leakage rate.

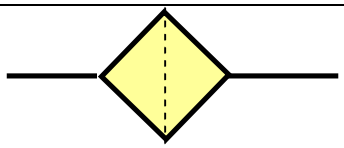
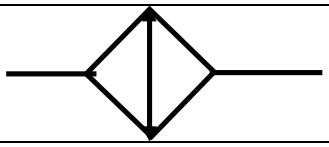
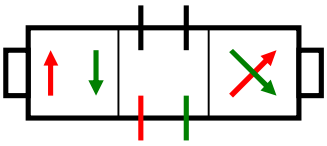
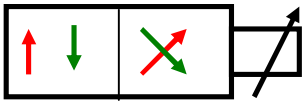
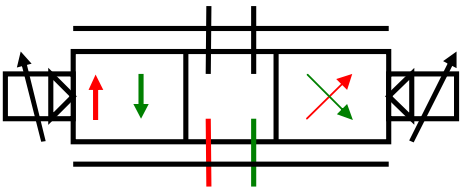
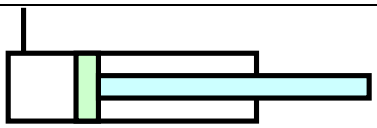
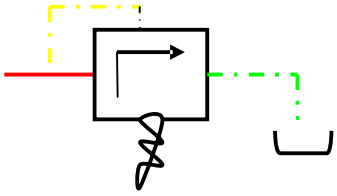
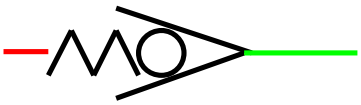
7. **Easy to Install and Handle:** Hydraulic components can be easily installed and handled due to less weight and size in compare to mechanical system.

8. **Portable:** Hydraulic plant can be used in mobile application.

9. **Compactness:** Hydraulic components can provide high power output with very small weight and size.

HYDRAULIC SYMBOLS:

	**Single Pump**
	**Double Pump**
	**Variable Pump**
	Return Line **Pressure Line**
	Pilot Line
	**Uni-Directional Motor**
	**Bi-Directional Motor**
	**Variable Motor**
	Stop Cock

	**Filter**
	**Cooler**
	**4/3 Way Valve**
	**4/2 Way Valve**
	**Servo Valve or Proportional Valve**
	**Single Acting Cylinder**
	Double Acting Cylinder
	**Relief Valve**
	**Check Valve/ Non-Return Valve**

Proper selection and care of hydraulic fluid for a machine will have an important effect on machine performance and on the life of the hydraulic components. Any liquid is essentially incompressible and therefore will transmit power instantaneously in hydraulic system. The most common liquid used in hydraulic system is petroleum based oil. Oil transmits power readily because it is only very slightly compressible, a negligible amount in most systems. The most desirable property of oil is its lubricating ability.

FUNCTIONS:

1. To transmit power from one point to another
2. To lubricate moving parts
3. To cool or dissipate heat
4. To seal clearance between parts
5. Cushioning of oscillations caused by pressure jerks.
6. Corrosion protection.
7. Scuff removal.

PROPERTIES:

1.1 Suitable viscosity:-viscosity is measure of fluid's resistance to flow. If a fluid flows easily, its viscosity is low. Fluid flows with difficulty have a high viscosity. Some methods of define viscosity are: absolute viscosity, kinematic viscosity, and relative viscosity and SAE numbers. Kinematic viscosity is the most common way of measuring viscosity. It is measured by the amount of time needed for a fixed volume of oil to flow through a capillary tube. The unit for kinematic viscosity is mm^2/sec or centistokes.

Too high a viscosity increases friction, resulting in –

1. High resistance to flow
2. Increased power consumption due to friction loss
3. High temperature caused by friction
4. Increased pressure drop due to resistance
5. Possibility of sluggish or slow operation
6. Difficulty in separating air from oil in reservoir.

Too low a viscosity resulting in –

1. Internal leakages increases
2. Excessive wear and even seizure may occur under heavy load due to break down of oil film between moving parts
3. Pump efficiency may decrease causing slower operation of the actuator
4. Leakage losses may result in increased temperatures.

1.2 Anti-rust and anti-corrosive:-rusting is the chemical union of steel with oxygen. Corrosion is chemical union between a metal and acid. Corrosion occurs as the acid acts on the metals. Rusting is caused by air bubble in the system. It is usually not possible to keep air and atmosphere born moisture out of hydraulic system. They contaminate the system and promote wear. There are several ways of preventing rust and corrosion. The best way is that hydraulic system may work at proper temperature and pressure. A fluid should be filtered properly

1.3 Oxidation resistance :- Fluid oxidation is the chemical reaction of the fluid with air which forms new substances or compounds, when hydraulic oil oxidized, it form gum, sludge. Some of these soluble compounds are acids which bites the metallic components in the system. It is the most common factor that reduces the fluid life. These contaminants close the orifice, increases wear and tear and causes valves to stick. The best control is through the good maintenance.

1.4 Resistance to foaming:- A small air bubble get entrapped during course of suction and delivery of released oil from circuit. Air also enters through vent hole and mixes with oil and affects the efficiency. Air also causes heating of the oil and hydraulic assemblies. Return pipe should be located well below in the hydraulic tank.

1.5 Low pour point: Pour point is the lowest temperature at which a fluid will flow. Beyond this it becomes so thick that it won't flow any more.

Method of identifying hydraulic oil:

One important method of identifying hyd. oil is the specification of viscosity class. The ISO standard and new draft of DIN 51524 explain that the viscosity classes lay down the minimum and maximum viscosity of hyd oil at 40^0C

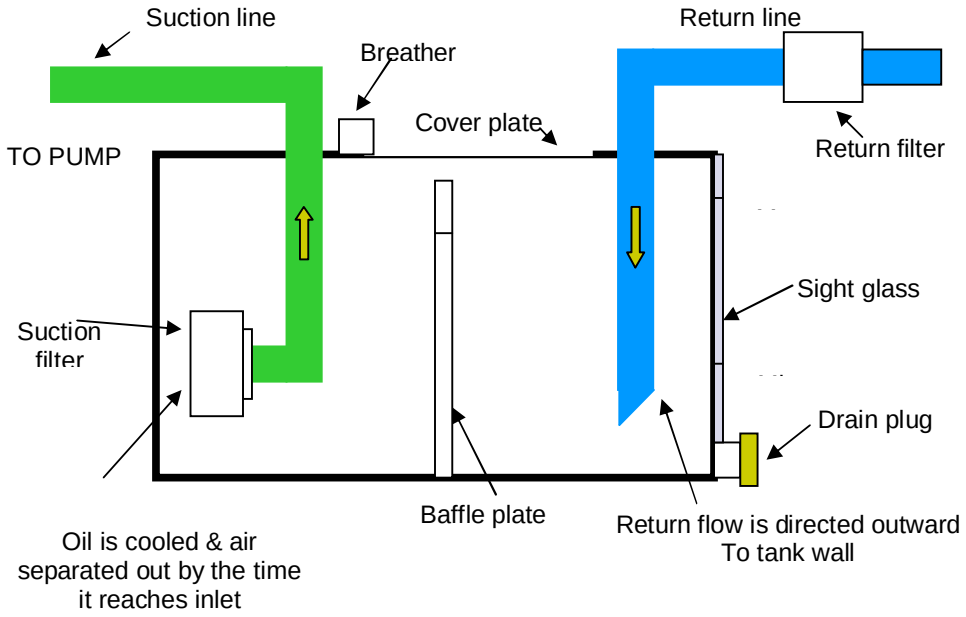
ISO VISCOSITY CLASSES	KINEMATIC VISCOSITY (MM^2 /S) AT 40^0 C	
	MIN	MAX
ISO VG 10	9.0	11.0
ISO VG 15	13.5	16.5
ISO VG 22	19.0	24.8
ISO VG 32	28.8	35.2
ISO VG 46	41.4	50.6
ISO VG 68	61.2	74.8
ISO VG 100	90.0	110.0
ISO VG 150	135	165

Qualities of hydraulic fluid:

1. Lowest possible density
2. Minimal compressibility
3. Viscosity not too low
4. Good viscosity temperature characteristics.
5. Good viscosity-pressure characteristics.
6. Good aging stability.
7. Low flammability.
8. Good material compatibility.

FUNCTIONS: The reservoir in the hydraulic system fulfils several task--

1. Acts as intake and storage reservoir for the hydraulic fluid required for the operation of the system.
2. Dissipates heat.
3. Separates air, water and solid materials.
4. Supports a built – in or built – on pump and drive motor and other hydraulic components such as valves, accumulator etc.



PARTS:

- Baffle plate: - It separates pump inlet line and return line. It is usually about 2/3 of the total height of the tank lower corner of the plate may be cut away to permits circulation. Thus the baffle plate
    1. Prevents local turbulence
    2. Allows foreign material to settle to the bottom.
    3. Give the fluid an opportunity to free of entrapped air.
    4. Helps heat dissipation.
- Inlet and Return line:-Most line of the tank terminates below the oil level. The line connections are often sealed. This prevents dirt from entering through these openings. Pumps inlet and return line must be below the oil level otherwise oil may be aerated and foaming may start. Connections above the oil level must be tightly sealed to prevent the entry of air in the system.
- Air breather: - An air breather is installed at the tank to vent air to the atmosphere and also atmosphere air exerts pressure on the oil surface through air breather, so screening element of air breather should be cleaned regularly.
- Sight glass: - This is provided to see the oil level in the hydraulic tank and oil is filled accordingly.
- Drain plug: - It is provided at the bottom of the tank to drain oil from tank at the time of cleaning the tank. Generally magnetic drain plug is provided to trap iron particles present in the oil.
- Return filter: - It is provided on the top of the tank. It traps contaminants present in oil which is returned from the hydraulic circuit to tank.

FUNCTION & IMPORTANCE OF FILTRATION:

About 75% of hydraulic maintenance is caused by dirty oil. Dirt can cause untold damage to the entire system. The use of a filter is an important stage in keeping dirt cut off the system and hence reducing hydraulic maintenance.
Filter is a device whose primary function is retention, by some porous medium, of insoluble contaminants from a fluid. Porous medium simply refers to a screen of filtering material that allows fluid to flow through it but stops other materials by porous medium. A simple screen or wire strainer is rated in microns for filtering fineness or a mesh number or its nearest seive number. The higher the mesh or sieve number, the finer the screen. When a filter is specified as so many microns, it usually refers to the filter's nominal rating and its value is in microns such that a 10 micron filter can trap particles having size more than 10 micron. So filters are of great significance in hydraulic systems for the reliable functioning and long service life of component.
It is the task of the filter to reduce the contamination to an acceptable level in order to protect the various components from excessive wear. It is necessary to use correct grade of filter and a contamination indicator is required in order to check the efficiency of the filter. Systems are often flushed using economical filters before commissioning.

TYPES:

1. **Inlet strainer & filter:-** Strainer is installed on pump inlet lines inside the tank, it is relatively course as filter being constructed of fine mesh wire. A 100 mesh strainer is suitable for thin oil, protects the pump from particles above about 150µ in size. There are also inlet line filters usually mounted outside the tank near pump inlet. A fine filter (unless it is very large) creates more pressure drop that can be tolerated in on inlet line of a pump.
   The filter must pass the full pump volume within the permitted inlet vacuum for that pump. The filter must provide bypass flow which is still with in that limit where the filter element is blocked. Inlet filters should be used only to prevent large particles from entering the pump & causing catastrophic failure.

2. **Pressure line filter:-** This filter can trap much smaller particles than inlet line filter. Such a filter is used where system components such as valves are less dirt tolerant than the pump. The filter traps fine contaminants from the fluid as it leaves the pump and also protects the system in the event of a catastrophic failure of the pump. Pressure line filters must be able to withstand the operating pressure of the system as well as any pump pulsation.

3. **Return line filter:-** These filters can also trap very small particles before the fluid returns to the tank. Return line filter is necessary in a system with a high performance pump which has very close tolerance & usually cannot be sufficiently protected by an inlet line filter. Full flow return filter should have enough capacity to handle max. return flow without opening the bypass valve (non return valve) the performance of any return line filter depends on magnitude of flow and pressure changes.
   The term "full flow" applied to a filter means that all the flow into the filter inlet port pass through the filtering element. In most full flow filters there is a bypass valve preset to open at a given pressure drop to divert flow past the filter element. This prevents the element from being subjected to excessive pressure which could cause collapse. The bypass opens when total flow can no longer pass through the contaminated element without raising the pressure.

FILTERING MATERIALS:

There are two basic classifications of filtering material viz. (1) Absorbent (2) Adsorbent.

1. **Absorbent filter:** Absorbent filter medium traps particle by mechanical means. Absorbent media are divided into two basic types viz. surface & depth. Surface media is most commonly used for coarse filtration. These are usually used with strainers. These are made of closely woven fabric. Depth media are generally used for finer filtration and are made of a wide range of materials. It has layers of a fabrics or fibers which provide paths for the fluid to flow through. These are usually used with filters. Particles collect on a number of surfaces arranged in layers.
2. **Adsorbent filter:** Such a charcoal & fuller's earth should be avoided in hydraulic system, since they may remove essential additives from the hydraulic fluid.

SOURCES OF CONTAMINATION:

1. **Built-in contamination**: Hydraulic system manufacturers generally are careful to provide internally clean products but, in spite of these efforts, new equipment usually contains some built-in contamination. These contaminants might include burrs, chips, flash, dirt, dust, fibers, sand, moisture, pipe sealants, weld splatter, paints and flushing solutions.
2. **Ingress or environmental contamination** is contamination that is added to the hydraulic system during servicing or maintenance (or from lack of maintenance) or is introduced to the system from the environment surrounding the equipment. Dirt contamination during operation owing to wear, ingress via seals and tank ventilation, filling up or changing hyd. fluid, exchanging components, replacing hoses.
3. **Self-generated contaminations**- This type of contamination is created internally within the system by the moving parts of hydraulic components. These contaminants are produced by wear, corrosion, cavitations and decomposition and oxidation of the system fluid. Every internal moving part within the system can be considering a source of self-generated contamination for the entire system.

CONTAMINANTS CONTROLS: Contaminants can be controlled in following ways –

i. Preventing contamination by keeping the system tight and using proper air and fluid filtration devices and procedures.
ii. Establishing fluid change intervals so the fluid will be replaced before it breaks down. If necessary the fluid can be tested in the laboratory at specific intervals to help establish the frequency of change.
iii. Keeping the reservoir filled properly to take advantage of its heat dissipating characteristics and to prevent moisture from condensing on inside walls.
iv. Repairing all leaks immediately.
v. The filters must provide sufficient dirt holding capacity for an acceptable interval between element changes

Beta Ratio: The beta ratio is also known as filtration ratio, is a measure of the particle capture efficiency of a filter element. It is therefore a performance rating.

$$\beta_x = \frac{\text{Number of particles in upstream}}{\text{Number of particles in downstream}}$$

Where,

x= size of particle in micron

Let no. of particles in upstream=5000, no. of particles in downstream=1000, x=10μ, then

$$\text{Beta Ratio, } \beta_{10} = \frac{5000}{1000} = 5$$

Now, particle capture efficiency of filter $\eta_{10} = (1- 1/\beta) \text{ X } 100 = (1-1/5) \text{ X } 100 = 80\%$.

So the particular filter tested is 80% efficient at removing 10 micron and larger particles.

SUB-DISCIPLINE: HYDRAULICS (LESSONS: 20 SESSIONS: 42)

Lesson-VI : Hydraulic Hose And Fitting. **Session 6:** Function, Types, Hose Specification, Hydraulic Fittings, Precautions During Mounting Hydraulic Hoses And Fittings.

FUNCTION:

Piping is a general term which embraces the various kinds of conducting lines that carry hyd. oil between components plus the fittings or connectors used between the conductors. Flexible hoses are mostly used in track machines to carry hyd. oil from one point to another. These offer more convenience in making connections and servicing. These are used when the hyd. lines are subjected to movement. Hoses are fabricated in layers of synthetic rubber and braided fabric or wire braids. Wire braided hoses permit high pressure. The inner layer of hose must be compatible with hyd. oil used. The outer layer is usually of rubber to protect braid layer. Low pressure hoses i.e. suction and return line hoses are reinforced with single wire braid while medium and high pressure hoses have double or multiple wire braid.

TYPES:

1. **Suction Hose:** This hose is provided between tank and pump. This is low pressure hose and has single wire braid. Dash no. of hoses used in suction line are 32, 48 and 64.
2. **Pressure Hose:** This hose is provided between pump and actuator. This is medium and high pressure hose and has double wire braid or multiple wire braid. Dash no. of hoses used in pressure line are 4, 6, 8, 10, 12, 16 and 20.
3. **Return Hose:** This hose is provided between actuator and tank. This is low pressure hose and has single wire braid. Dash no. of hoses used in return line are 6, 12, 16, 20, 24 and 32.

HOSE SPECIFICATION

i. EN (European Norm)- EN 853- 1 SN-Single wire braid, 2 SN-Double wire braid
ii. DIN (Deutsch Industry Norm) –DIN 20022-2 Wire braid, DIN 20023- spiral wire
iii. SAE (Society pf Automotive Engineers) -100R1 – single wire braid, 100R2 – two wire braid, 100R5 – single wire braid, 100R9 – 4 spiral wire reinforced.

SAE 100R1:

Type A: This hose shall consist of an inner tube of oil resistant synthetic rubber, a single wire braid reinforcement, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

SAE 100R2:

The hose shall consist of an inner tube of oil resistant synthetic rubber, steel wire reinforcement according to hose type as detailed below, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type A: This hose shall have two braids of wire reinforcement.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

SAE 100R5:

The hose shall consist of an inner tube of oil resistant synthetic rubber and two textile braids separated by a high tensile steel wire braid. All braids are to be impregnated with an oil and mildew resistant synthetic rubber compound.

SAE 100R9:

Type A: This hose shall consist of an inner tube of oil resistant synthetic rubber, 4-spiral plies of wire wrapped in alternating directions, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

Hose Parameters:

i. Dash size- Pipes are represented generally in dash no. E.g. 4, 6, 8, 10, 12, 16, 20, 24, 32, 48, 64.
ii. Inside diameter- Inner dia. of hose=dash no. ÷ 16 (in inches)
iii. Reinforcement over diameter
iv. Maximum working pressure
v. Minimum bend radius
vi. Burst pressure

Hose failure due to:

1. Using wrong hose for the job.
2. Improper assembly & installation.
3. External damage.
4. Faulty hose.
5. Faulty equipments.

PRECAUTIONS WHILE MOUNTING HOSES:

1. The hose should be provided in the end filling properly.
2. It should be made long enough without tension.
3. It should be avoided to exceed the min bend radius.
4. Twisted hose should not be installed.
5. At vibrated place the hoses should be secured with proper packing.

FITTINGS:

Hose fittings may be either reusable (screw-together, bolt-together, etc.) or non reusable (crimp or swage). It is recommended that hose fittings have a swivel nut or an SAE split flange on each end so that hose assembly does not have to be turned or twisted for proper installation.

Two types of fittings are manufactured for hoses:

1. Swaged type or crimped type- which is non reusable.
2. Detachable type which has as socket and threaded nipple. This fitting can be used again and again until hose wear out or damages. The socket grips the hose & a nipple is inserted into this hose & screwed into the socket. This gives a firm strong attachment of the hose to the fittings.

PRECAUTIONS WHILE PROVIDING FITTING ON HOSE:-

1. The place of work should be cleaned first.
2. Rubber and wire cuttings should not be left in pipes.
3. Before providing fitting compressed air should be passed through pipes.
4. The other end of the pipe should not be left loose on the ground.
5. After preparing the pipe compressed air should be passed through pipes to remove any foreign material remaining inside.

FUNCTION:
Seals are required to maintain pressure, to prevent fluid loss and to keep out contamination. Excessive leakage any where in a hydraulic circuit reduces efficiency and result in power loss. Mostly hydraulic components are built with operating clearances which allow a certain amount of internal leakage for lubrication purpose. Additional internal leakage occurs when component begins to wear. Internal leakages may cause temperature rise of hydraulic oil.

TYPES:
There are various types of seals used in hydraulic components.

(a)	Positive seals	These prevent even a minute amount of fluid from getting past.
(b)	Non positive seals	These allow a small amount of material leakage, such as the clearance of a spool in its bore to provide a lubricating film.
(C)	Dynamic seals	These are installed between parts which do move relative to one another, thus one of the part must rub against seal. Therefore, these seals are subject to wear.
(d)	Static seals	A seal that is compressed between two rigidly connected parts like flange joints. These do not wear fast and usually remain trouble free.

O-Ring Seals:
Probably the most common seal in use in modern hydraulic equipment is the O-ring. And O-ring is a molded, synthetic rubber seal which has a round cross-section in the free state. The O-ring is installed in an annular groove machined into one of the mating parts. At installation, it is compressed at both the inside and outside diameters. However, it is a pressure-actuated seal as well as a compression seal. Pressure forces the O-ring against one side of its groove and outward at both diameters. It thus seals positively against two annular surfaces and one flat surface. Increased pressure results in a higher force against the sealing surfaces. The O-ring, therefore, is capable of containing extremely high pressure. O-rings are used principally in static applications. However, they are also found in dynamic applications where there is a short reciprocating motion between the parts. They are not generally suitable for sealing rotating parts or for applications where vibration is a problem.

Backup (Non extrusion) Rings:
At high pressure, the O-ring has a tendency to extrude into the clearance space between the mating parts. This may not be objectionable in a static application. But this extrusion can cause accelerated wear in a dynamic application. It is prevented by installing a stiff backup ring in the O-ring groove opposite the pressure source. If the pressure alternates, backup rings can be used on both sides of the O-rings.

T-Ring Seals:
The T-ring seal is used extensively to seal cylinder pistons, piston rods, and other reciprocating parts. It is constructed of synthetic rubber molded in the shape of a “T”, and reinforced by backup rings on either side. The sealing edge is rounded and seals very much like an O-ring. Obviously, this seal will not have the O-ring’s tendency to roll. The T-ring is not limited to short-stroke applications.

Lip Seals:
Lip seals are low-pressure dynamic seals, used principally to seal rotating shafts. A typical lip seal is constructed of a stamped housing for support and installation alignment, and synthetic rubber or leather formed into a lip which fits around the shaft. Often there is a spring to hold the lip in contact with the shaft. Lip seals are positive seals. Sealing is aided by pressure up to a point. Pressure on the lip (or vacuum behind the lip) "balloons" it out against the shaft for a tighter seal. High pressure cannot be contained because the lip has no backup. In some applications, the chamber being sealed alternates from pressure to vacuum condition. Double lip seals are available for these applications to prevent air or dirt from getting in and oil from getting out.

Cup Seals:
A cup seal is a positive seal used on many cylinder pistons. It is pressure actuated in both directions. Sealing is accomplished by forcing the cup lip outward against the cylinder barrel. This type of seal is backed up and will handle very high pressures. Cup seals must be clamped tightly in place. The cylinder piston actually is nothing more than the backing plate and retainers that hold the cup seals.

Piston Rings:
Piston rings are fabricated from cast iron or steel, highly polished, and sometimes plated. They offer considerably less resistance to motion than leather or synthetic seals. They are most often found on cylinder pistons.
One piston ring does not necessarily form a positive seal. Sealing becomes more positive when several rings are placed side by side. Very high pressures can be handled.

Choice Of Seal:

A seal should have effective performance which has become a challenge of the high working pressure and fast cylinder speed. The choice of the seal is guided by following:-

i. Surface finish
ii. Loads
iii. Temperature
iv. Pressure

A seal may be of very good quality, but its surface life does not depend merely on seal material but is greatly influenced by surface finish and method of installation.

SEAL MATERIAL:- PTFE (Poly Tetra Fluoro Ethylene) SEAL

The material did not exhibit any change whatsoever when subjected to practically all known chemicals and its surface was so smooth that hardly any foreign substances remained. Moisture and solar radiation (sunshine) caused neither volumetric change nor disintegration and brittleness. The crystalline change associated with the melting point of the material starts at 327^0C without there being any typical thermoplastic liquefaction. For the above reasons, process technology similar to powder metallurgy is utilized. PTFE powder is compressed into blocks or rods, sintered and then mechanically machined to the required shapes. Based on experience over the last 30 years, the materials industry has developed PTFE types that for certain defined applications can also thermo-plastically processed. The possibility of compounding i.e. matching physical properties to specific applications through the addition of fillers, is an important factor for the use of PTFE in the manufacture of seals and guide elements. In-spite of its remarkable properties, pure unmixed PTFE has limited use for applications where high mechanical loading is required due to its tendency towards cold extrusion (creep)

The influence of filler materials is particularly illustrated by:

- Ø Improvement in the flow strength.
- Ø Reduction of friction and wear.
- Ø Increase in strength.
- Ø Increase in thermal shape stability.
- Ø Increase in hardness.

The most important standard fillers are:

- Ø Glass fibers
- Ø Carbon/Graphite
- Ø Molybdenum disulphide (M_OS_2)
- Ø Bronze
- Ø Polymers
- Ø Pigments

Special characteristics of PTFE:

At low temperatures : Even at -269^{0}C (boiling point of Helium) PTFE still has residual extensibility, so that it can also be used under extreme conditions, e.g. in space. The temperature-dependent elongation or shrinking that occurs as with other plastics is reduced by the fillers.

At high temperatures: PTFE has exceptional thermal resistances, so that it can be used at temperatures up to 269^{0}C (dependent on working conditions). Fillers have no influence on the PTFE's own thermal resistance. Most of the fillers are stable up to 400^{0}C, so that they do not restrict high temperature use.

PRECAUTIONS DURING PROVIDING HYDRAULIC SEALS:

1. A special driver should be used for inserting lip-type shaft seals.
2. Cup seals must be clamped tightly in place.
3. Several piston rings are placed side by side for more positive sealing.
4. The packing is compressed by tightening a flanged follower ring against them.
5. There should be no dent mark on groove where seal is to be provided.
6. Seal of proper size should be used.
7. The operating temperature should always be kept well within the temperature range of the seals being used. At very low temperatures, a seal may become too brittle and at too high temperature, a seal may harden, soften or swell.
8. Seal must be lubricated prior to installation, otherwise the seal will wear quickly and leak.

CAUSES FOR SEAL AND 'O' RING FAILURES

1	Freedom to roll	Unsatisfactory groove shape and not following the groove completely causes early wear and leakage.
2	Reduced contact area	Due to unsatisfactory design causes single point contact causing early wear and leakage.
3	High temperature	Attacking the rubber material causing early damage.
4	Poor rubbing surface	Unclean surface, scratches on cylinder surfaces cause seals& O-rings to wear very fast.
5	Eccentricity	Cause loading one side only, due to which the seals wear on one side and get damaged.
6	Side loads	Cause loading one side only, due to which the seals wear on one side and get damaged.
7	Excessive stretching	Less in size as such O-ring have to be stretched too much causing early wear and sometimes even breaking.
8	Poor quality of rubber.	Seals wear due to poor quality of rubber and improper hardness.

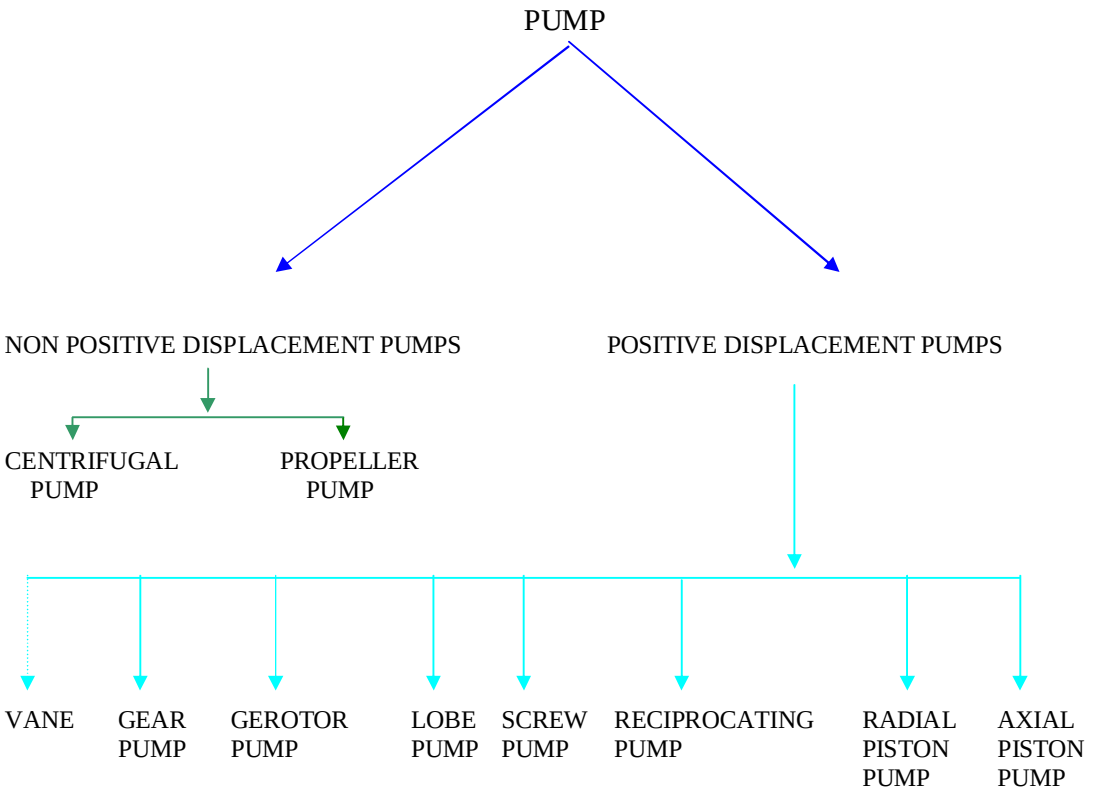
DEFINITION:

Pump is a device which converts mechanical energy into hydraulic energy. Basically pump creates flow from hydraulic tank to system.

FUNCTION:

The hydraulic pump in a hydraulic system converts mechanical energy in a drive unit into hydraulic energy (pressure energy).The pump draws-in hydraulic fluid due to partial vacuum and drives it out into a system of lines. The resistances encountered by the flowing hydraulic fluid cause a pressure to build up in the hydraulic system. Thus the fluid pressure in a hyd. system is not predetermined by the pump. It builds up in accordance with the resistances in extreme cases until a component is damaged. In practice it is prevented by installing a pressure relief valve directly after the pump or in the pump housing at which the max operating pressure recommended for the pump is set.

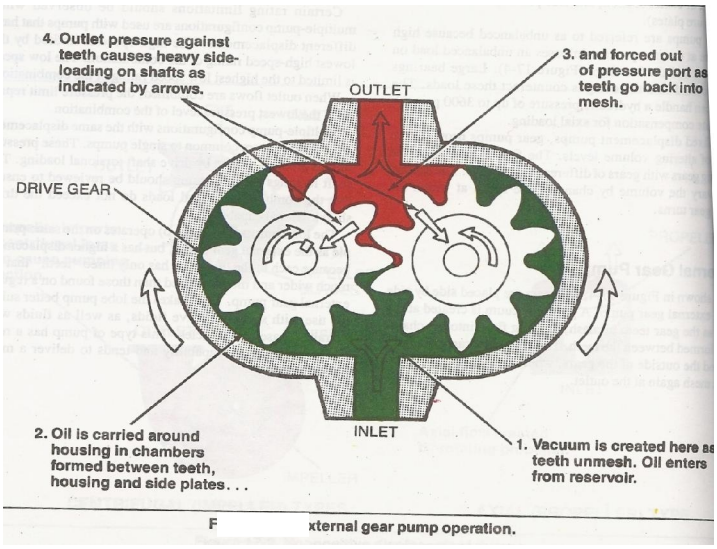
CLASSIFICATION:



Displacement:

The flow capacity of a pump can be expressed as displacement per revolution or output in GPM. Displacement is the volume of liquid transferred in one revolution. It is equal to the volume of one pumping chamber multiplied by the number of chambers that pass the outlet per revolution. It is expressed in cubic inches per revolutions.

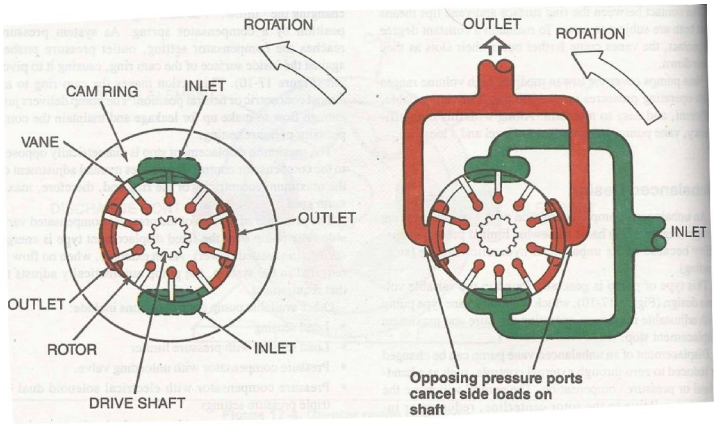
EXTERNAL GEAR PUMP:-



F xternal gear pump operation.

The pump consists of drive gear and a driven gear and closed in closely fitted housing. The gears rotate in opposite direction and mesh at a point in housing between inlet and outlet ports as the teeth of gear separate, fluid is drawn into the inlet chamber, due to partial vacuum the fluid is trapped between the gear teeth and housing and carried through two separate paths around the outlet chamber. As the teeth re-mesh, fluid is forced through the outlet port. Close fit of the gear teeth within the housing is required to provide a seal between inlet and outlet ports, minimizing internal leakage. High pressure at pump outlet imposes an unbalanced load on the gears and bearing supporting them. Most gear pump are fixed displacement pump. Internal leakage increases with wear. However the units are fairly durable and more dirt tolerant than other type.

VANE PUMP:



Basically this pump consists of a cam ring and a splined drive shaft carrying a slotted rotor. In each slot of rotor vane is fitted which is free to slide. Thus following the ring profile as the rotor rotates. The vanes are held against the ring contour by a combination of centrifugal force and system pressure. Since system pressure is not usually present until the pump develops flow, centrifugal force is necessary to eject the vanes when the unit is started. Once the pump is in operation fluid at system pressure is directed to each rotor slot to hold the vanes against the ring contour. The vanes divide the area between the rotor and cam ring into a series of varying size of chambers. The pump inlet is situated in that part of pump where the chambers are expanding in size and the vanes are moving outward from rotor. Fluid is drawn into the pump by the partial vacuum, caused by this expansion. At the pump outlet the chambers are reducing in size, the vanes moving inwards and the trapped fluid being forced through the outlet port..

AXIAL PISTON PUMP:-

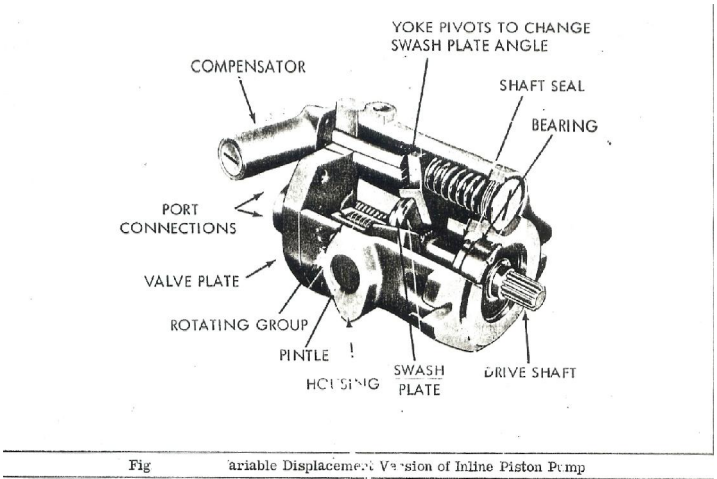


Fig ariable Displacement Version of Inline Piston Pump

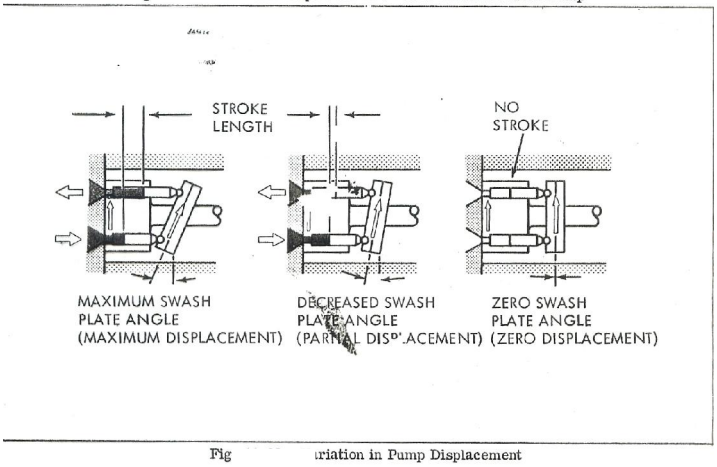


Fig riation in Pump Displacement

The circular arrangement of a piston is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinder barrel which is firmly attached to the drive shaft by means of a key. The piston ends are of ball and socket design and run on slipper pads. These are held on a swiveling swash plate by means of holding discs. On the fixed displacement model the swash plate form a part of the housing and therefore has a fixed swash angle. On the variable displacement model the swash plate is built into the housing and can be swashed to angle of $\pm 15^0$ from centre. The piston travels a stroke relative to the swash angle which determines the pump displacement. When the swash plate is in centre position i.e. vertical to the drive shaft, the piston stroke and thus the pump displacement are zero. Swashing the pump over center changes the direction of flow without changing the direction of rotation. Control of the axial piston pump via inlets in a port plate. At in any one time four of these moving pistons are connected via these inlet ports with the tank side. Further four pistons are connected with the pressure side and displace fluid. A charge pump is mounted on the same shaft of the axial piston pump. This pump draws oil in from the hyd. tank and supplies it to the hydrostatic loop to keep it charged. The charge pump relief valve is set at 30 bar. The either ports of the axial piston pumps are known as low pressure port and high pressure port and denoted by a letter ‘A’ & ‘B’. In either sides pressure relief valve is provided which is set at certain pressure to suit that hydraulic circuit. Such relief valves are called cross relief valves.

PRECAUTIONS FOR INSTALLING HYDRAULIC PUMPS:

1) Clean entire oil from tank, remove scaling paint, dirt etc. flush it with fresh oil.
2) Clean the filter (choked filter may cause cavitation.)
3) Check suction and return lines for air Leakages, loose connection and loose connection in delivery will cause fluid leakage.
4) Sealant tape and shellac with pump should be used while providing fittings on the pump.
5) While assembling direction of rotation should be checked carefully.
6) Suction and delivery ports to be kept in desired directions.
7) All the bolts, O-rings should be properly fitted at proper torque.
8) All blades should be properly fitted. Keeping attention on their direction.
9) All bolts should be properly tightened at a uniform pressure.
10) Oil seal and bearing should be properly fitted.
11) Driving shaft should not be eccentric to the pump shaft.
12) All joints and pipe connection should be preferably applied with hard grease.
13) There should be no seepage form the pipes and pump premises should remain dry.
14) Start the pump at low r.p.m. preferably not more than 1000 r.p.m.
15) Run the pump at this rpm for about 20 min.. and then apply pressure to it.
16) observe the sound if it is taking air the sound is unpleasant and abnormal, at this stage stop the pump and check for air leakage.
17) If suction pipe is getting squeezed it means suction is choked, stop the pump and check filter and suction pipe.
18) After applying pressure if there is no sound, see heating effect on the pump this should be normal.
19) Now the pump is ready for working.
20) Do not start pump immediately after filling the tank a period of at least 12 hrs. so that entrapped air may escape from the oil. Normal recoupment of oil should also be done after working hours.
21) During severe winter the pump must run idle before putting load, for 15-30 min., so that cavitation effect due to high viscosity at lower temperatures is avoided.
22) Max. running temperature of hydraulic fluid for day of working must not cross 80^0 C.

AERATION:

Aeration occurs on account of presence of air in dissolved and free form in the hydraulic oil and renders the oil spongy. Air is always present in small quantity in the oil say up to 10% but this increased inclusion of air in oil reduces its lubricating properties and ultimately reduces the life of the pump.

CAUSES:

The following are the reasons of air inclusion in the oil.

1. Low oil level in the reservoir causes whirl pool at the intake and air is sucked by the pump along with the oil.
2. Restrictions in inlet pipe cause pressure to drop, which helps suction of air into pump.
3. If the return pipe opens above the hydraulic oil level in the reservoir it accompanies foaming in the tank and air inclusion.
4. Turbulent flow (intake and return) also causes air inclusion.
5. If the filter cartridge joint is not perfectly sealed or there is any void in the suction line, the pump sucks air through the same.
6. Leaking pump shaft seal, cylinder rod seals or other leaking unnumbered connections in the intake line cause aeration.

EFFECTS OF AERATION:

Aeration causes lack of lubrication, erodes the end plates of pump and vane tips are also worn out earlier. The vanes bounce and cause irregular ripples on the inner side of the cam ring. Wearing of these fast moving parts create excessive clearance between the end plates and rotor as well as between vanes/blades and cam ring and ultimately the pressure drops. The pump stops functioning properly and can not build up pressure thus the pump reaches a premature death.

CAVITATION:

It is a sort of vacuum created in the hydraulic oil which breaks the fluid into layers or cavities and the fluid does not fill the line perfectly. It can occur equally in pump, motor or cylinder etc.

CAUSES:

The following are the probable causes of cavitations in the pump and other hydraulic equipments:-

1. Filter is clogged.
2. Sharp bend in the suction line.
3. Obstruction in suction line.
4. High viscosity hydraulic oil used in machine.
5. Pump inlet is too high above the oil level in the tank.
6. Tank, if not ventilated properly-oil shrinks in volume as it cools.
7. The load is more than the delivery of the pump.

EFFECTS OF CAVITATION:

The effects in case of cavitations are similar to those occurring in aeration i.e.

i. Erosion of end plates.
ii. Rippled cam ring.
iii. Worn-out vanes tips and loose in slots.
iv. Pitting in the cam ring near inlet port.

TROUBLE SHOOTING :

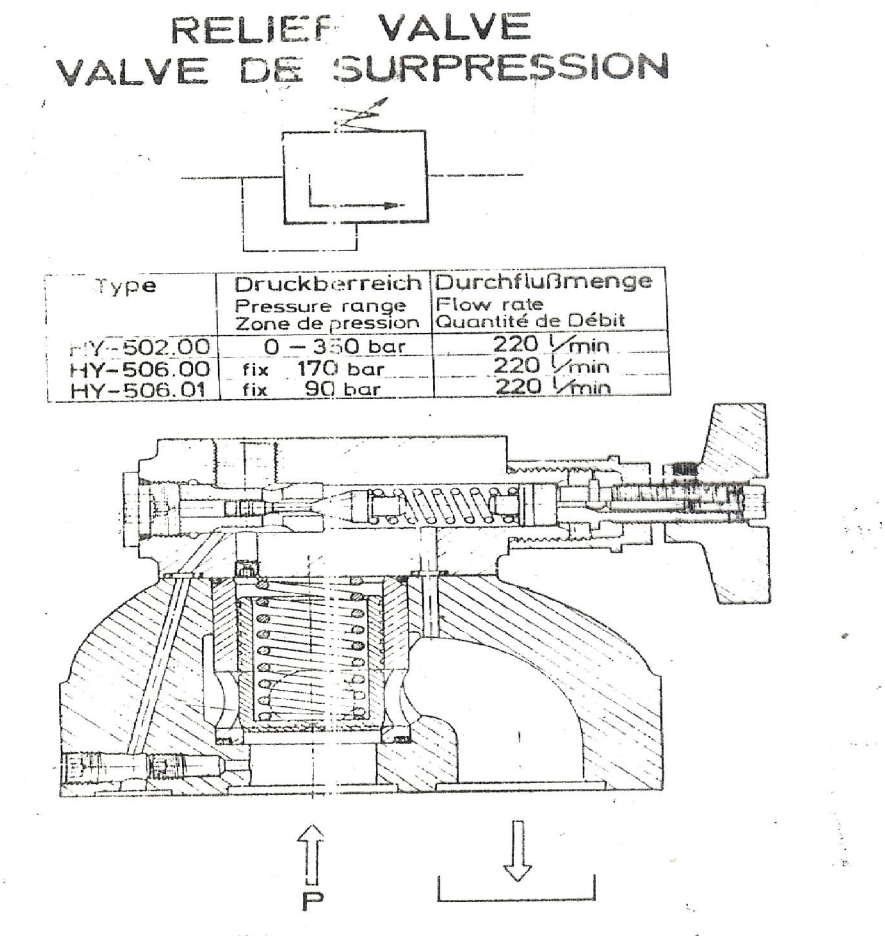
PROBLEM	CAUSES	REMEDIES
1. Pump not delivering oil.	1. Pump driven in wrong wrong direction.	1. We can check the pump rotation by hand priming, pour the oil in intake port and rotate the shaft and see if the oil is coming from outlet or not. If not change the direction by repositioning the cam ring turned by 90^0.
	2. Intake filter or pipe choked.	2. Clean or replace the faulty one.
	3. Oil level too low in the tank.	3. Fill the tank with hydraulic oil.
	4. Pump shaft or rotor broken.	4. Replace the pump shaft or rotor broken.
	5. Air traps in suction line.	5. Check the suction line and replace

2). Pump making noise.	1). Oil level too low.	1). Fill the tank with hydraulic level that more air influence is prevented.
	2). Restricted or partially clogged intake filter or line.	2). Clean or replace the intake filter or line. Suction filter should be changed in time.
	3).Tank is not vented properly.	3).Air breather screening element should be cleaned regularly, so that atmospheric pressure exert effectively on the oil surface in tank and good suction may take place
	4).Viscosity of oil too high.	4).Use proper grade oil. In winter Season oil becomes thick so no free flow takes place, warm up the oil by starting pump for few minutes.
	5).Air leak at pump intake pipe joints.	5).Check for any loose connection or joint and tighten them.
3). Bearing failure.	1). Chips or other contaminants.	1). Replace bearing and check source of contaminants.
	2). In adequate lubrication.	2). Excessive heating of oil should be avoided.
	3).Pump running too fast.	3). Adjust the R.P.M of prime mover
	4).Excessive or shock loads.	4). Excessive load due to operating pressure may damage bearing so reduce operating pressure.

HYDRAULIC VALVES:

In hydraulic systems, energy is transferred between the pump and the consuming device along appropriate lines. In order to attain the required values – force or torque, velocity or rpm – and to maintain the prescribed operating conditions for the system, valves are installed in the lines as energy control component. These valves control or regulate the pressure and the flow rate. In addition each valve represents a resistance.

RELIEF VALVE:



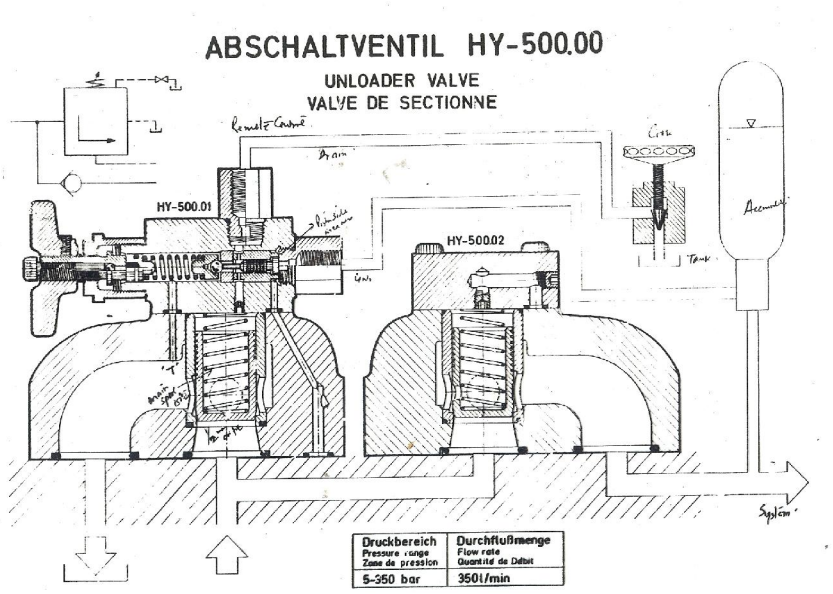
It is found in virtually every hydraulic system. It is a normally closed valve connected between the pressure line and the tank. Its purpose is to limit pressure in the system to a preset maximum by diverting some or all of the pump's output to tank when the pressure setting is reached.

Relief valve consists in two sections (1). Cover section which includes poppet, spring, and adjusting screw & vent connection. (2). Body section which contains the piston, spring& seat. The valve pressure setting is determined by the adjusting screw position which varies the heavy spring compression. The balanced piston is normally held against the set by the light spring. System pressure is present in lower chamber of piston and also passes to the upper chamber through a pilot line. With system pressure less than the valve setting the pilot poppet is held against its seat by spring force. Pressure in both chambers equalizes and the piston is hydraulically in balance and held against its seat by the light spring.

When system pressure exceeds the heavy spring setting and forces the poppet away from its seat. Fluid then flows through poppet seat to tank port. The pressure in upper chamber is limited by the setting of the heavy spring. When pressure in lower chamber exceeds upper chamber sufficiently, pressure unbalance overcomes the force of the light spring and lifts the piston. Excess fluid then flows past the bottom of the piston to tank. When system pressure drops below the valve setting, the popper reseats. Control flow through pilot line stops and pressures in both chambers are again effectively equalized. The light spring then forces the piston towards the seat when the balanced piston is closed against its seat, the unloading stops. The pump delivery now goes to the system.

Venting: Relief valves can be vented to unload pump delivery to tank in the manner – connect a shutoff valve to the vent port of the main relief valve. This removes pressure at the top of the balanced piston. Pressure in the lower chamber overcomes the light spring, unseats the balanced piston and diverts all the delivery of pump to tank.

UNLOADER VALVE:



An unloader valve is used in accumulator charging circuit to (i) limit max. pressure and. (ii) unload the pump when the desired accumulator pressure is reached. In construction, it contains a compound, balance piston relief valve, a check valve to prevent reserve flow from the accumulator & a pressure operated plunger which vents the valve at the selected pressure.

Normally, the relief valve piston is in balance and is held seated by its light spring. Flow is through the check valve to the accumulator/system. When preset pressure has been reached, the relief valve poppet has unseated limiting pressure above piston and on the poppet side of the plunger. Further increase in system pressure acting on the opposite end of the plunger has caused it to force the poppet completely off its seat, in effect, venting the relief valve and unloading the pump. The check valve has closed permitting the accumulator to maintain pressure in the system.

Because of the difference in area between the plunger & poppet seat (approx. 15%), when pressure drops to about 85% of the valve setting, the poppet & piston reseat & the cycle is repeated.

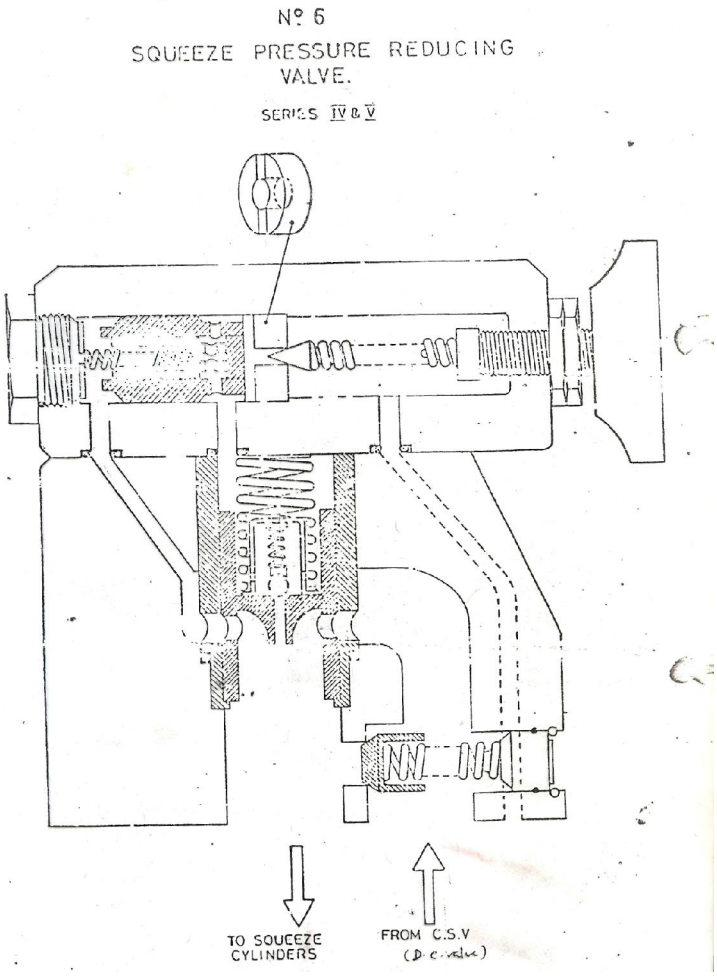
TROUBLE SHOOTING IN UNLOADER VALVE:

Sl.No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump	Check the pump and replace if required
		2. Leakage in the system	Check the leakage and rectify the fault
2	Pump O.K. no leakage in the system,still no pressure	1.Choked up orifice of main spool	Clean the orifice.
		2.Secondary stage vent open to tank	Close the vent
		3.Safety valve at Zero setting	Set safety valve as per value written in the circuit.
3	Pressure does not rise to required value even after complete tightening the control knob	1.Worn out pump is not able to push the fluid against set resistance.	Replace the pump.
		2. Leakage in the system	Check the leakage and rectify the fault.
		3. Leakage at seat of ball in control head	Check the seat and ball. If defective replace it.
		4. Safety valve setting lower than unloader valve setting	Set safety valve 10-15 % higher than unloader setting.
4	Unloader does not unload	1. Nil or low nitrogen pressure in the accum-ulator	Check pressure recharge the accumulator
		2. Punctured bladder	Change the bladder.
		3. Leakage in the system	Locate fault and rectify the leakage.
		4. Less delivery from pump than demand of the circuit.	Replace the pump
		5. Partial leakage at ball seat in control head	Replace the ball and seat.
		6. Wrong connection of control head spool from the system.	Correct the connection.
		7. Vent line of unloader connected to return line.	Connect line to drain line.

TROUBLESHOOTING IN RELIEF VALVE

Sl. No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1.Defective pump flow	Check flow with the Meter and replace pump if Required. .
		2.Leakage in the system	Arrest the leakage.
2.	Pump OK & no leakage in sys. still no pressure.	1.Choked up orifice of main spool .	Take out the spool and clear the orifice.
		2.Secondary stage vent open to tank	Close the vent
3.	Pressure does not rise to required value even after complete tightening the control knob.	1.Excessive clearance in pump matching parts due to wear	Replace the pump.
		2. Leakage in the system	Check the leakage & rectify the fault.
		3. Leakage at poppet seat	Check the seat and poppet,if defective Replace it.
		4.Under size valve in relation to flow of pump.	Provide proper size valve.
4.	Valve sticks	1. Valve stressed.	Loosen bolts and tighten uniformly.
		2. Oil temperature too low.	Warm up system by starting hydraulic system.
		3. Piping stressed.	Providing proper bends in piping.
		4. Drain line under pressure.	Install line or separate from return line.

PRESSURE REDUCING VALVE:

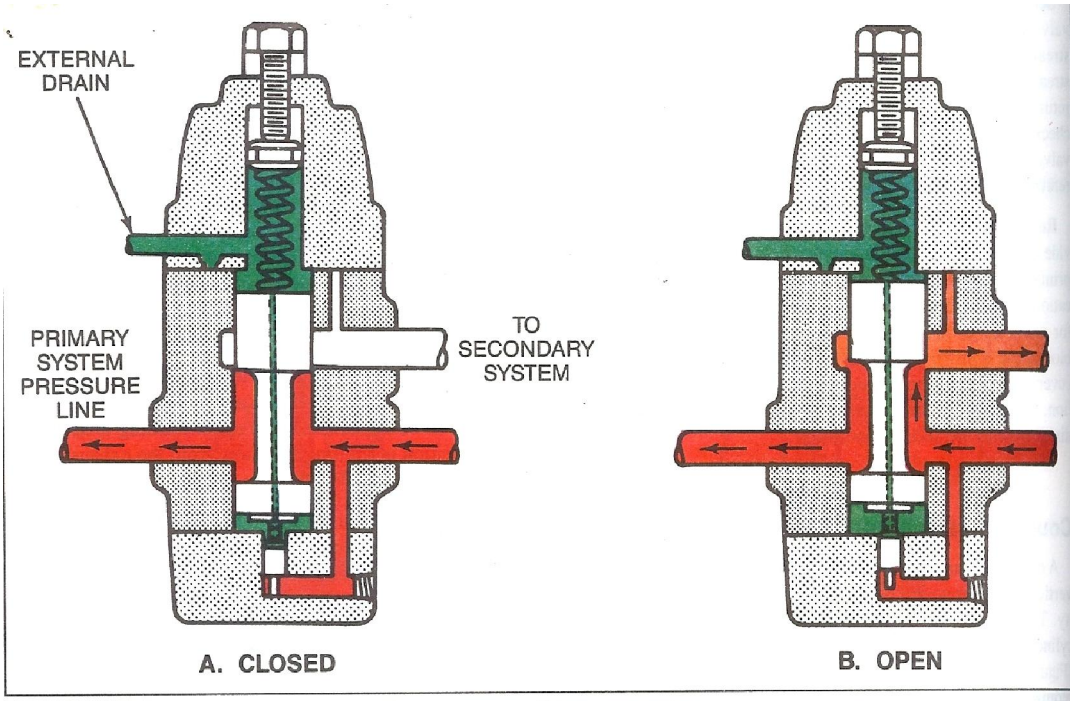


Pressure reducing valves are normally open pressure controls used to maintain reduced pressure in certain portions of the system. They are actuated by pressure sensed in the branch circuit & tend to close as it reaches the valve setting thus preventing further build-up.

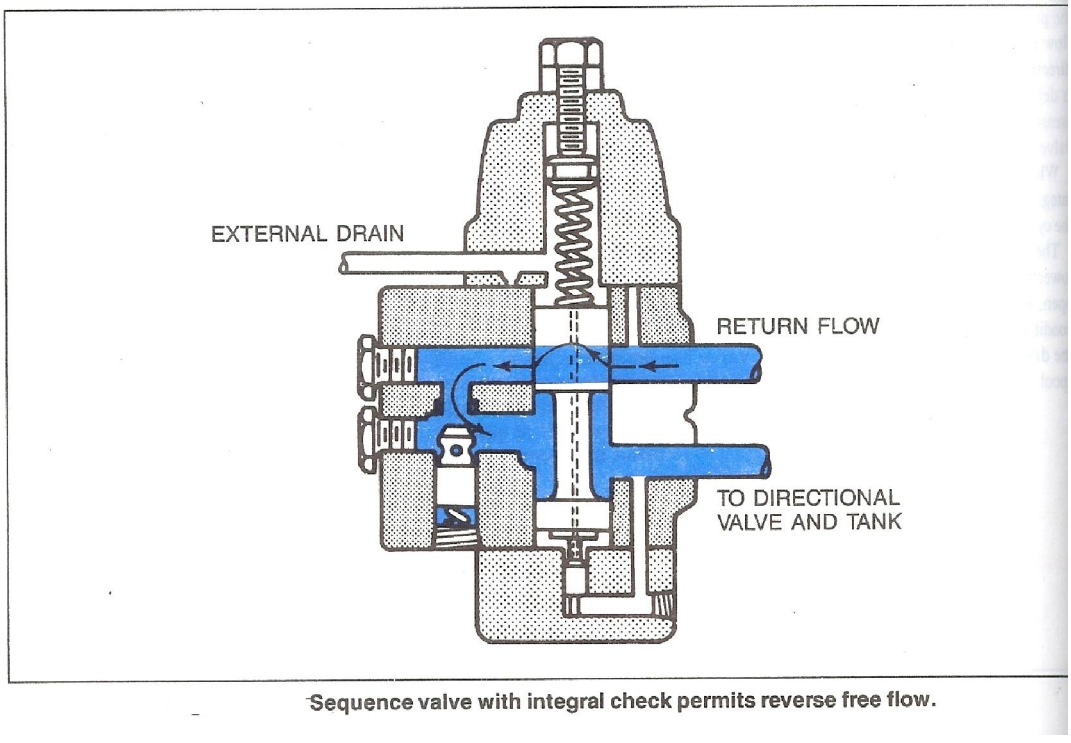
The pilot op. pressure reducing valve has a wider range of adjustment & generally provides more accurate control. The op. pressure is set by an adjustable spring in the pilot stage in the upper body. The spool is hydraulically balanced through an orifice in its centre and the light spring holds it in the wide open position.

When pressure has reached the valve setting and the pilot valve is diverting flow to the drain passage limiting pressure above the spool. Flow through the orifice in the spool creates a pressure difference that moves the spool up against the spring force. The spool partially closes the outlet port to create a pressure drop from the supply to the branch system.

SEQUENCE VALVE:



Sequence valve.



Sequence valve with integral check permits reverse free flow.

A sequence valve is used to cause actions to take place in a system in a definite order, and to maintain a predetermined minimum pressure in the primary line while the secondary operation occurs. Fluid flows freely through the primary passage to operate the first phase until the pressure setting is reached. A typical application is clamping from the secondary after the work piece is firmly clamped.

To maintain pressure in the primary system, the valve is internally operated. However, the drain connection must be external, since the secondary port is under pressure when the valve sequences. If this pressure were allowed in the drain passage, it would add force and raise the pressure required to open the valve.

TROUBLE SHOOTING:

Sl. No.	Problems	Causes	Remedies
1.	Valve flutters	1. Valve seat defective	Exchange parts
		2. Pilot control defective	Repair pilot control
		3. Oil speed too high	Install valve of greater nominal size
		4. Wrong oil grade	Respect oil recommendations
		5. Dirt in system	Flush system if needed pickle and flush out
		6. Damping defective	Repair valve or change spring
2.	Valve sticks	1. Valve stressed	Loosen bolts and tighten uniformly
		2. Oil temperature too low	Warm up system through pump or install heating
		3. Piping stressed	Incorporate balancing bends
		4. Drain line lacking or under pressure	Install line or separate form return
		5. Dirt in system	Flush system or if needed pickle and flush
		6. Wrong oil grade	Respect oil recommendations
		7. Water condensation in system	Check cooler and check system for condenser effect
		8. Oil gumming	Clean spool and if needed change oil
		9. Body parts wrongly fitted	Observe assembly sequence in service instructions
		10. Wrong seals	Replace seals prescribed
3.	Valve does not function	1. Valve spring broken	Change spring
		2. Valve sticks	Establish cause and repair defect
4.	Valve overheats	1. System temperature too high	Observe maximum pressure
		2. Oil speed too high	Install valve of greater nominal size

FUNCTION:

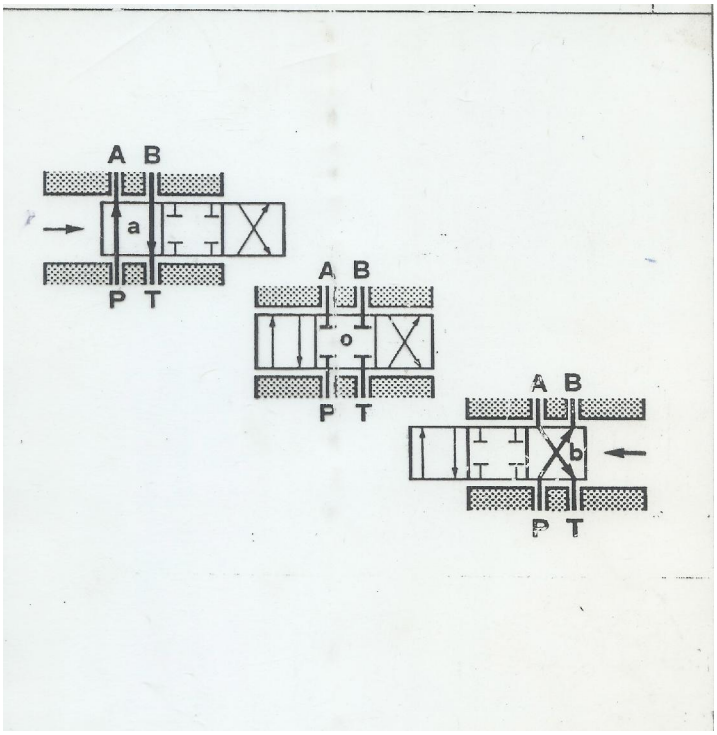
There are several types of valves in hydraulic system. Some are used to limit and regulate the pressure, while other controls the direction of fluid flow. The direction of pressurized fluid is controlled by D.C. valve and thus the direction of movement. They can be simple check valve, more complicated pilot and solenoid operated valves. It can be manually or automatically operated. Valve body has a precision machined bore in which a very close tolerance spool is suspended on a film of hydraulic fluid. Spool lands and body cavities are designed to divide the bore openings into separate chambers. Ports in the body lead into this chambers so that spool positions determine which ports are opened or closed.

TYPES:

There are three types of D.C. valves:-

1. Spring centered valve.
2. Spring offset valve.
3. Pilot operated valve.

<u>Spring centered valve</u>:



This valve is provided with spring and centering washer at each end of spool. The spring and washer centre the spool with in the valve body when solenoids are de-energized where it is necessary to stop or hold an actuator at some mid point in its travel, a 3 position valve is used. The third position is achieved by centering springs. Flow conditions in this centre or neutral position are determined by the work requirement of the system.

Spring offset valve:

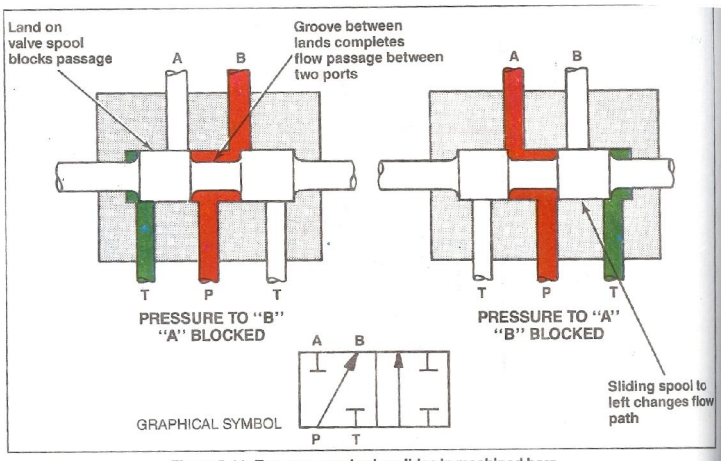


Figure 8-11. Two-way spool valve slides in machined bore.

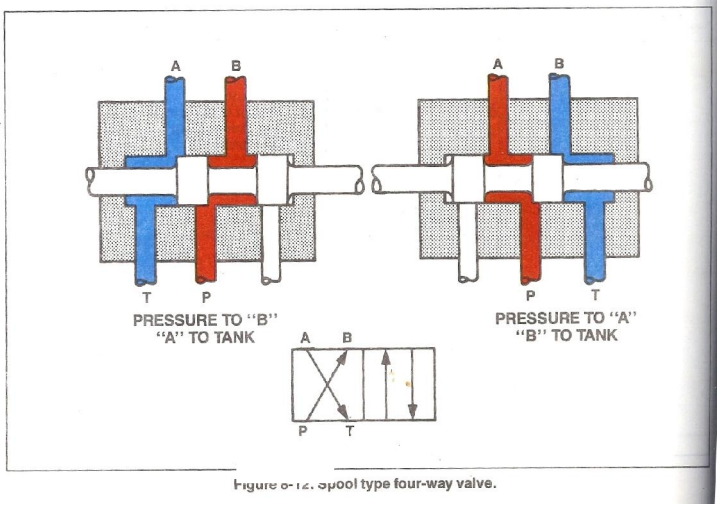
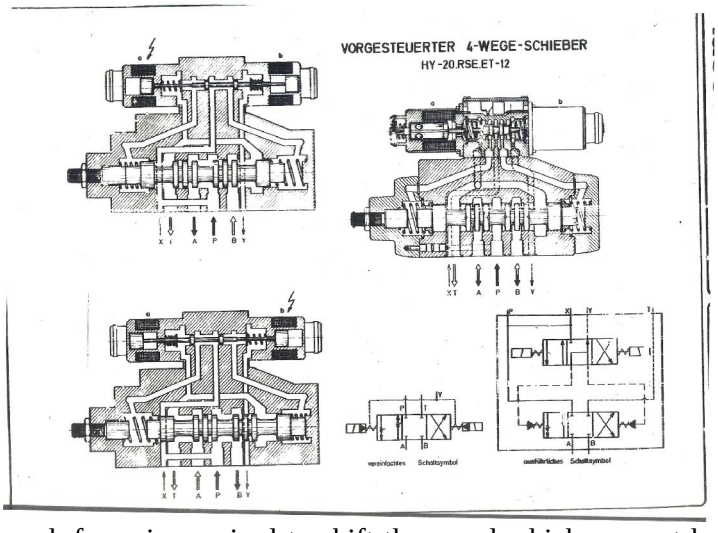


Figure 8-12. Spool type four-way valve.

These valves use one solenoid only. Spring returns the spool to offset position when the solenoid is de-energized.

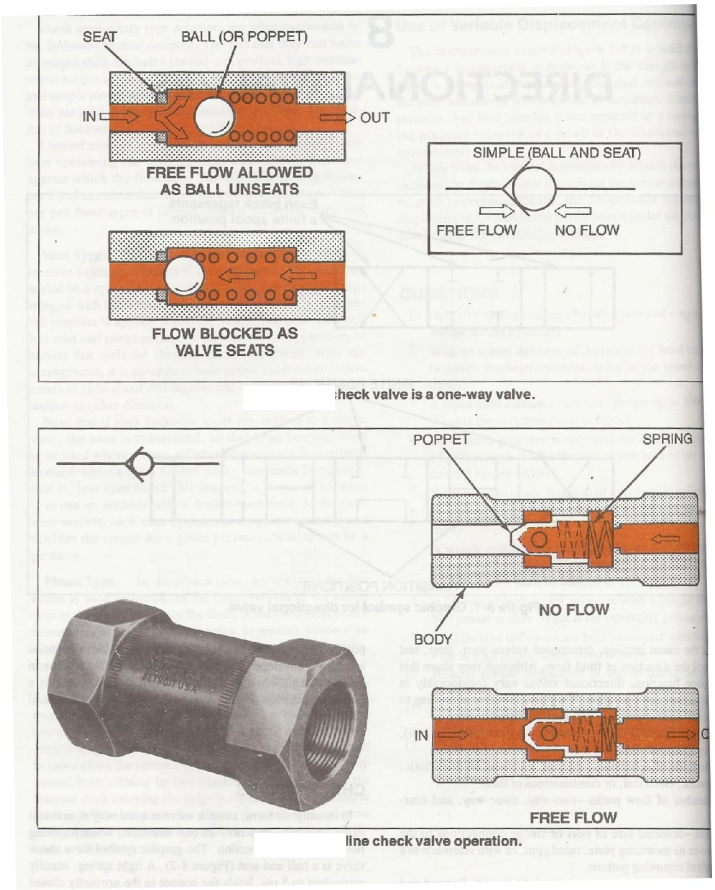
Pilot operated valve:



In larger valves much force is required to shift the spool which can not be shifted by 24 V D.C. Therefore pilot operated D.C valve is used. This valve is operated by pilot pressure against either spool end. The pilot oil furnished from a small 4 way valve i.e. is pilot valve

which is actuated by solenoids. Thus we may control high flow rates with low solenoid power. Pilot valve or master valve is mounted on top of the larger “slave valve”. The normal position of pilot valve is A – B to T.

NON RETURN VALVE (CHECK VALVE):



Non-return valves block the flow in one direction and permit free flow in the other. As there must be leaks in the closed direction, these valves are always of poppet design and are constructed according to the following basic principle.
The sealing element (generally a ball or cone) is pressed against an appropriately shaped seat. The valve is opened by volumetric flow in the flow direction, the sealing element being lifted from the seat.

PILOT OPERATED CHECK VALVE:

Pilot operated check valve designed to permit free flow in one direction and to block return flow until opened by a pressure signal. This valve is used to support vertical cylinders which come downwards due to leakage in D.C valve. Normal position of D.C valve is always A – B to tank. It is a variation of directional poppet valve and commonly used in hydraulic system. It works on the principle that in order to allow and additional flow over the valve seat in opposite direction a small cylinder with a piston and piston rod acts on the closing part and lifts it from the seat when pressured the area ratio between control piston and valve seat is the deciding factor for the operation of valve.

LOGIC VALVE (CARTRIDGE VALVE):

Refinements in hydraulic system development have led to greater use of manifold blocks. A manifold block greatly reduces the number of fittings required for the interconnecting lines between components in a system. This eliminates many potential leakage points and reduces fluid waste from leakage. A cartridge valve is inserted into a standardized cavity in a manifold block and held in place with either self-contained screw threads or a cover secured with bolts to complete the cartridge valve design concept.

Cartridge valves are two types: (1) Slip-in cartridge valves and (2) Screw-in cartridge valves.

Advantages of Cartridge valve:

Cartridge valves provide several advantages over conventional line-or subplate-mounted spool-type directional, pressure, and flow control valves. In many applications, the advantages include:-

1. Greater system design flexibility.
2. Lower installed cost.
3. Smaller package size.
4. Better performance and control.
5. Improved reliability.
6. Higher pressure capability.
7. More efficient operation.
8. Elimination of external leakage and reduction of internal leakage.
9. Greater contamination tolerance.
10. Faster cycle times.
11. Lower noise levels.

Operation of Slip-in Cartridge Valves:

These valves are used in hook lifting-lowering circuit of Unimat machine. Most Slip-in cartridge valves are poppet type elements that are normally controlled by another valve to provide a complete hydraulic function. These valves are similar to poppet check valves and consist of an insert assembly that slips into a cavity machined into a manifold block. A control cover bolted to the manifold secures the insert within the cavity. The insert includes a sleeve, a poppet, a spring and seals.

The cartridge valve insert can be viewed as the main stage of a two-stage valve. It has two main flow ports, “A” and “B”. Drilled passages in the manifold connect the “A” and “B” ports to other cartridge or to the operating hydraulic system. Similarly, a drilled pilot passage in the manifold connects the control port “X” as desire.

Notice the orifice in the drilled passage between the “X” port and the spring chamber “AP”. The purpose of this orifice is to reduce the speed at which the valve poppet opens and closes. Various orifice sizes are available to optimize or tune cartridge response in relation to that of the entire hydraulic system. The hydraulic system designer can select the orifice size that provides maximum operating speeds with minimum hydraulic shock.

PRECAUTIONS DURING MOUNTING D.C. VALVE:

1. On solenoid operated D.C. valve make sure that the electrical ground is connected to the valve that prevents the possibility of shock hazards developing if a coil were to short out to the frame
2. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow. Tubing must not be bent too sharply the recommended radius for bents is three times more than the pipe inside diameter.
3. The selection of valve should be according to the circuit.
4. The normal configuration of valve should be checked. Pour hydraulic oil in P port and check the position of A, B and T port.
5. O – Ring should be checked on the grooves provided between valve and base plate.

TROUBLE SHOOTING

PROBLEM	CAUSE	REMEDIES
1.Valve spool stick.	1). Dirt in the system.	1). Disassemble, clean and re- assemble
	2).Body parts wrongly fitted.	2). Fit properly. Clean
	3).Rusting due to water Condensation	3). Clean or replace if required.
	4). Solenoids not operated	4). Check electrical supply and source
	5). Spool is stressed.	5).Check surface, clean, tighten the bolts. Oil film should be available between valve body and spool.
2.Solenoid not function-ing	1).Faulty electrical circuit.	1). Check and rectify.
	2).No current.	2). Check the electrical wires and supply.
	3).Coil burnt out.	3). Replace
3.Leakage in valves	1).Connections not sealed	1).Check and rectify.
	2).Wrong seals	2).Replace by proper size.
	3).Defective valves, cracks in body.	3).Repair or replace.
4. Valve overheats	1) System pressure too high	Reduce pressure setting
	2) Wrong oil grade	Use proper grade oil
	3) Dirt in the system	Flush system and clean the valve
	4) Faulty electric circuit	Check electric circuit
	5) Spool defective	Repair spool

FUNCTION:

- Ø Proportional valves control and vary pressure, flow, direction, acceleration and deceleration.
- Ø They are adjusted electrically are actuated by proportional solenoids.
- Ø Output flow is proportional to the input signal.
- Ø By varying the input signal solenoid adjusts the spool movement to vary the flow through the valve.
- Ø To control the speed of the spool a gradually increasing or decreasing signal (a ramp function) is fed to the control amplifier and thus we get a smooth, shock free movement.
- Ø Used for Tamping unit lifting-lowering and satellite drive.
- Ø Maximum voltage 24V DC, current range-250mA to 750mA
- Ø For Tamping Unit Lowering current-650mA
- Ø For Tamping Unit Lifting current-600mA

Working of Proportional Valve:

D.C conventional valves are 'Yes' or 'No' type valve. These valves are completely 'OFF' or 'ON' type that means either the ports will be completely closed or completely opened and these types of valves are known as finite positioning valves. During operation the movement of actuator is not controllable.

To get a controlled and measured amount of actuation, other types of valves known as proportional valves has been introduced and such valves are known as infinite positioning valves. These valves are also known as direction cum flow control valve. To get measured amount of correction or actuation and accordingly the movement of spool of the valve is proportionate to the current. It means what ever amount of correction or actuation we need. That only will be done. Neither this will be less nor will be more.

In this valve how much amount of current flow through coil, proportional amount of fluid will pass through it. It means its operation is proportional to signal it receives i.e. as movement will be such that it corresponds to the controlling signal. Higher the amounts of signal, higher the actuation. Lower the amount of signal, lower the actuation will be. So we need a proportional movement and proportion actuation.

The amount of movement of the spool in either direction is electrical from an electrical i/p signal. This signal is converted via an electrical amplifier to a current signal to the relevant solenoid the force generated moves the main spool against the main spring. The positional transducer then ascertains the actual position of spool and fills this back as a voltage signal to the amplifier. The input signal and actual values are then compared electrically. From these two values a signal is generated and fed to the solenoid in order to give a defined position to the main spool. The main spool has metering slots cut into it which give a progressive flow characteristic.

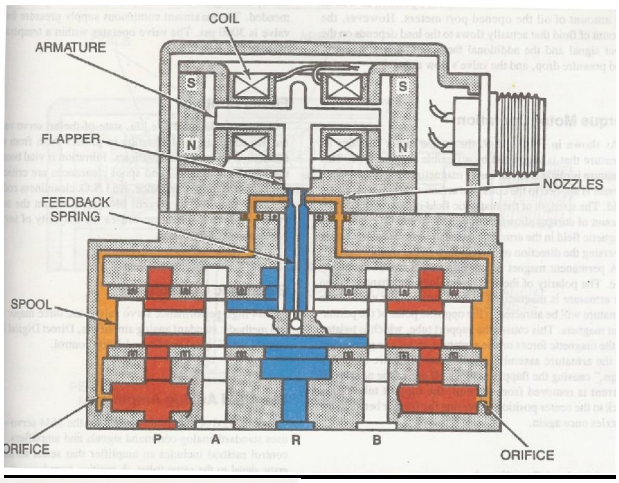
TROUBLESHOOTING OF PROPORTIONAL VALVE:

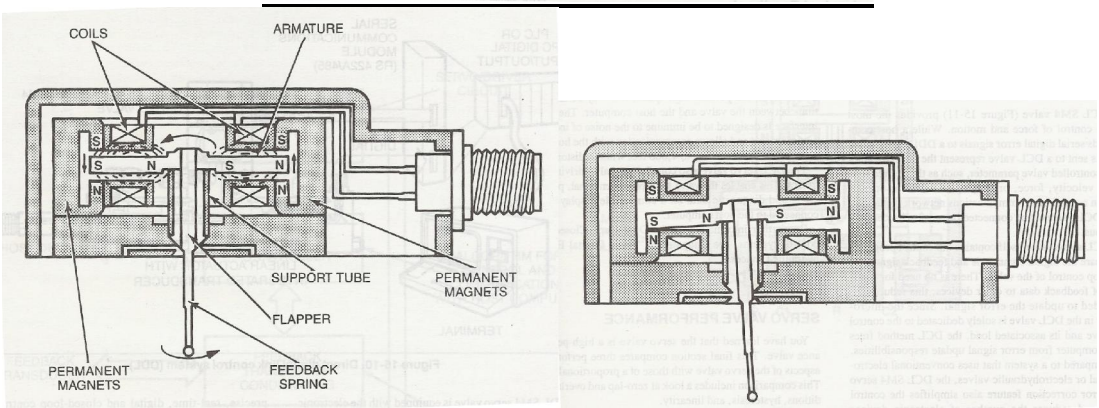
Sr.No.	Trouble	Causes	Rectification
1.	Spool sticks	a) Spool stressed	Loosen union and tighten uniformly.
		b) Dirt in the system	Clean the valve and flush the system.
		c) Body parts wrongly fitted	Dismantle valve, observe assembly sequence and reassemble.
		d) Wrong seals	Replace seals prescribed.
		e) Oil temperature too high	Check cooling circuit.
		f) Spool defective	Repair or replace.
		g) Return pipe under high pressure	Dismantle the connection and clean. If required lead pipe separately to tank.
2.	Proportional valve does not function.	a) Proportional solenoid defective	Replace.
		b) Electric circuit faulty	Check circuit & PCB.
		c) Proportional filter clogged	Replace.
		d) No current	Check electrical installation.
3.	Proportional valves overheat.	a) Oil temperature too high	Check cooling circuit, reduce pressure setting.
		b) Wrong oil grade	Use recommended oil.
		c) Dirt in the system	Flush system.
		d) Faulty electrical circuit	Check and rectify.
		e) Spool defective	Repair or replace.

FUNCTION:

- Ø Servo valve is a directional valve that may be infinitely positioned to control of both the amount and the direction of the flow. A servo valve coupled with the proper feedback sensing devices provides very accurate control of the position, velocity, or acceleration of an actuator.
- Ø Small input signal causes a large output of hyd. Power.
- Ø A low power control signal can produce output of several hundreds horse-power.
- Ø In airplanes, jet planes servo valves are used for fast response.
- Ø Used in lifting and lining circuit in 09 CSM, 09-3X, Unimat-3X, new Duomatic.
- Ø For track lifting – 2nos and for alignment- 1no servo valve is provided.
- Ø Voltage-3V DC, Current-15mA.
- Ø Contaminated oil is not desirable.
- Ø Maintain the oil cleanliness to NAS-5 class.
- Ø Before installing the servo valves flush the system.
- Ø Filter should be replaced in non-contaminated atmosphere.
- Ø Null should be adjusted properly, if null gets disturbed.

Working of servo valve:





Servo valve consist of an electrical torque motor, nozzle flexure tube, flapper and sliding spool. In the torque motor there are upper and lower pole plates, permanent magnet and an armature. The armature is supported for limited movement by a flexure tube. The flexure tube acts as a seal between the electromagnetic and hydraulic portion of the valve. The coils surround the armature one on each side. The flapper is rigidly attached to centre of armature. The flapper extends down inside and passes between two nozzle tips and flapper. Flapper motion varies the nozzle openings. The pressurized oil is supplied to each nozzle through a

filter and inlet orifices. Differential pressures caused by flapper movement between the nozzles are applied to the ends of the valve spool. Due to nozzle area difference force develops accordingly more on one side and spool is shifted and 'P' may connect 'A or B' depending upon our requirement. A feed back wire is deflected by spool movement so that feed-back torque is applied to the armature.

Input signal in the torque motor coils causes clockwise or anticlockwise torque on the armature. This torque displaces the flopper between the two nozzles. Thus pressure difference is created due to area difference in nozzle and moves the spool either left or right. The spool displacement causes a force in feed back wire, which opposes the input signal torque. Spool movement continues until the feed-back wire force equals the input signal force. So the spool stops and remains displaced until electrical input changes to a new level. The actual flow from the valve to the load will depend upon the load pressure. In neutral position leakage rate is 0.005 cc/sec.

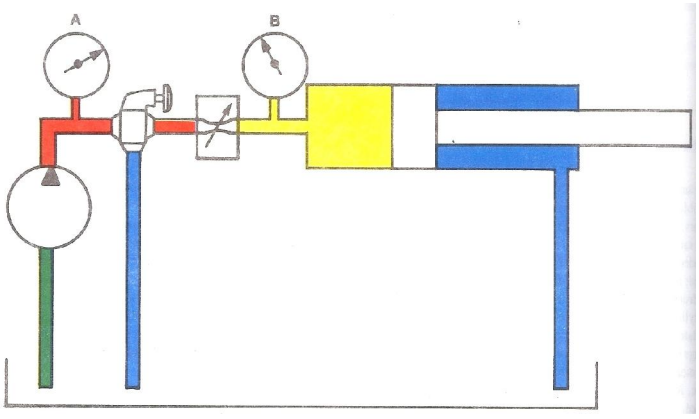
TROUBLESHOOTING IN SERVO VALVE:

Sr. No.	Fault	Causes	Rectification
1.	Servo valve spool sticks.	a) Feed tube dirty	Check system for dirt and clean filter.
		b) Fine filter dirty	Check system for dirt and clean filter
		c) Mechanical return sticks	Valve should be dismantled.
		d) Valve stressed	Loosen unions and tighten uniformly
2.	Servo valve does not function.	a) Electric circuit defective	Check electric circuit.
		b) Rotary magnet system defective	Repair system or replace torque motor.
		c) No differential current	Check electrical installation.
		d) No pressure	Check pump and relief valve.
		e) Oil gummy	Clean valve, flush system and change oil if needed.
		f) Oil temperature too high	Check cooling circuit, check for any line restrictions and reduce pressure setting.
		g) Servo filter clogged	Replace filter.
3.	High null basis (High input current required to maintain the hydraulic cylinder stationary)	a) Incorrect Null adjustment	Readjust the null.
		b) Partially plugged inlet orifice assembly	Clean the inlet.
		c) Partially plugged filter element.	Replace the filters element.
		d) Partially plugged Nozzle	Servicing required.
4.	Out flow obtain from one part only	Plugged inlet orifice	Clean inlet orifice.
5.	Low flow gain (Problem in getting high speed)	Plugged button filter	Replace the filter element.
6.	High threshold (jerky, hunting motion)	Sticky spool	Servicing.
7.	Servo valve overheats.	a) Wrong current	Check current use servo valve tester.
		b) Mechanical return sticks	Needs opening valve.
		c) System pressure too high	Reduce pressure settings.
		d) Wrong oil grade	Respect oil recommendations.
		e) Dirt in system	Flush the system.

FUNCTION: By controlling the rate of flow in a hydraulic circuit, it's possible to control the speed of hydraulic cylinder or motors. A more typical method is to use a flow control valve. By varying the size of opening, one can vary the amount of oil entering the cylinder and thus control its speed. Three factors affect flow rate: pressure, fluid temperature, and orifice size. If any one of these factors is increased, the flow rate increases.

TYPES:Control of flow in hydraulic circuits can be accomplished with a meter-in circuit, a meter-out circuit or a bleed-off circuit.

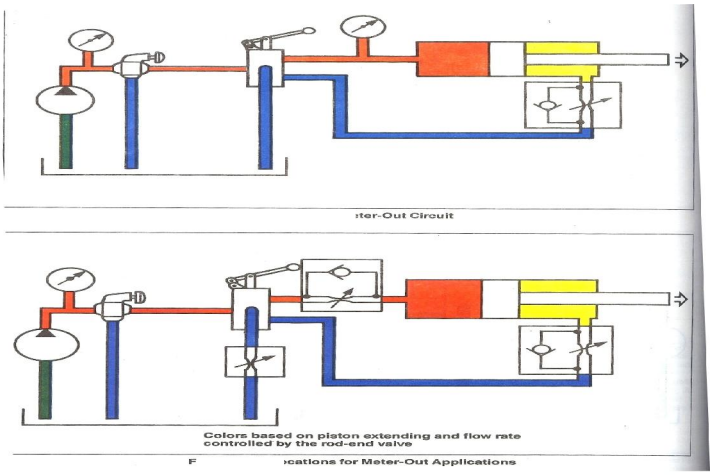
Meter-In circuit:



In meter-in operation, the flow control valve is placed between the pump and actuator. In this way, it controls the amount of fluid going into the actuator. Pump delivery in excess of the metered amount of diverted to tank over the relief valve.

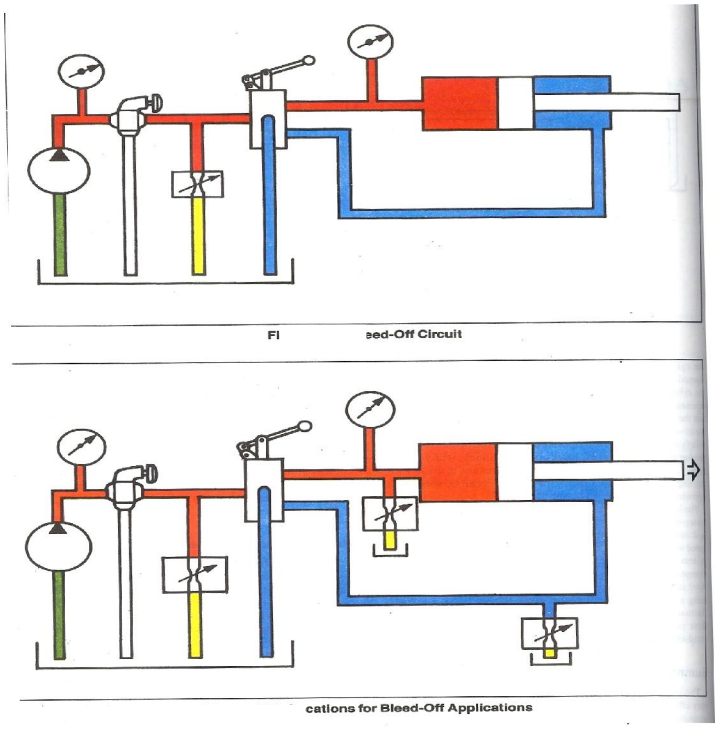
Meter-in circuit can only be used with opposing loads. If the load tends to run away, it would pull the cylinder piston ahead of the oil supply; and since the exhaust flow has a free path back to tank, the meter-in circuit could not prevent the load from running away.

Meter-Out circuit:



The flow control is on the outlet side of the cylinder to control the flow coming out. This is known as a meter-out circuit. If the flow control were closed completely, the oil could not exhaust from the cylinder and it could not move. Regulating the size of the opening controls the flow rate and thus the speed of the cylinder. Although metering into the cylinder is fine with an opposing load, but if the load tends to run away, a better way is to meter out. In fact, a meter-out circuit works if the load pushes or pulls.

Bleed-Off circuit:



The flow control is simply bleed off the main line to control cylinder speed. For instance, with the flow control completely closed, the full flow from the pump would go into the cylinder. However, the moment the flow control is opened up, some bleed off of that pump delivery occurs and the cylinder starts to slow down. Adjusting the size of the opening will bleed off any amount necessary to control how fast the cylinder moves. In the case, unlike the meter-in or meter-out circuits, there is no excess flow going over the relief valve and the pump operates at only the pressure that is needed to move the work load on the cylinder, which saves energy. The bleed-off circuit will not prevent a load from running away. As with meter-in circuit, it can be used with opposing loads only.

TROUBLESHOOTING IN FLOW CONTROL VALVE:

Sr.No.	Fault	Causes	Rectification
1.	Device does not function	a) Device stressed	Loosen bolt and tighten uniformly.
		b) Seat defective	Exchange seat.
		c) Throttle valve defective	Exchange cone.
		d) Non-return valve sticks	Check cone and seat, if needed exchange it.
		e) Fine throttle-valve sticks	Exchange restrictor
		f) Compensator mechanism defective	Disassemble controller and exchange defective parts.
		g) Piston sticks	Check system for dirt, exchange piston.
		h) Spring broken	Exchange spring.
		i) Corrosion on setting mechanism	Clean if needed change.
		j) Wrong choice of device	Install controller of correct nominal size.

INTRODUCTION:

Unlike gases, which are compressible and can be stored for a period of time, hydraulic fluids are usually incompressible. Accumulators provide a way to store these fluids under pressure. Hydraulic fluid enters the accumulator chamber and acts on a piston or bladder area to either rise the weight or compress a spring or a gas. Any tendency for pressure to drop at the accumulator inlet forces fluid back out into the system.

In many hydraulic circuits, the demand of pressurized oil is not constant. The demand of pressurized oil may be temporarily so great that pump cannot supply it alone and one or several motions will be starved of oil and machine will slow down or the system pressure will drop or both. One way is the large pump may be provided to supply the maximum demand need by the system. But it is expensive in both, the initial and running cost. The better way is to use a pump which can supply the average demand of oil and put one or more accumulators in the system. The pump can recharge the accumulator during the idle period.

FUNCTIONS:

1. It acts as an emergency unit. In case of sudden power loss e.g. pipe or joint failure, pump breakdown etc. the accumulator can provide sufficient energy to complete an operational cycle.
2. As a leakage compensator. Oil reserve for maintaining pressure to compensate leakage losses and to maintain pressure for longer period.
3. As an anti vibration device. It prevents pressure knocks and unpleasant operating noise resulting from system. Rapid valve closer can produce shock waves resulting in over pressurization of pipes, joints, valves, etc. The accumulator can neutralize or reduce the shock.

TYPES:

1. Weight type
2. Spring type
3. Piston type
4. Bladder type
5. Diaphragm type

WORKING OF BLADDER OR DIAPHRAGM TYPE ACCUMULATOR:

Operation of an accumulator is automatic. A combination of oil (which is non-compressible) and nitrogen gas (which can both expand and compress) make the accumulator work. When the oil pressures rises, incoming oil compresses the gas. When oil pressure drops, the gas expands forcing out oil. The gas is separated from the oil by bladder. This prevents mixing of the gas and oil and keeps gas out of the hydraulic system. Oil forces the bladder to compress until the resistance of gas is equal to oil pressure. When the hydraulic system needs oil, the compressed gas inside the bladder forces oil to maintain the system flow. The bladder is precharged through the valve core with nitrogen gas. The other end of accumulator contains the oil valve which connects the hydraulic circuit. A rubber sealing ring is provided near at the oil valve to protect the bladder during operation.

QUICK CHECK FOR NITROGEN PRESSURE:

1. Start the engine so that hydraulic pump supplies pressurized oil to the accumulator.
2. Close the pressurized oil supply to the system.
3. Connect the pressure gauge provided in the circuit (driving cabin) to indicate the hydraulic pressure.
4. Stop the engine immediately and keep on watching the pressure gauge. The gauge needle starts coming down slowly.
5. The pressure gauge needle stops momentarily at a place (pressure) and then immediately comes down to zero.
6. The pressure shown by the gauge needle at this momentary stoop over accumulator which should not be less than 80 atmospheres.

CHECKING AND FILLING WITH CHARGING UNIT:

Make sure that Hydraulic pressure is released from the system before attempting to fill or check the Accumulator for Nitrogen.

PROCEDURE:

1. Remove the protecting cap from top of accumulator.
2. Remove the closing nipple from the Accumulator gas valve.
3. Close the venting screw on the charging unit. Turn the handle fully clockwise.
4. Turn the spindle on filler head fully anticlockwise.
5. Connect the filler head to the gas valve and by turning knur clockwise.
6. Connect the charging unit to nitrogen bottle and tighten nut.
7. For checking only nitrogen bottle is not necessary. On new types of charging units a check valve prevents a gas return flow from the accumulator.
8. Turn the spindle on filler head gently clock wise.
9. Read the existing nitrogen pressure in the accumulator on pressure gauge.
10. If a recharging is necessary, open the bottle valve gently until a filling pressure of 90 atm is reading. Shut the bottle valve properly again.
11. Open gently the venting screw on the charging until the required pressure 80 atm is reading on the pressure gauge. Shut the venting screw properly again.
12. Remove the charging unit from the nitrogen bottle.
13. Turn the spindle on filler head fully anticlockwise.
14. Release nitrogen pressure left in the charging unit by opening the venting screw.
15. Disconnect the charging unit from the gas valve on the accumulator.
16. Check the sealing of the gas valve.
17. Fit the closing nipple on to the gas valve and also the protecting cap.

FUNCTIONS:

Cylinders are drive components which converts hydraulic power in to mechanical power. They generate linear movement through the pressure on the surface of the movable piston. Cylinders are linear actuators.

Construction:

A hydraulic actuator constructed of piston or plunger operating in a cylinder housing or tube by energy laden liquid is known as cylinder. The piston of a cylinder is provided either with seals or piston ring to impart sealing effect with inner surface of the cylinder tube and stands for the efficiency of the cylinder. The efficiency of a cylinder is reduced as soon as the seals/rings start wearing resulting in internal leakage of the fluid. The rod of the piston is also provided with seal and scraper arrangement to stop out flow of liquid form cylinder and wiping out dust etc., from the piston rod.
The cylinder barrel/tube is generally seamless steel tube which has been cold worked and steel piston rod is highly polished usually hard chrome plated to resist puffing and scoring. This piston is generally made out of brass or cast iron.
The seals provided are made out of oil and heat resistant synthetic rubbers like Nit rile, Neo-preen and Buna-N. For high temperature working Viton is much suitable. These days polyurethane finds good use in manufacture of seals which are not only heat and oil resistant but wear very slowly which reduces maintenance problem to the minimum.

TYPES:

1. **Ram type:** It is perhaps simplest actuator. It has only one fluid chamber and exerts force in only one direction, most are mounted vertically and retract by the force of gravity on the load. Ram type cylinders are used in elevators jacks and automobile hoists.

2. **Single acting cylinders:** A single acting cylinder has only one port allowing pressurized oil for its actuation. The return stroke of the piston or plunger is achieved either by gravitational action or spring force releasing the oil back to the tank. The oil flow in single acting cylinder is controlled by reversing directional control valve.

3. **Double acting cylinders:** A doubling acting cylinders has got two ports through which oil flow is controlled by directional control valve (generally solenoid valve) in such a way that if one of the two ports is connected to the in flow of liquid from pump the other is connected for back flow to tank and vice-versa. Such cylinders are called differential cylinders.

4. **Telescopic cylinders:** A telescopic cylinder is used where collapsed length must be shorter than could be obtained with a standard cylinder upto 4 to 5 sleeves can be used.

5. **Double rod cylinders:** Cylinder has two equal power stroke. Such cylinders are called non-differential cylinder as they have equal areas on either side.

CYLINDER CUSHION:

Cylinder cushion are often provided either or both ends of a cylinder to slow it down near the end of stroke to prevent the piston from hammering. Deceleration begins when the tapered

cushion ring or plunger enters the cap and begin to restrict exhaust flow from the barrel to port. During the final fraction of the stroke the exhaust oil must discharge through an adjustable orifice. The cushion feature also includes a check valve to by pass the orifice during its return stroke.

ESSENTIAL PARTS OF A CYLINDER:

1. BARRELS: Barrels are usually seamless tubings, honed to a fine on the inside, bore to be parallel and without longitudinal scratches. Other wise oil will leak from one side to other during working due to high working pressure and frequent bursting of seals will occur.

2. PISTON: Piston usually made of cast iron or steel, incorporate seals to reduce leakage between it and cylinder barrel. Step cut automotive type piston rings are used where some leakage can be tolerated.

3. END CAPS: The end caps plug the barrel ends and provide cylinder ports. These are secured with the help of tie bolts.

4. SEALS: Various types of seals are used in the cylinder to prevent leakage and contaminants.

CYLINDER MOUNTINGS:
The main function of a cylinder mount is to provide a means of anchoring the cylinder. There are variety of ways to mount the cylinder including the tie rod, bolt mount, flange, trunnion, side lug and side tapped, and clevis. Rod ends are generally, threaded for attachment directly to the load or to accept a clevis, yoke or similar coupling device.

CYLINDER RATINGS:
The ratings of a cylinder include its size and pressure capability. Main features are-

i. Piston diameter
ii. Piston rod diameter
iii. Stroke length

Cylinder speed, the output force available, and the pressure required for a given load all depend on the piston area, when extending the rod. When retracting the rod, the area of the rod must be subtracted from the piston area.

To find the speed of a cylinder when size and gpm delivery are known, use the following formula:
Speed (Inches Per Minute) =

$$\text{GPM} \times \frac{231}{\text{Effective Piston Area in Sq. In.}}$$

DEFINITION:

Hydraulic motor converts the movement (Kinetic energy and pressure – potential energy) of a stream of hydraulic fluid in the continuous rotating force or movement. More specifically the kinetic energy of a fluid is converted into the kinetic energy of a fluid is converted into the kinetic energy of a rotating shaft in a hydraulic motor. The output of the shaft is the point where the motor is connected to the machine or device to be operated. The pressure of the fluid admitted to the motor determines its force or output. Motor's rating is represented in torque, GPM, cubic inches/rev A hydraulic motor converts hydraulic energy into mechanical energy. It is a rotary actuator. In construction it is almost some as hydraulic pump. The gear's, rotor are pushed by pressurized fluid and torque is developed i.e. continuous rotating motion is developed hydraulic motor's are externally drained Hydraulic motors are rated according to displacement (size),torque capacity, speed and maximum pressure limitations.

CLASSIFICATION OF HYDRAULIC MOTORS:

Hydraulic motors can be classified by application into three categories:

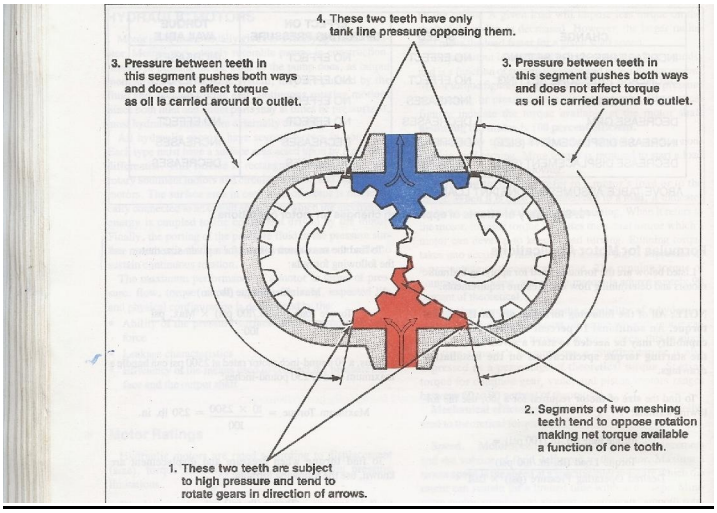
(1) High Speed, Low Torque Motors (HSLT)-in line piston motor , bent-axis motor vane motor and gear motor.
(2) Low speed, High Torque Motors (LSHT)-internal gear motor, vane rolling motor radial piston motor and axial ball piston motor.
(3) Limited Rotation Motors (Torque Actuators)

TYPES OF MOTORS:

1.Gear motors –including external and internal (gerotor and rolator or orbital) motors
2.vane motors—including unbalanced, balanced, fixed, variable and cartridge (high performance) types
3.piston motors-including in-line, bent-axis, and radial motors (fixed, variable and cam type)
4.screw motors-
5.Torque Generators – including

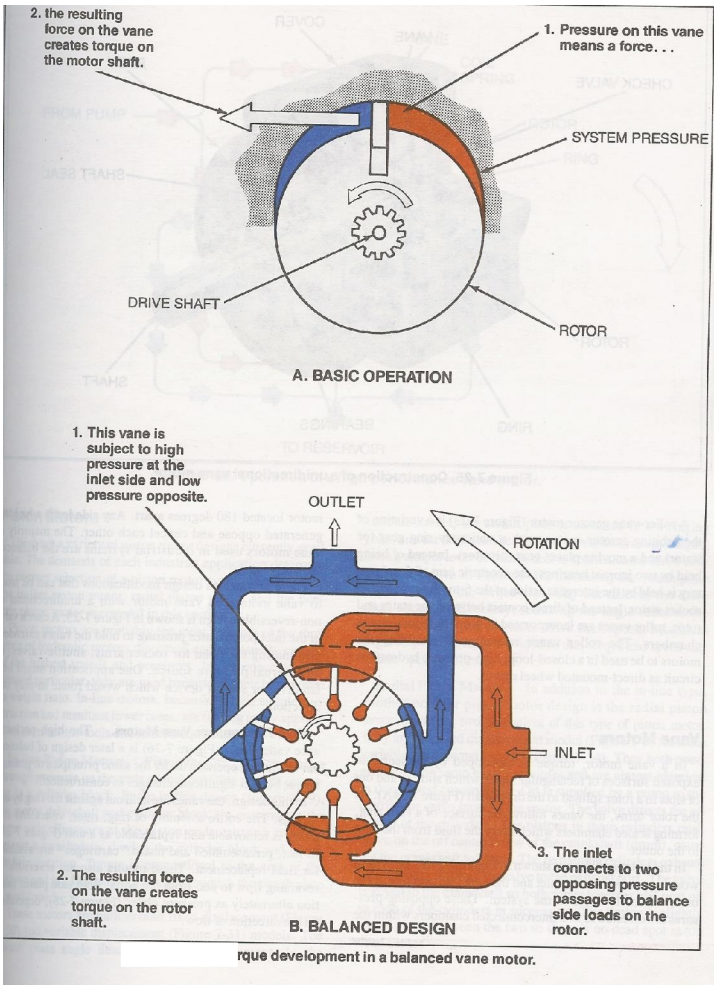
WORKING:

1. **Gear motor:**



A gear motor develops torque through pressure on the surfaces of gear teeth. The two gears mesh and rotate together, one gear coupled to drive shaft. The displacement of a gear motor is fixed and is equal to volume between two teeth multi plied by number of teeth. Generally gear's are not in balance with respect to pressure at the outlet result in high side loads on the shaft and gears as well as the bearings. Gear motor's are simple and more dirt tolerant.

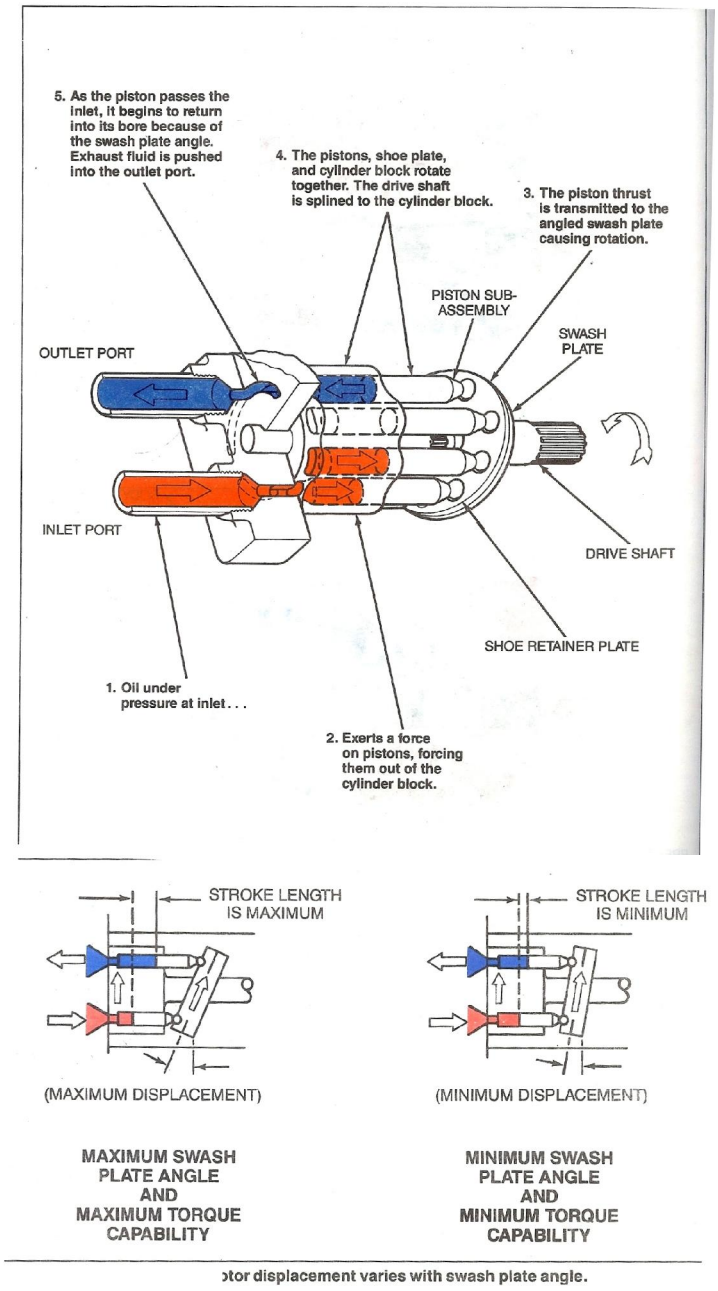
2. **<u>Vane motor</u>:**



rque development in a balanced vane motor.

In vane motor torque is developed by pressure on exposed surface of rectangular vanes, which slides in and out of slots in a rotor to drive shaft. As the rotor turns the vanes follow the surface of cm ring, carrying the fluid from inlet to outlet. In operation pressure under the vanes also holds them in contact with cam ring some devices are used to hold the vanes, may be spring clips or small springs beneath each vane pushing it out.

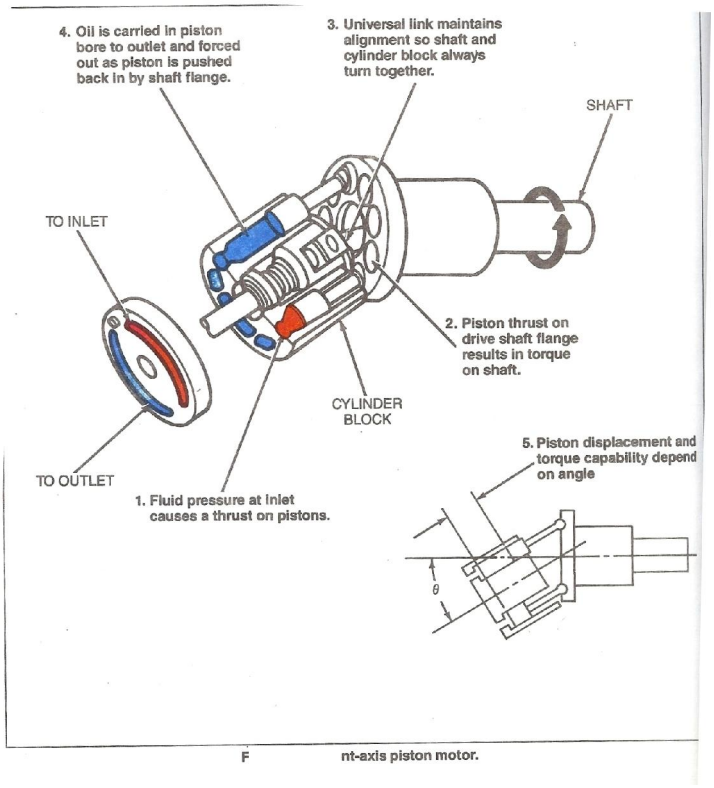
AXIAL PISTON MOTOR:



The axial piston motor is an energy converter with an axial piston arrangement in a barrel shaped body in swash plate-design motor circular arrangement of 9 pistons is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinderal barrel which his firmly fixed to the drive shaft by means of a key. The piston ends or of burn and surface design and run on slipper pads. These are held on a swiveling but not rotating swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle which determines the pump displacement. The function of hydraulic motor is the reverse of that of the pump. Energy laden fluid is directed to the hydraulic motor while fluid is being directed at atmospheric pressure from a tank to the pump which then receives a specific amount of energy via the drive motor and the fluid is supplied to the system as pressure fluid. By charging the direction of the active components of this

pressure fluid, hydraulic energy is converted into mechanical energy (as a torque) via the driven shaft (31). The energy- free fluid is now returned from the hydraulic motor to the tank. On this particular design too, 4 pistons are pressurized 4 are connected to the tank, and 1 is in an intermediate position. The bores in the pistons leading to the ball and socket serve to reduce the high surface pressure in the ball and socket and on the sliding disc that is to say – they serve to provide a hydro-static bearing. For special applications these hydraulics motors can also be equipped with any of the control and regulating devices

BENT AXIS DESIGN MOTOR:



F nt-axis piston motor.

The axial piston motor of bent axis design is an energy converter which converts the energy of the input fluid via a rotary movement into a torque on the driven shaft. The output speed is proportional to the displacement on the so called swept volume, and the torque is proportional to the operating pressure for to be more to the pressure drop between the inlet and outlet. As a rule motors with fixed displacement that is with a fixed swivel angle are used. Variable displacement units are, however, used in some applications.

The rotary group takes from of a complete interchangeable unit and consists of the angled barrel type body with output shaft, supported in the housing by robust bearings.

Pressure oil is supplied via the spherical port plate and those pistons not connected, the hydraulic energy being transmitted to the driven shaft by means of the stroke and output force of 3 pistons are converted into a torque. The now energyless fluid is returned to the tank by means of the return stroke of the 3 pressure unloaded pistons. The seventh piston remains in the crossover position. Due to the spherical design of the port plate torque free bearing of the barrel body is always given, even with maximum loading, the resulting forces in the motor housing being fully absorbed.

MOUNTING PRECAUTION:

1. Motor's rating should be according to the work load.
2. All hydraulic connections must be tight. Loose connections will permit air to be drawn into the system causing noisy and erratic operation or will permit the hydraulic fluid to leak out.
3. Incoming and outgoing ports should be kept in desired direction.
4. All mounting screws should be properly tightened to prevent misalignment of shaft connections.
5. Shaft connecting devices such as keys, collars, etc. must be properly seated to avoid slippage and possible shearing of the shaft.
6. Tubing must not be bent too sharply. The minimum radius for bends is three times the inside diameter of the tube.
7. Sometimes motor is mounted indirectly to work load using pulleys and V-belts or chain or spur gear arrangements. Because of slippage possibilities flat belts must not be used. It is important to check for correct alignment and excessive belt tension. This is necessary to prevent excessive side loads imposed on the drive shaft bearings.

TROUBLE SHOOTING:

PROBLEMS	CAUSES	REMEDIES
1. Motor not running	1. No incoming pressure	1. Check pump and relief valve.
	2. Shaft seizure due to misalignment.	2. Align correctly the shaft with work load.
	3. Shaft seizure due to excessive load.	3. Check load and load capacity of motor.
	4. Too much play in the shaft.	4. Replace bearing.
	5. Oil spill at motor.	5. Check if port plate is in contact.
	6. O-ring on port plate effective.	6. Replace O-ring.
	7. Motor type too small.	7. Replace for larger type.
2. Slow motor operation.	1. Inlet pressure too low.	1. Increase pressure by setting relief valve.
	2. Motor parts defective	2. Replace defective parts.
	3. Oil temperature too high.	3. Check for line restrictions, wrong fluid viscosity and also check cooling circuit.
	4. Outlet pressure too high	4. Check outlet line
	5. Port plate does not make contact.	5. Disassemble motor and repair.

FLUID TEMPERATURE CONTROL:

Every hydraulic system operates most efficiently, when the fluid temperature is held with in a certain limit. There is an ideal temperature at which the resistance to fluid flow is minimum. While the fluid still retains its lubricating and sealing characteristics. Temperature higher than the desired level can reduce the lubricating characteristics of hydraulic fluid. Some fluid may breakdown forming undesirable contaminants. This can lead to plug orifices, piping or valves etc. When the fluid viscosity decreases at high temperature, the lubricating film formed by the fluid may be destroyed. This allows metal to metal contact and the fluid temperature rises.

To control the temperature of hydraulic fluid many circuits use a heat exchanger. This heat exchanger may either heat or cool the hydraulic fluid depending on the requirement of the circuit. Heat exchangers are of three types-heaters, water coolers and air coolers.

WATER COOLERS:

In a typical water cooler, hydraulic fluid is circulated through the unit and around the tubes containing the water. The heat is removed from the hydraulic fluid by the water, which can be regulated thermostatically to maintain a desired temperature. The water is filtered to prevent the cooler from clogging. By circulating hot rather than cold water, this type of temperature control can also be used as a heater.

Water flow requirements are usually equal to between ¼ and 1/3 of the system oil flow. The availability of cooling towers and water recycling reduces the cost, but water taken from these sources usually has a higher temperature than that of municipal systems.

AIR COOLERS:

The fluid is pumped through tubes that are bonded to fins made of aluminum or some other metal that transfers heat to the outside air. The cooler usually has a blower to increase the heat transfer. Air coolers are less efficient than water coolers and tend to be ineffective in areas of high ambient temperatures. The initial installation cost is higher than that of water coolers, but the operational costs are usually less.

MAINTENANCE ASPECT:

For effective cooling hydraulic cooler should be fully functional. Following maintenance steps should be carried out-

1. Cooler fins should be properly cleaned as dust particles sticks to the fins which reduces the cooling effect. Never clean the fins by oil. Use air for cleaning.
2. Cooler fan should run at sufficient speed otherwise heat dissipation does not takes place properly. Pressure setting for running of fan motor should be properly done.
3. Cooler tubing should be properly cleaned so that oil may flow freely. If cooler is getting chocked, the bypass valve opens and oil goes to tank without cooling.
4. Fan blades should be of proper orientation.

SUB-DISCIPLINE: HYDRAULICS (LESSONS: 20 SESSIONS: 42)

Lesson-XVI-A: Hydraulic Circuits **Session-25:** Closed Loop Circuit of 3X and CSM

Lesson-XVII: Demonstration of Hydraulic Transparent Models **Session-25:** Hydraulic Motors, D.C. Valves, Cylinder, Accumulators Pressure Gauge etc.

Demonstration of internal detail of working of above said components is done and explained.

Lesson-XVII: Demonstration of Hydraulic Transparent Models **Session-26:** Pressure Control Valves, Flow Control Valves, Check Valve, Pilot Operated Check Valve etc.

Demonstration of internal detail of working of above said components is done and explained.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-27: Vane Pump & Vane Motor

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-28: Axial Piston Pump

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-29: Check Valve and POC Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-30: D.C. Valves

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-31: Proportional Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-32: Servo Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

SUB-DISCIPLINE: HYDRAULICS (LESSONS: 20 SESSIONS: 42)

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room

Session-33: Relief Valve & Unloader Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room

Session-34: Pressure Reducing Valve and Cylinder

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XIX: Hydraulic Circuits **Session-35:** Constant Pressure Circuit of 3X and CSM

The constant pressure circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-36:** Constant Pressure Circuit of Duomatic, Unimat and BCM

The constant pressure circuits of the above mentioned machines are discussed in detail in the model room.

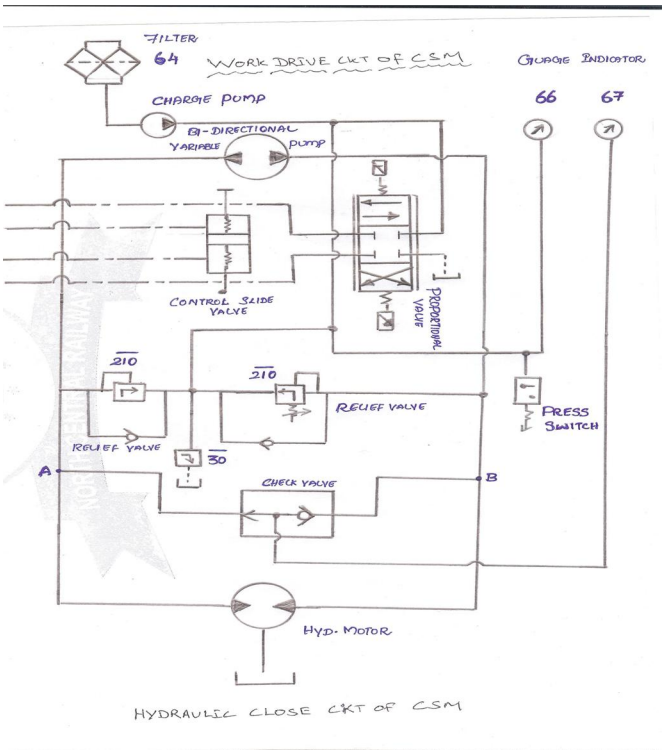
The closed loop work drive circuit of the 09 - CSM machines.

EXPLANATION OF A HYDRAULIC CLOSED LOOP CIRCUIT:

Basically hydraulic circuits are working on two principles. First is open circuit and second is closed circuit. In open hydraulic circuit, after the actuation work is over return oil goes back to the tank directly via hydraulic cooler. In the case of closed loop circuit, the return oil does not go back to the tank directly but it rotates within the circuit.The typical example of a closed loop circuit is the work drive circuit of 09-CSM.In the hydraulic circuit of work drive of 09-CSM, there is a charge pump provided inside the axial piston pump and this charge pump is a gear type of pump. This charge pump sucks oil from the reservoir and gives a positive feed to the main pump (axial piston) capacity 90cc. The pressure setting of this charge pump is 30 bars.As we know the axial piston is a variable type of pump where pump delivery is possible only with the change of swash plate angle. If swash plate angle is zero, than there will be no pump delivery.

More the angle change more will be pump delivery. For change of direction of pump flow, a proportional; valve is provided. When it is operated say RHS side, charge pump pressure acts over it and then transfers the pressure to control slide valve which in turn presses mechanical leverage and them there is swash angle displacement in RHS, the pump delivery takes place and the flow of hydraulic pump is converted into pressure energy with a relive valve i.e. at 210bar. This pressure of 210 bar is used for the movement of hydraulic motor, which is connected to axle. Similarly when LHS side of proportional valve is activated then again control slide valve is activated and operated in reverse direction and the pump delivery takes place for another port. The cross relief valve provided is set at 210bar. This pressure is utilized for the movement of hydraulic motor and power is transmitted. In the circuit hydraulic pressure gauges have been provided which shows the pressures of axial piston pump and charge pump. This should be ensured that no gauges should be defective. In case it is defective, it should be replaced immediately. The figure of above Hydraulic Circuit explanation is given below:

WORK DRIVE CIRCUIT OF CSM.



Lesson-XIX: Hydraulic Circuits **Session-38:** Closed Loop Circuit of BCM, SBCM & BRM

The closed loop circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-39:** Regenerating Circuit of Tamping Machines

The regenerating circuit of tamping machines is discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-40:** Intermittent Circuit of Non-Tampers

The intermittent circuit of non-tamping machines is discussed in detail in the model room.

Lesson-XX: Demonstration of Hydraulic Equipment Sets
Session-41: Demonstration of Hydraulic Circuits Using Fluidsim Software & Work exercises

Different hydraulic circuits are drawn using FluidsimH Software and the circuits are made and verified through the model components of hydraulic equipment set available in the model room.

Lesson-XX: Demonstration of Hydraulic Equipment Sets**Session-42:** Demonstration of Hydraulic Circuits Using FluidsimH Software & Work Exercises

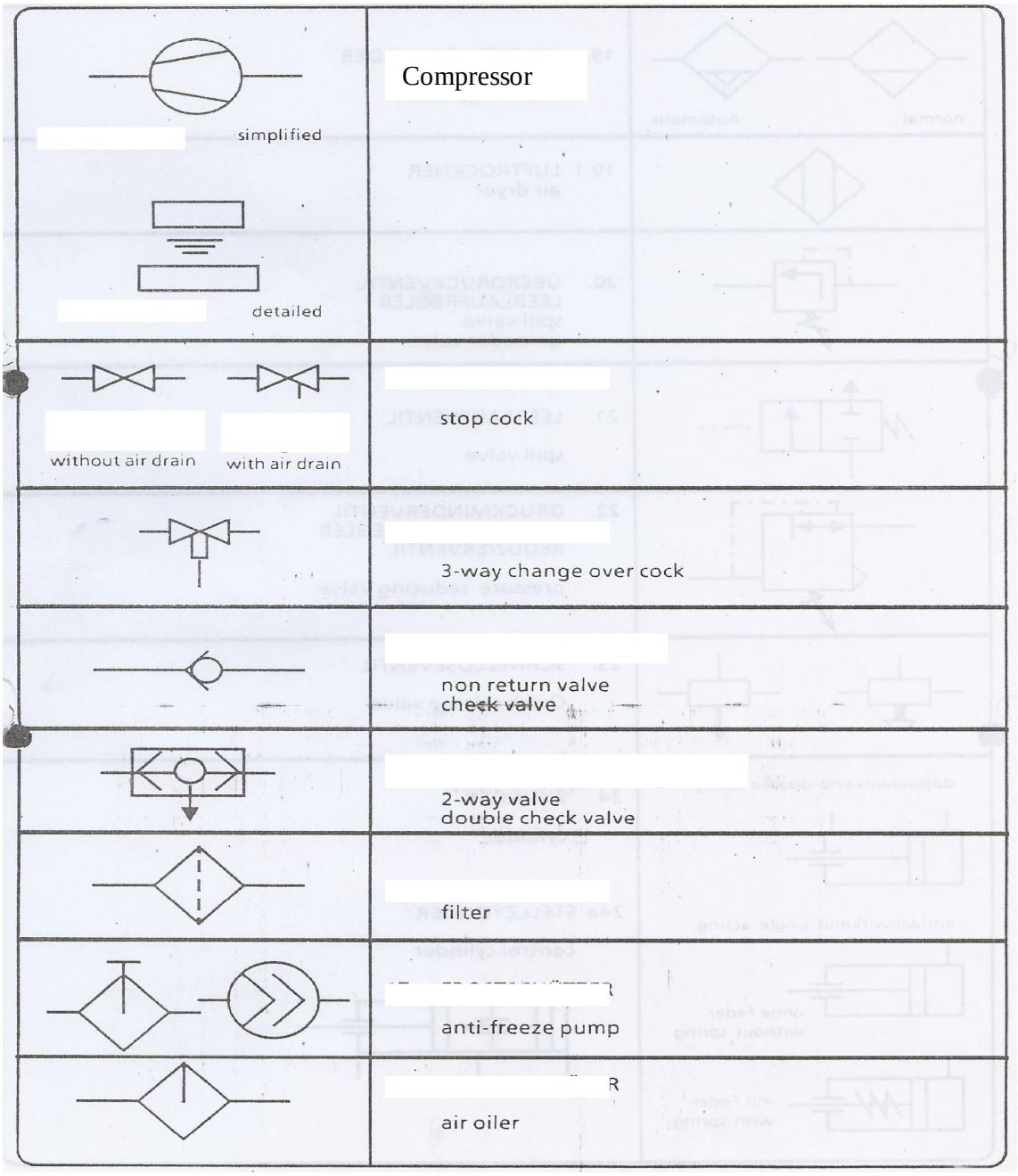
Different hydraulic circuits are drawn using FluidsimH Software and the circuits are made and verified through the model components of hydraulic equipment set available in the model room.

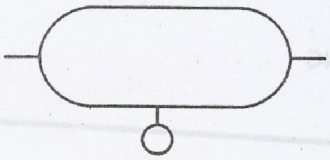
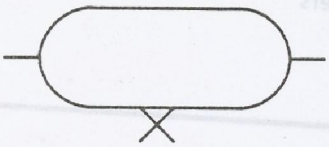
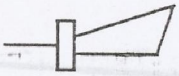
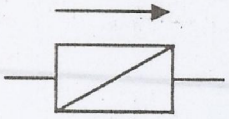
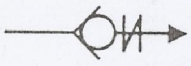
SUB-DISCIPLINE: PNEUMATICS (LESSONS: 05 SESSIONS: 08)

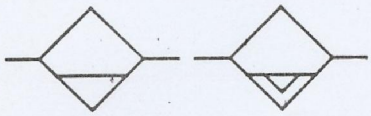
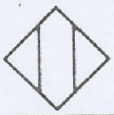
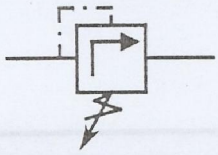
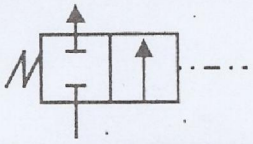
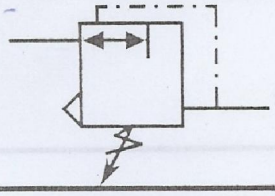
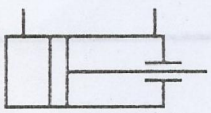
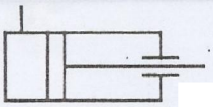
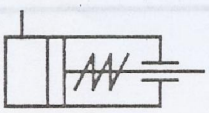
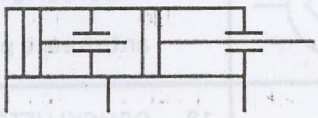
Lesson-I: Pneumatic Symbols**, Session-01:** Pneumatic Symbols And Application Of Air On Track Machines

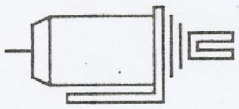
PNEUMATIC SYSTEM:-The word pneumatic has been derived from Greek word. Which refers to flow of air and now a days it includes flow of any gas. In a system under pressure. The pneumatic power is used in industry, workshop and machine to perform various jobs. Broadly speaking the pneumatic power is covered under the heading fluid power. One of which is hydraulic which utilizes water or oil for power transmission and other is pneumatic system that uses gas or compressed air by transmitting the force on track machine we are concerned with the compressed air for pneumatic system. The most common source of pneumatic is compressor which is responsibly for developing compressed air and its utilization for various purposes on machine.

PNEUMATIC SYMBOLS:

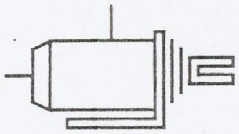


	plug in coupling
 with drain valve  without drain valve	air reservoir air receivers
	horn
	overflow valve, spill valve
8 bar 	preloaded valve safety valve

	water separator
	air dryer
	unloader valve
	spill valve
	pressure reducing valve
	Quick release valve
double acting   	cylinder control cylinder 



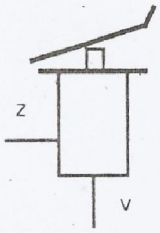
normal



with spring loaded

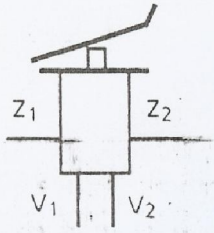
brake cylinder

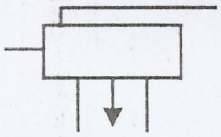
single brake circuit



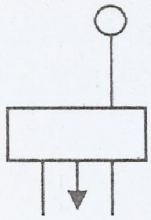
foot operated brake valve

double brake circuit

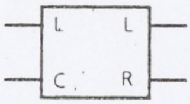
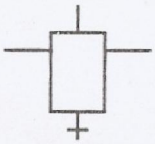
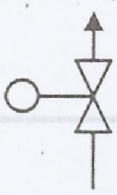
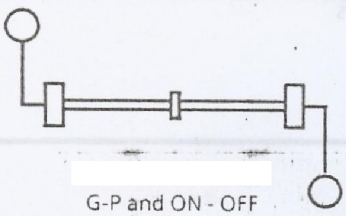
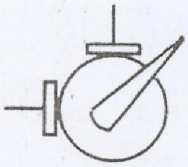
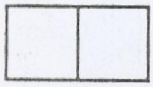


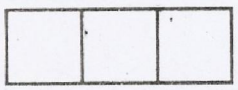


drivers brake
valve for indirectly operated brakes



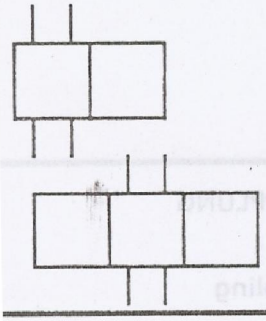
drivers brake
valve for directly operated additional brakes

	control valve (KE-valve)
	drip collector
	brake line - house coupling
	Emergency brake valve
 G-P and ON - OFF	change over linkage
	engine acceleration valve (throttle valve)
 without centralisation	valves

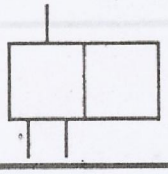


valves

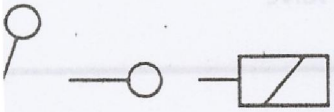
vith centralisation



4-way-valve

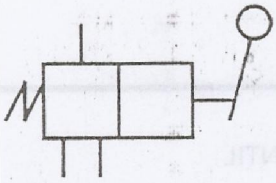


3-way-valve



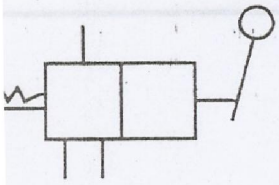
actuating symbols

er cam solenoid



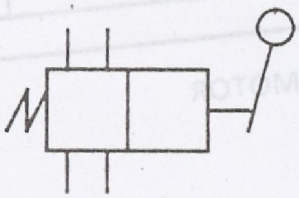
3-way-valve

centralisation by spring

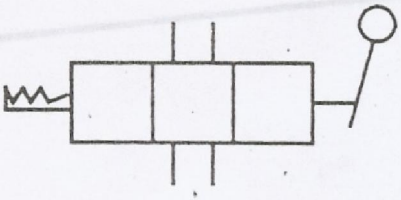


ith mechanical rest position

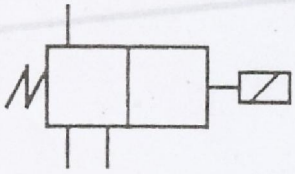
4-way-valve



centralisation by spring

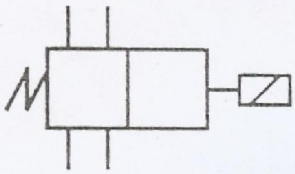


with mechanical rest position

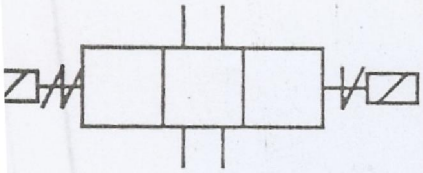


3-ways

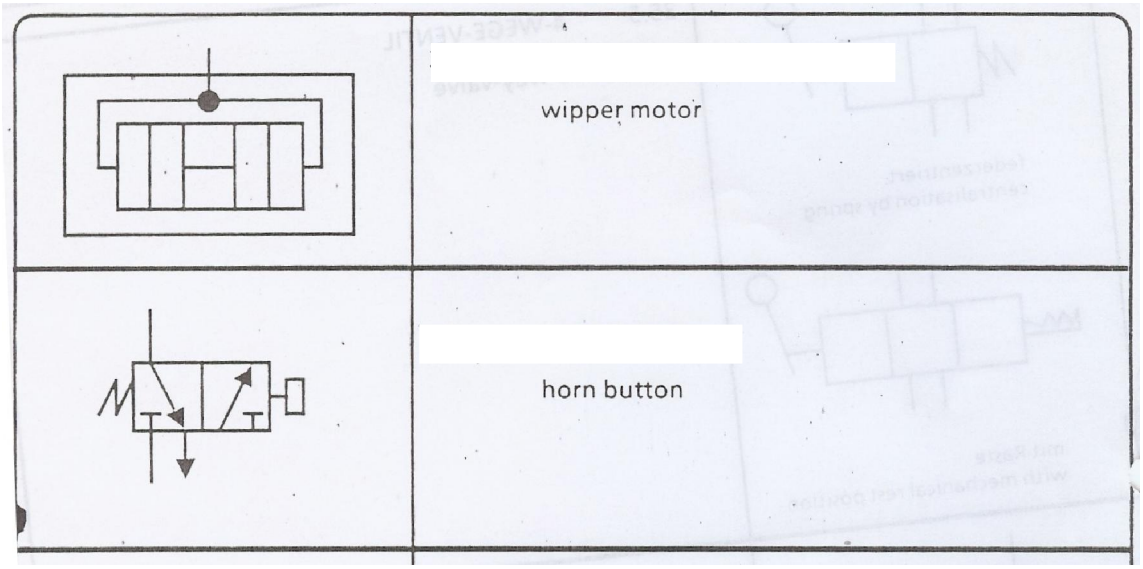
solenoid valve



4-ways



4-ways



APPLICATION OF PNEUMATIC POWER:-

1. Application of brakes.
2. Locking & unlocking of tamping unit, lifting unit, boogies.
3. Lifting and lowering of different bogies.
4. Clapper cylinder.
5. Pneumatic horn.
6. Lubricating system.
7. Application of datum.
8. Wiper.
9. Tightening of leveling / chord/ lining/ chord.
10. Filling the diesel tank.
11. Spray painting.
12. Engaging / disengage pinion to satellite gear.
13. Engaging / disengage the dog clutch
for work drive in CSM /UNIMAT.

AIR COMPRESSOR: Compressor is a machine which converts air at atmospheric pressure into high pressure by changing its volume. There are two types of compressor

1). Reciprocating Compressor.

2). Rotary compressor.

Compressor can be driven by an electric motor or by a diesel/ petrol engine, which serves as a prime mover to the pneumatic power unit.

Reciprocating compressor:-A reciprocating compressor can be single or multiple piston compressors. The more the number of piston in a compressor. the more powerful a compressor is. The multi piston cylinder block of a compressor has crank shaft having same number of crank connection has the number of piston and cylinder in it. The crank shaft is connected to the prime mover .With each cylinder. there are two ports known as inlet and exhaust port depending on their functions. The compressor unit is provided with a sump for storing the oil in it for lubricating and cooling of various components of compressor assembly.

When the crank shaft of compressor rotates and the piston of air compressor takes an inward stroke, atmospheric pressure being higher than the pressure in the compressor cylinder, the flow of air takes place through the inlet port when the crank rotates further and piston moves forward stroke, the inlet valve closes and exhaust port opens thus sending the compressed air to the system/ air container (air tank). The compressor reduces the volume of air thereby increasing its pressure.

If the compressor is a multi stage, one piston sends compressed air to another cylinder and thus to tank. The capacity of a compressor is depending upon the number of cylinder in it. The term single or multistage depends upon the no. of stages or steps that a reciprocating compressor uses to compress air to its final pressure. Single stage compressors are more economical for a pressure below 100 psi but for higher operating pressure multistage compressors are more beneficial.

The capacity of a compressor is defined as volume of air displaced per minute. In FPS (Foot pound system) is denoted by CFM (Cubic ft min) and in M.K.S is LPM (Liter per min).

COOLING COIL:-

As the compressed air has get its temperature risen due to compression, the temperature has to be brought down. This is done by cooling coil which is a helical copper tube by which the cooling coil comes in contact with atmospheric air and therefore the compressed air inside the cooling coil cools down.

PRESSURE VALVES:

Pressure control valves are elements which predominantly influence the pressure or are controlled by the magnitude of the pressure. They are divided into the three groups:

1. Pressure regulating valve
2. Pressure limiting valve
3. Pressure sequence valve

PRESSURE REGULATING VALVE:
The role of this valve is to maintain constant pressure even with fluctuating supply. The input pressure must be greater than the required output pressure.

PRESSURE LIMITING VALVE:
The pressure limiting valves are used mainly as safety valves (pressure relief valves). They prevent the maximum permissible pressure in a system from being exceeded. If the maximum pressure has been reached at the valve inlet, the valve outlet is opened and the excess air pressure exhausts to atmosphere. The valve remains open until it is closed by the built-in spring after reaching the preset system pressure.

PRESSURE SEQUENCE VALVE:
The principle on which this valve acts is the same as for the pressure limiting valve. If the pressure exceeds that set on the spring, the valve opens.

AIR DRYER:-

Condensate (water) enters into the air network through the air intake of the compressor. The accumulation of condensate depends largely on the relative air humidity. The relative air humidity is dependent on the air temperature & the weather condition.
The service life of pneumatic system is considerably reduced if excessive moisture is carried through the air system to the components. Therefore it is important to fit the necessary air drying equipment to reduce the moisture content to a level which suits the application & the components used.
Drying of the compressed air is a achieved by leading the air flow from compressor through a desiccant granulate (Means of adsorption). The granules are of reticulate molecular structure, thus achieving an active surface being large enough to absorb the moisture out of the air. The drying agent is a granular material (gel) consisting almost of silicon dioxide.

WATER SEPERATOR:

The presence of moisture results in the following types of after effects on the pneumatic components and the system is badly affected.

1. Rusting & corrosion.
2. Formation of emulsion.
3. Reduction in lubricating property of oil.
4. Choking of small orifices, valves and system.

So it is imperative that the moisture from the air is removed to avoid crippling of the system.

The first step in process of compressed air after pressure regulation is its filtration or removal of moisture contents which is harmful not only that it may result in rusting but also it may form emulsion with lubricating oil which will block the pneumatic assemblies. The air under pressure enters through inlet of a specially designed water separator having provision for baffle and quite zone. The water droplets are thrown from air stream by virtue of their centrifugal force when they strike the deflector with louvers at the entrance. The water collected at the bottom of quite zone is drained out through the drain tap provided at the bottom or by removing the transparent bowl container.

AIR OILER:

There are certain pneumatic tools and equipments which require lubricated air to reduce wear and corrosion and there are certain other components which do not tolerate oil in the air stream. The importance of lubrication can be well imagined as it not only decreases friction but also prevent corrosion of pneumatic assemblies and simultaneously increases the efficiency.There are two types:

1. OIL FOG LUBRICATOR:

It has a transparent bowl which is filled with oil according to consumption. It has a siphon tube dipping in it which open upon a needle valve. When the air under pressure passes through the venturi section, it is atomized and causes the follow of oil in the form of oil fog (1 drop/10 cu. ft/min) which lubricates the parts through which it passes.

2. CONSTANT DENSITY LUBRICATOR:

It is very simple in construction. A transparent bowl serves as an oil container in which dips the lower end of the siphon pipe having filter attached to its bottom. Air under pressure enters from inlet pore to the container and keeps the oil under constant pressure (regulated by pressure regulator).

D.C. VALVES:

Direction control valves used in pneumatic system are similar to those used in hydraulics. Their primary function is to direct flow of air from one place to another in the system. DC valves are devices which influence the path taken by an air stream. Normally this involves one or all of the following:

- Ø Opening the passage of air and directing it to particular air lines.
- Ø Canceling air signals as required by blocking their passage.
- Ø Relieving the air to atmosphere via an exhaust port.

DC valve is characterized by its number of controlled connections or ways, the number of switching positions and the method of actuation.

Designs are categorized as follows:

1. Poppet valves
   1.1. Ball seat valve
   1.2. Disc seat valve
2. Slide valves
   2.1. Longitudinal slide valve (spool valve)
   2.2. Longitudinal flat slide valve
   2.3. Plate slide valve.

POPPET VALVES:
With poppet valves the connections are opened and closed by means of balls, discs, plates or cones. The valve seats are usually sealed simply using flexible seals. Seat valves have few parts which are subject to wear and hence they have a long service life. They are insensitive to dirt and are robust. The actuating force, however, is relatively high as it is necessary to overcome the force of the built-in reset spring and the air pressure.

SLIDE VALVES:
In slide valves, the individual connections are linked together or closed by means of spools, flat slide or plate slide valves.

AIR RECEIVER/CONTAINER:

Before discussing an air receiver, let us be clear in mind that unlike liquids (which are virtually impressible) is readily co9mpressible. That is why a large quantity of air can be stored in a comparatively smaller vessel or container. The more the air in a container, the higher is the pressure and stronger should be the container to with stand that pressure.

CYLINDERS:

A pneumatic cylinder converse compressed air pressure into mechanical linear force. When the compressed air enters on of the ports of the cylinder, it transmits movements to the piston and its rods and becomes mechanical force to do some work. The flow rate of the pneumatic power determines the piston speed and output in horse power.

PIPING, HOSES AND FITTINGS:

Piping is an important part of pneumatic system. It is not only to transmit the pneumatic power to various components, but also to keep it clean and free from contaminants. The pipes utilized on the machines should be flexible and strong enough to withstand the working pressure of the system.

As a thumb rule, the testing pressure of a pipe should be double that of working pressure and bursting pressure double that of the testing pressure.

The working pneumatic pressure on track machine varies between 6.5 – 7.0 kg/cm^2.

The inside diameter of pneumatic pipe is 6.3 mm and 12.6 mm are used for general transmission and brake system of the machine.

SUB-DISCIPLINE: PNEUMATICS (LESSONS: 05 SESSIONS: 08)

Lesson-III: Pneumatic Circuits, **Session-04:** Pneumatic Working Circuits

---

Pneumatic working circuits of different machines are discussed in detail.

Lesson-III: Pneumatic Circuits, Session-05: Pneumatic Brake Circuits

---

Pneumatic brake circuits of different machines are discussed in detail.

Lesson-IV: Pneumatic Circuits**, Session-06:** Failure Analysis and Troubleshooting of Pneumatic Assemblies

---

Lesson-V: Demonstration of Pneumatic Equipment Sets, **Session-07:** Demonstration of Pneumatic Circuits Using FluidsimP Software & Working Exercises

---

Different pneumatic circuits are drawn and the circuits are made and verified through the model components of pneumatic equipment set available in the model room.

Lesson-V: Demonstration of Pneumatic Equipment Sets, **Session-08:** Demonstration of Pneumatic Circuits Using FluidsimP Software & Working Exercises

---

Different pneumatic circuits are drawn and the circuits are made and verified through the model components of pneumatic equipment set available in the model room.

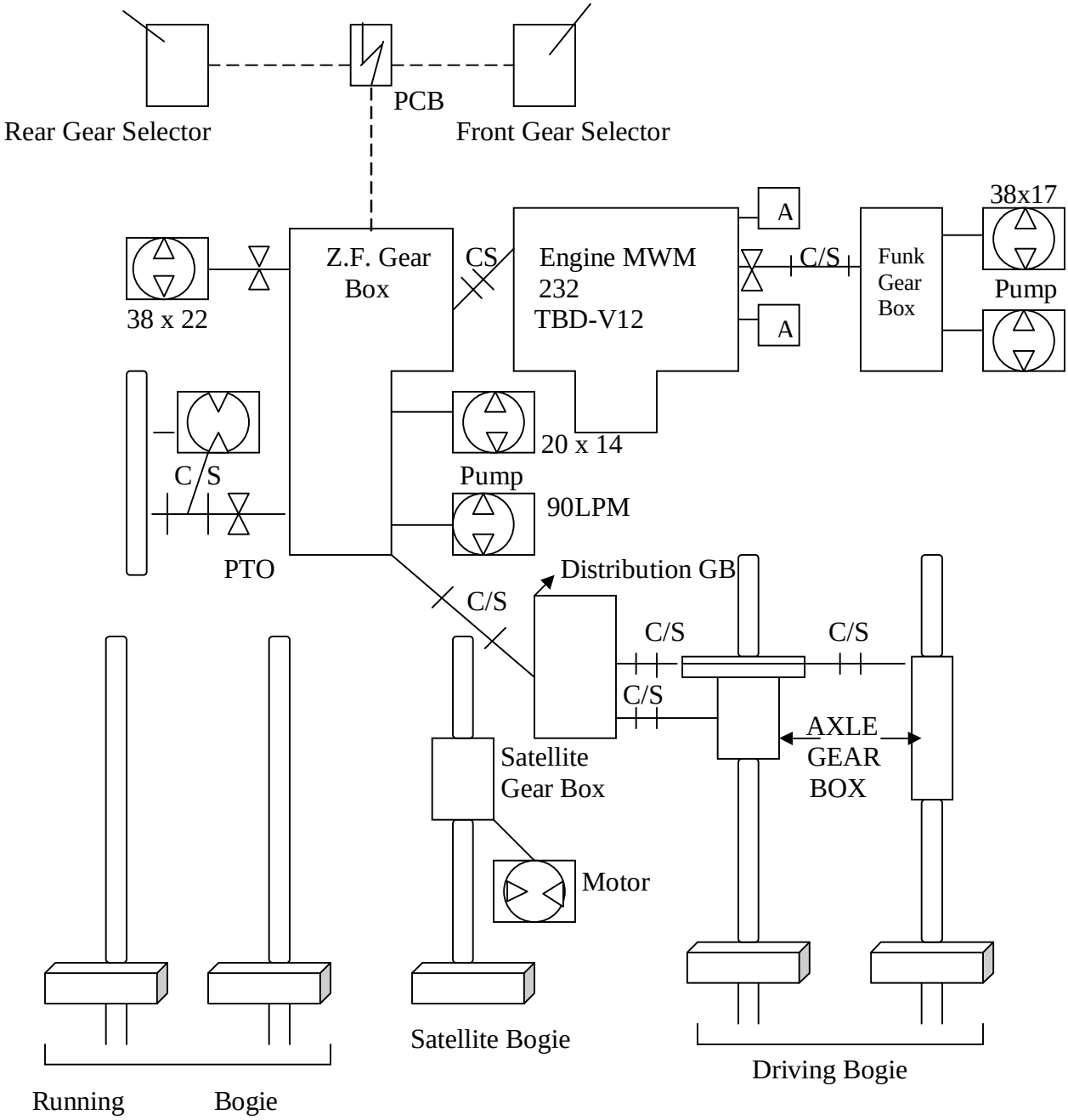
SUB: HYDRAULICS, PNEUMATICS & MECHANICAL

Duration: 74 Sessions = 148 Periods

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-I: Power Transmission **Session-1:** Block Diagram, Types of Power Transmission, Mechanical Transmission, 'V' belt, Chain, Pulley, Cardon Shaft.

POWER TRANSMISSION



POWER TRANSMISSION

In mechanical Engineering, the word power transmission is widely used term in all types of transmission applicable involved mechanical arrangement. The following are the various

mechanical power transmissions generally available in day to day working which are given as under:

'V' Belt transmission
Chain drive transmission
Pulley drive transmission
Gear drive transmission

'V' BELT TRANSMISSION:

This is the Mechanical Power Transmission method in which 'V' belts are used and the power is transmitted from one point to the another. In this method power transmission is affected on account of wear and tear and slippage etc. Generally following are the different categories of belts used in transmission in machines, A-33, A-34, A-41 & A-42 etc..

VEE BELTS

RUBBER BELTS:

Rubber belting is one of the important medium of transmission of mechanical power.

They are trapezoidal in X section.

The vee belts are designated by suffices letter A. B. C. & D which standard dimensions followed universally by all belt manufacturers.

(i) Installation & Maintenance:

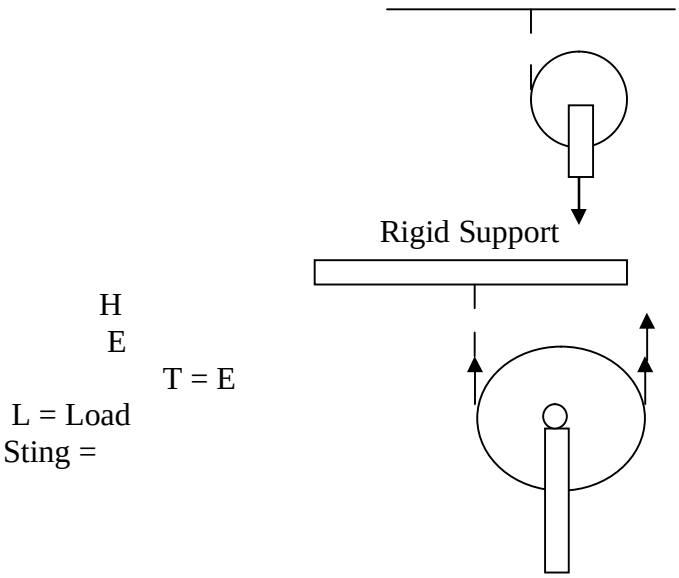
1. Check pulley groves for damage, dent make, burs and excessive wear before mounting the belts.
2. Check drive and driven units for alignment.
3. Move the drive unit towards driven unit to mount the belts in groove.
4. Avoid excessive and un even tension.
5. All ways use pulley with larger dia.
6. Check for pulley groves angle and proper positioning of belt.
7. Check the belt tension daily.
8. If it is required to be change a belt in a multi belt drive unit, change all the belts with new set.
9. During storage, keep the belts hanging.
10. Store the vee belt in cool and dry place.

(ii) Chain Drive Transmission:

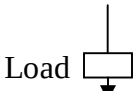
This is the method of power transmission in which chain is used for transmitting power from one end to another. In this method chain is interlinked and power transmission takes place. In track machines, following are the applications of chain drives such as simplex chain, duplex chain of PQRS machines, cutting chain of BCM etc.

(iii) Pulley Drive Transmission:

This is also a method of power transmission in pulleys is used and we get mechanical advantages by the fixed support following figure:



(Single movable pully)



As per the figure: An inextensible Sting of negligible Mass-Passes around the grooved rim of the pulley. One end of the sting is tied to a hook 'H' at a rigid support and the effect 'E' is applied at its free end.

The tension 'T' acts on the string on both sides of pulley as shown in the above figure.

Load is balanced L = T+T = 2T and effort E = T.

Mechanical advantage = $\frac{\text{Load L}}{\text{Effort E}}$

therefore MA $= \frac{2T}{T} = 2$

So by applying an effort equal to half the load (in ideal situation) i.e. single movable pulley acts as a Force multi pliers) P

(iv) Gear Drive Transmission:

In this method of power transmission Gears are used for transfer of power from one point to another. More teeth of Gears are meshed to each other. There are two gears which are connected to each other one is drive gear and the another driven gear. Depending upon no. of teeth, Gear Ratio is decided. The arrangement of gears on drive and driven gear can be such that driven gear can rotate faster or slower.

(v) Cardon Shaft Transmission:

In this method power transmission is achieved through different cardon shafts and accordingly power is transmitted from end to the another. Different sizes of cardon shafts are used on different track machines.

PRECAUTIONS DURING FITMENT OF CORDON SHAFT:

Shaft should be dynamically balanced

Male portion	-	Long
Female portion	-	Short
In road vehicle	-	Male portion in the direction of driving.
In Track Machine	-	Male portion in towards working direction.

To avoid the dropping of cordon shaft cradle is provided.

- Arrow mark on male and female portion should be in line. If there is no arrow mark then yoke should be in same plane for both male & female.

- In female shaft, there is through hole from yoke centre to other end, so that excess grease may come out, other wise this will act as a solid part.
- Bolts should be fit tightly, bolts should be of proper size.
- Greasing in X (cross) and splines should be done after 50 Hrs.
- Play in splines and yoke should be checked every 50 Hrs.
- Nylon locked type nuts should be use.

SUB-DISCIPLINE:- MECHANICAL (LESSONS: 14 SESSIONS: 24)

Lesson-II: Gear Box and Clutch Assembly in UNO/DUO **Session-2:** Working, Construction and Maintenance practices of Main gear box and Clutch assembly.

GEAR BOX AND CLUTCH ASSEMBLY IN UNO / DUO

MAIN GEAR BOX, SIX SPEED AND REVERSING GEAR BOXES:

The track machines are driven/traveled from one station to another station by means of either hydraulics system or mechanical. System. In mechanical system of traveling, Gear Boxes are used. In Duomatic old, Unomatic and other machines various Gear Boxes are used such as main gear box directional Gearbox reversing gear box, reduction gear boxes and six speed Gear Boxes etc.

Following are the Gear Boxes used on 08-Duomatic machine.

1. **Main Gear Box = 1 No.**
   From engine the power comes to this gear box. This gear box distributes the power in three directions:
   Main power to reversing and Six speed gear box.
   RH side for operating Hydraulic pump – 38 x 17 GPM
   38 x 22 GPM
   L.H. side for operating hydraulic pump – 38 x 17 GPM
2. **Reversing Gear Box 1 No.:**
   In this gearbox arrangement has been provided to drive the machine in either direction at the same speed.
3. **Six Speed Gear Box 1 No.:**
   This gear box is used to achieve different gear ratio and speed from 1^{st} to 6^{th} .
4. **Differential distributor Gear Box 1 No.:**
   (Power is transmitted from different distributor gear to both Axle Gearbox.
5. **Axial Gear Box 2 Nos.:**
   Power transmission to axle by crown tail pinion arrangement is the out come of machine movement.

MECHANICAL GEAR BOXES USED ON 08-DUOMATIC MACHINE:

Main Gear Box: 1 No.

From engine the power comes to this gear box. This gear box distributes the power in three directions

1. Main power to reversing and six peed gear box.
2. RH side for operating Hydraulic Pump 38 x 17 GPM
   38 x 22 GPM
3. L.H. side for operating Hydraulic Pump 38/17 GPM

1. Reversing Gear Box: 1 No.
   In this gear box arrangement has been provided to drive the machine in either direction at the same speed.
2. Six Speed Gear Box: 1 No.

Through this gear box we achieve different gear ratios & speed i.e. from 1st to 6th.

3. Differential Distributor Gear Box: 1 No.
   Power transmission from differential distributor gear box to both axle gear boxes.

Axle Gear Box: 2 No.

Power transmission to axle by crown-tail pinion arrangement & machine moves.

MAINTENANCE PRACTICES OF GEAR BOXES:

The modern track machines are very complex and costly assets. Even one day down time is very costly. Increased availability of machines result in more output with good quality at cheaper ratio.

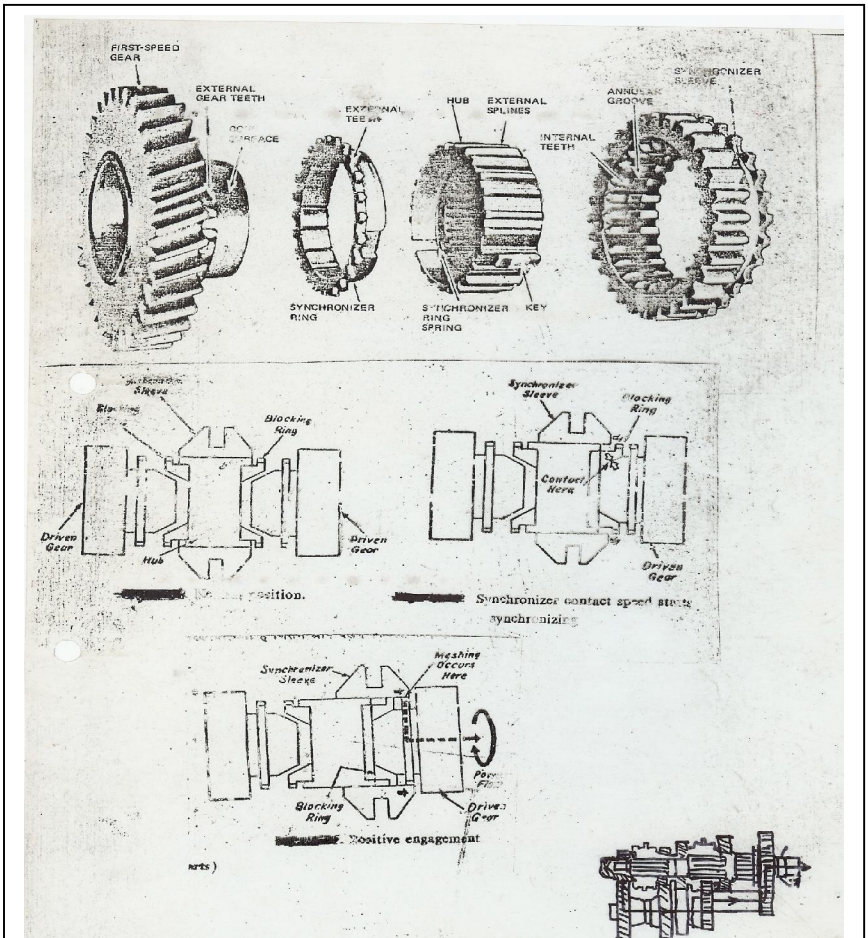
As this is a mechanical gear box, lot of wear and tear takes place on amount of its movement the gear box should be filled with the proper graded oil i.e. SAE-C-90 and while working with this machine as mechanical gear boxes are provided, it is to be ensured that when machine is required to be operated, whenever we want to put the machine in working mode i.e. at the time of engagement of hydraulic pump, first of all the engine should be stopped and the lever is to be operated for engagement of working pumps,. Similarly when the work is over it is to be ensured that engine is stopped and the lever is operated to disengage the working pump for travelling mode.

This should also be ensured that no dust or dust is allowed to enter the gear box as ti is very much harmful for the smooth functioning of Main Gear Box directional gear box or Six Speed Gear Box.

During assembling this factor should also be taken into consideration.

ENGAGER BODY FOR DUOMATIC MACHINE PART NO. G – 70-11

Engager body shall be manufacture out of EN-353 engager body shall be slide fit with crown gear and drive shaft components found suitable in visual inspection as well as correct from the dimensional characteristics minimum one engager body of each lot should be taken randomly for its chemical testing



SUB-DISCIPLINE:- MECHANICAL (LESSONS: 14 SESSIONS: 24)

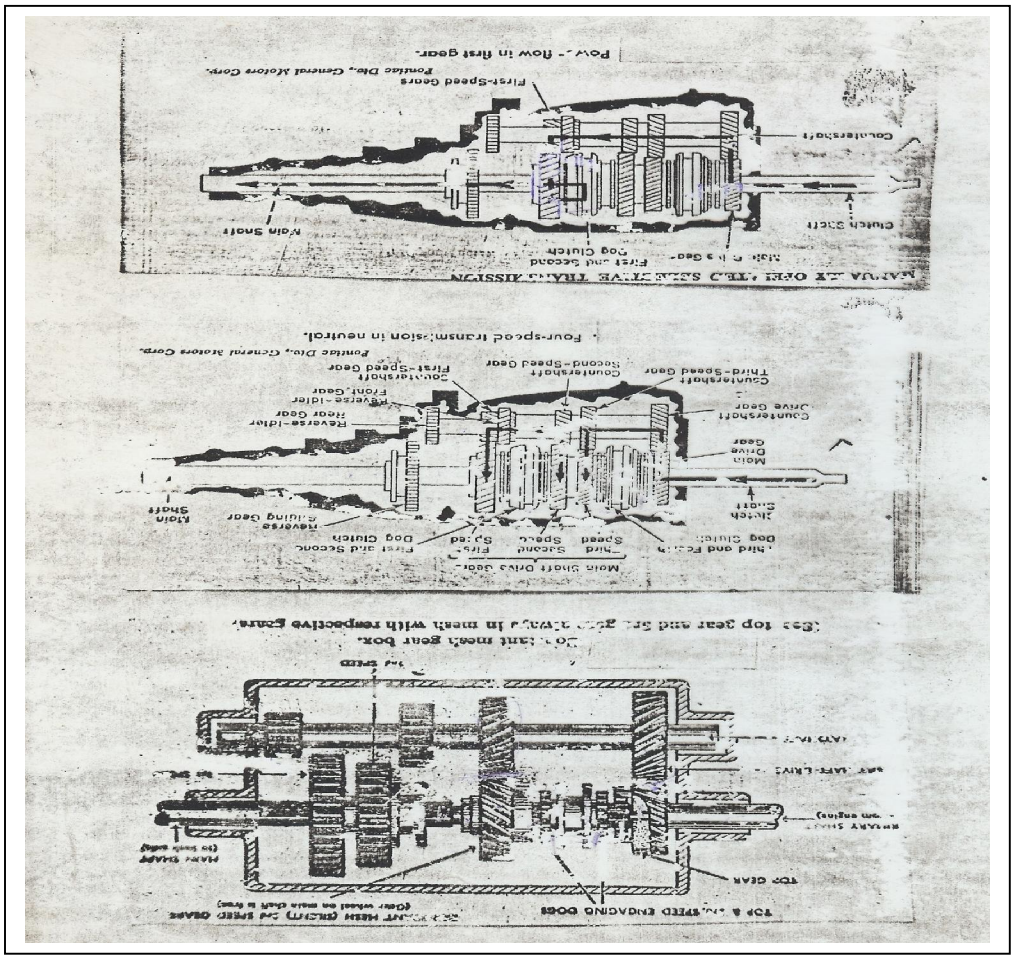
Lesson-II: Gear Box and Clutch Assembly in UNO/DUO **Session-3:** Working, Construction and Maintenance practices of Reversing gear box and Six speed gear box.

MAINTENANCE OF REVERSING AND SIX SPEED GEAR BOXES:

The track machines are driven/traveled from one station to another station by means of either hydraulics system or mechanical system. In mechanical system of traveling, Gear Boxes are used. In Duomatic old, Unomatic and other machines various Gear Boxes are used such as main gear box directional Gearbox reversing gear box, reduction gear boxes and six speed Gear Boxes etc.

For reversing gear box proper lubrication has to be ensured and proper matching of gears to be provided so that there is no problem with regards to the movement of the machine. Proper maintenance schedule has to be observed as per the manual laid down for this purpose.

For six speed gear box it is also to be ensured that proper clearance of gears are maintained and proper backlash along with the proper matching of gears are in co-operated. As per the laid down procedure for schedule maintenance, six speed gear box maintenance to be done accordingly.



SUB-DISCIPLINE:- MECHANICAL (LESSONS: 14 SESSIONS: 24)

Lesson-III: Distributor Gear Box **Session-4:** Working, Construction and Maintenance practices.

Distribution Gear Box (Its construction and maintenance practices):

This is the Gear box use for the purpose of power transmission in different track machine and with the help of this distributor gear box power is directed and distributed to different directions with the help of cardon shaft as per requirement. As this gear box is subjected to maximum wear & tear due to mechanical arrangement of gears, maximum care should be taken with respect to its maintenance as well as changing of the gear oil provided for the gear box. Attention should also be paid with regards to the contamination because if contamination is entrapped in the gear box, it will damaged the gear box.

(Fig.)

SUB-DISCIPLINE:- MECHANICAL (LESSONS: 14 SESSIONS: 24)

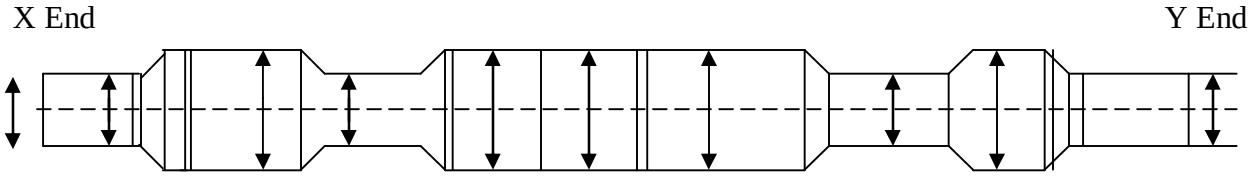
Lesson-IV: Driving and Running Axle **Session-5:** Function, Parts and Maintenance aspects, setting of crown & tail pinion

---

Driving and Running Axle:

Driving axle is the power axle this axle has the arrangement of Crown & Peinion Assembly. Wheel is pressed and 50 Tonne load. There is arrangement of axle gear box assembly. In axle gear box assembly roller bearing NU-2220 or NU-2224 is provided. The driving axle being powered axle gets power through cardon shaft transferred through flying over. Schedule maintenance of the axle is to be carried out by greasing of axle gear box housing as per requirement. All new Track Machines working in Indian Railways are powered axles. They have been provided with the hydraulic motors for power transmission.

Driving Axle



Running Axle:

Running axle is normally known as idle axle and it is not a powered axle. Running axle has arrangement of Axle & Wheel only. Wheel pressing is carried out in the axle to complete the whole assembly. Wheel is pressed at 50 tonne load. There is no crown and pinion arrangement in running axle. There is axle box assembly provided on running axle. This consists of roller bearing NU-2220 or NU-2224 alongwith the distance pieces. Under the maintenance schedule the axle box bearing are greased through bearing grease periodically. As per latest circular of Track Machine Manual the driving axle and running of different machines such as BCM, Unimat, CSM & DGS are required to under go Ultrasonic testing for their better performance.

Crown and Tail Pinion Assembly:

Clean axle and bevel gear check the bevel gear bore with boring gauge for taper and ovality, to be removed by grinding the above defect.

To hold the axle vertically by a Crane with a device fixed to the locking taped holes. Check with spirit level that the device is perfectly vertical.

Heat the bevel gear placed on a cylindercal support perfectly leveled with spirit facing down ward to about 220^0C with anyactelene flame so that after its bore 0./mm larger than the diameter of bevel seat on the axle. Cool the axle from around bevel seat if possible. Introduce the axle from the above fill the bearing collar touches the bevel. After 5-10 minutes, bevel gear will be tight on the axle. For proper meshing of (Crown bevel gear, shims are provided for wheel proper alignment.

Working Principle of Z.F. Gear Box: (Zahnrad Fabric – Friedrichshafen:

The power transmission in various tamping machines have been associated with mechanical methods of transmission of transmission as envisaged by Plasser & Theurer. Gone are the days when we were utilizing mechanical gear boxes such as six speed gear boxes, directional gear boxes etc. but with the past experiences it has been observed that such mechanical gear boxes have typical arrangement of gear-train etc. which were not only subjected to wear and tear but also at the same times it tends to more-failure and more maintenance.

So, in order to eliminate all such things new conception for power transmission is the Generation of Z.F. Gear Box.

ZF is a German Nomenclature
ZF stands for Zaharaid Fabrick
Original ZF is 4WG.65II WK

Abbreviations are:

4	-	Speed
WG	-	Hydro-dynamic fluid
65	-	Input – Torque
II	-	Electric – Shift
WK	-	with converter clutch
Gear box oil	-	Ultra -10
Capacity	-	Approximately 45 Ltrs.

Manufacturers –

BP	-	Actuma Super with ultra 10W
10C	-	Servo ultra 10
HP	-	HP auto transmission fluid.

Various Parts of Z.F. Gear Box:

Torque Converter:

Torque Converter is a special type of fluid coupling. It is very much effective when the engines speed is increased. At idle speed it does not transmit any power and keeps as slipping. Thus the vehicle is declutched automatically in manual transmission if the driver does not declutched property the engine stops. This problem is overcome in automatic power transmission. In this case need is to idle the engine only within the converter the oil is the medium of the power transmission. At about 80% of pump speed i.e. impeller the turbine becomes one and the turbine movement becomes equal to the pump movement.

Some of the toque converters are provided with a converter clutch W.K. which locks the turbine with impellor and then prevents the slip and improves the fuel efficiency. The torque converter then acting as a fluid clutch. It consists of three main parts.

1. Impellor
2. Stator
3. Turbine.

1. **Impellor –** It is a depend having curved blade to its inner face and attached to engine fly wheel. As the fly wheel turns the impellor also turns and throws the oil with a certain velocity. The velocity and mass being projected which is actually responsible for turning

the unit. The oil escaping from the impellor wheel enters to the turbine wheel giving the direction of movement.

2. **Turbine –** Turbine is attached to the driven-unit i.e. input of gear box and faces of impellor on account of which the oiler projected from the pump causes the turbine to run. The turbine shaft runs the gear system.
3. **Stator –** It is a curved fine wheel mounted on a free wheeling device between the impellor and turbine. As the fluid leaves the turbine, the fluid would be thrown back to the pump in reverse direction i.e. opposite to that of rotation of pump. Thus, it requires more power to drive it. The oil coming from the turbine is directed by the stator vanes in a direction which is favourable to the directions of moving of pump. The stator (reaction member) following the turbine wheel has the task of redirect against the oil which is streaming out of the turbine and direct it to the correct streaming direction to the pump wheel. The stator receives a reaction movement due to this reversing motion. Thus it improves the efficiency of converter. Also the oil in favourable direction gets added up with the oil which would normally had been projected by the pump and thus multiples the torque. As the turbine speed increase the direction of oil coming from turbo charges. Thus the oil direction does not appose the impellor movement. Also of the direction of oil is such that the stator direction is reversed. The stator stepson free wheel and allowing the oil to flow in the required direction.

   As the conversion is increasing the correspondence with the speed difference between pump wheel and turbine, therefore the maximum. Conversion takes place when the turbine wheel is not moving with increasing output speed, the torque conversion gets decreased. The out put speed is automatically adopted to required output movement of the torque converter.

   A gear pump of capacity volts/minutes circulations oil to converter and used for shifting of gears. Gears pump supplies pressurized oil of pressure (10-12 bar) for actuation of clutches. This oil is controlled by electrically operated solenoid valves which get current from PCB and is operated by electric solenoid which get current from PCB and is a function of engine rpm and turbine speed.

   Gear shifting is operated by electrical solenoid which are provided on top of the gear (M_1 M_2, M_3 & M_4.
   Power transmitted through torque converter to selected gears.
   Current consuming of each solenoid is equal to 0.25A – 0.5A.

Function of the Gearbox:

Driving of machine in case of traveling.
Providing the input of mechanical energy to hydraulic pumps.
Transmit the engine power to different units of machine.

Main Assemblies:

Torque Converter
Gear Train
Shifter Assembly
Selector Lever
Power Take Off
Final Drive

Special Features:

It is a hydrodynamic Gearbox.
Gearbox is electrically controlled.
It has separate hydraulic system.

No clutch paddle is required.
Medium of power transmission is fluid.
No movement of gears as in mech.Gbox
More than 2500 types of components.

Torque Converter:
It is initial power receiver.
Medium of power transmission is fluid.
Impeller, turbine and turbine are main parts.
Pressurized fluid is acting over moving impeller blades.

SUB-DISCIPLINE:- MECHANICAL (LESSONS: 14 SESSIONS: 24)

Lesson-V: Z.F. Hydro-dynamic Gear Box **Session-7:** Precautions during working and Maintenance aspects.

PRECAUTIONS DURING WORKING AND MAINTENANCE ASPECTS:

1. Z.F. Hydrodynamic gear box should be handled by a skilled & trained workman only with a special emphasis on cleanliness.
2. It is preferable to keep special tools recommended by OEM for limited maintenance operations to be carried out at field or else similar indigenized tools must always be made available in the machine.
3. Use only recommended brand of Locktites, i.e.:
   270 No. for nuts & bolts
   574 No. for Sealant (Liquid Gasket)
   641 No. for Bearing surface.
4. Replace oil ULTRA-10/SAE 15-W-40 (as the case may be) after every 500 hrs. of working. During oil replacement, strainer should be checked for any accumulation of impurities over magnetic rod. 'O' Ring over strainer must be replaced at the time of oil change.
5. Check the oil level weekly:
   (a) While the machine is in horizontal plain.
   (b) Keep transmission in neutral position.
   Cold level at 40^0C & 1000 RPM – Lower mark.
   Hot level at 80^0C & 1000 RPM – Upper mark
   Where 80^0C is not achieved, checking at 40^0C for lower mark will serve the purpose.
6. Replacement of pressure filter (25 micron) at the interval of 250 hours of working.
7. Replace the filter along with oil in case of buzzer alarm heard for choking of filters.
8. Check external connections at regular interval for their tightness.
9. Operation of gear shifting should not be done below:
   1200 r.p.m. of the engine.
10. Towing speed restriction of 10 Kmph should be followed; otherwise it may lead to the damage of gearbox. Connecting two machines for block operation should not be done.
11. Shifting of gear should be carried out at the proper time. Any delay or early shifting will reduce the gearbox life in long run.
    Proper Time for Lockup indication
    Indicator is not provided in operating panel, gears are being shifted only based on experience and assumptions. A LED connection may be provided in cabins as has been provided in SPURT car. CPOH can provide circuit diagram if desired.
12. Frequent variation of speed should be avoided.
13. Z. F. key should be put off only after stopping of machine as two clutches out of seven clutches remain engaged even in neutral position and counter speed of the wheel through cardon shaft will affect those clutches which may damage the frictional bearings and slippage of clutch may occur.
14. If for any reason external impurities enter the gearbox, working of machine should be stopped and after rectification of defect complete oil should be replaced. In that case clean the gearbox as much as possible including torque converter.
15. Pressure cut off switch should be checked for its functioning at 2.5 bar. Early or late cut off may reduce the life of the costly Z.F. gearbox.

16. In case of any obstruction while moving, r.p.m. should be reduced and brakes should be applied below the cut off pressure i.e. 2.5 bars. Avoid the excessive application of brake above 2.5 bars.

FAILUES ANALYSIS & TROUBLE SHOOTING:

COMMON FAILURES OCCURED IN Z. F. GEARBOX ALONG WITH THEIR REMEDIAL AND PREVENTIVE MEASURES BASED ON FIELD EXPERIENCE.

MAIN NPRESSURE HAS GONE TO ZERO AND MOVEMENT OF THE MACHINE STOPPED

Case Study:
Earlier it happened on different machines that suddenly during the course of working, main Pressure dropped to'0'. After checking the oil level And functioning of electrical pressure gauge, it was observed that 0.6mm orifice, provided on intermediate plate in shifter assembly was found choked completely.
Due to contamination of oil. After cleaning of plate & orifice, gearbox started functioning with normal pressure.

Remedial Measures
(a) Check the functioning of pressure gauge by providing spare hydraulic gauge (0-25 bar) in place of electrical, if it is ok.
(b) Check of flow of ZF pump by flow meter or any other suitable means (Shaft key of pump may get slipped), if it is ok.
(c) Check the intermediate plate for choking of pressure orifice, clean if choked.
(d) Finally overhaul the shifter assembly or get assistance from CPOH.

Preventive Measures
The machine operator must be attentive for 25-micron pressure filter choking buzzer due to passage of contaminated oil and once it is heard or in case of hydraulic oil entering in ZF gearbox chamber due to bursting of pump oil seal (38-22, 38-17,20-14, variable pump) stop the working of machine and clean the gearbox immediately by flushing out oil as much as possible including torque converter. Under any circumstances safety switches or filters should never be bypassed.

Flickering Movement of Pressure Gauge and Sound Observed from Torque Converter
Case Study
At times this happened in field after replacement of oil. Reason for such failure is, less oil level due to improper topping up or due to external leakage. After checking it has been found that recommended procedure for checking oil level was not followed properly by field staff.

Remedial Measures:
(a) Check the oil level at recommended procedure
And refill the oil as per requirement.

(b) Check & attend the external leakage if any.
Preventive Measures

(a) Check the oil level as under:
At 1000 rpm and 40°C-Lower mark (Cold level).
At 1000 rpm and 80oC-Upper mark (Hot level).
Checking oil level at less than 1000 rpm will generate malfunctioning.

(b) Fill extra oil while travelling on gradients (Ghat section).

3. Machine Movement Stopped but Pressure and Temperature Are OK.

Case Study

This happens due to dislocation of towing lever bolt /splines during process of working. In past it did happen on few machines. On investigation it has been found that field staff normally do not put their attention on this particular subcomponent. For this small failure several times machines had been under break down for 5 to 10 days for want of CPOH staff. After checking it was observed that towing lever bolt /splines were dislocated during the process of working.

Remedial Measures

(a) Towing lever was found dislocated from its locking. Tightened the bolts of the lever.
(b) In case it is spline type, temporary arrangement by welding can also be done over shaft and lever.

Preventive Measures

(a) Check the tightness of nuts regularly.
(b) In case of spline type shaft, replace the shaft and lever.

Engine Taking additional Load or Engine Stopped While Shifting First Gear.

Case Study

In several machines it was observed that machines are under break down for the said problem and help of CPOH is sought for. After going through the failure it was observed that it happens mainly due to failure of electrical circuit. In exceptional cases torque converter clutch also gets damaged. Early actuation of lockup clutch is the reason behind such failure.

Remedial Measures

(a) Check electrical connection of lockup circuit.
(b) Check inductive transmitter resistance 1.5K-Ohm & distance from pulse disc shall be kept 0.7mm to 1mm.
(c) Check the functioning of electronic module. Frequency 650Hz at 14000 rpm for lock in.

4. Preventive Measures

Check the 24-Volt power supply over WK valve by keeping the machine in towing mode and increase the rpm after engaging the gear. Electrical supply of 24 D.C. should reach to WK valve at 1400 rpm and above & should k not beless than said rpm in any case otherwise adjust the gap of inductive transmitter as above at (b).

5. Excessive Temperature

Case Study

In several machines it has been observed by CPOH that improper operation has resulted in rising of temperature of the gearbox. Early late shifting of gear is one of the reasons behind this failure. It is also suggested that working of the machine above 120°C should be prohibited. Safety switches should never be bypassed.

Remedial Measures

Keep the machine in neutral. Increase the RPM from 1200 to 1500, within 2 to 3 minutes temperature should drop quickly to normal. If not, then ask the assistance from CPOH as the overhauling of shifter assembly is required in that case.

Preventive Measures

(a) Don't overload the machine.
(b) Keep the rpm minimum up to 1200 while passing through down grades.
(c) Don't down k shift on higher speed.
(d) Check the oil level regularly; less oil may lead to such failure.

6. Burning Of Clutches:

Case Study

In few machines it has been observed that fume suddenly starts coming out through breather though the pressure and temperature was normal. It happens due to choking of lubrication line resulting in hunger of oil in clutch assemblies. Once this happens, the only solution left is to overhaul the complete gearbox at CPOH.

Remedial Measures:

Complete overhauling is required. Burning of any clutch at normal pressure and temperature is due to choking of lubrication lines (internal tubing's).

Preventive Measures:

Check the lubrication oil pressure, if it reaches to 3.5 bar and above at 1000 rpm, stop the machine and ask CPOH for further check as in case of choking of lubrications lines, complete oil will go to sump by pressing the valves setting. In no case lubeoil pressure should rise above 3.5 bars at 1000 rpm continuous watching of lube oil pressure of the gearbox can save an extensive damage.

7. Main Pressure Is Tool Low:

Case Study

It is observed that many old machines are kept on working for a long time at lesser main pressure. Working at lesser pressure below 10 bars may lead to slippage of clutch and finally can damage the gear box. Initial symptom of this failure oil turning out blackish.

Remedial Measures:

(a) Check pressure gauge for its functioning by providing hydraulic pressure gauge.
(b) Tighten the Allen bolts over shifter assembly upto 50 Nm. Pressure will increase by this process from 1 to 2 bar.
(c) Contact CPOH for further checking, as the overhauling of complete shifter assembly or gearbox is needed in this case.

Preventive Measures:

(a) Nut bolts (external) should be checked during schedule maintenance.
(b) Operating the machine at less pressure can damage the gearbox due to slippage of clutch.

8. Abnormal Sound

Case Study

Abnormal sound may be observed due to damage of any mechanical component inside, damage of bearing, nut & bolts, locks etc in the process of working. In case of any abnormal sound machine working should be stopped immediately to avoid further damage to gearbox.

Remedial Measures

Complete overhauling is required to be carryout in workshop.

Preventive Measures

(a) Don't tow the machine above 10 Km/h.
(b) Skipping speed should be avoided.

(c) Down Shifting should be done at recommended speed.
(d) Acceleration of machine should be avoided after placing the brakes.

9. Oil Becomes Blackish

Case Study

Black colour of oil is the indication of poor health of gearbox. Complete checking of the gearbox including replacement of oil is required to be carried in this case.

Remedial Measures:

(a) Replace oil and 25-micron pressure filter. Keep watch on the colour of replaced oil.
(b) Check the lubrication pressure, if it is 3.5 bars at 1000 r.p.m. stop the machine. Further operation of gearbox may lead to excessive damage. If pressure is within range, replace oil, check strainer, if nothing is found in it, and keep on working by frequent checking of lube oil pressure unit till it reaches to 3.5 bars.

Preventive Measures

(a) Don't keep on working if the main pressure is less than 10 bar.
(b) Filter/oil should be replaced as per prescribed schedule.

Jerks Observed In All Three Speeds

Case Study

Whenever jerks are observed while shifting the gear, itis the indication of poor condition of the gearbox. Clutch gaps are increased resulting longer gear shifting time (recommended gear shifting time is1.17 seconds to 1.7 seconds). Early checking of the gearbox is required after said indication during working.

Remedial Measures

(a) If jerks are felt only while placing the first gear,
Check external connections.
(b) If jerks observed in all three speeds complete gearbox needs checking, may ask CPOH for the same/

Preventive Measures

(a) Shifting of gears should be done at proper time, for that lockup indication may be provided over operating panel.
(b) Down shifting should be avoided.
(c) Check your pressure switch for its functioning replaces if required

good maintenance practices

ZF Hydrodynamic gearbox should be handled by a skilled & trained workman only with a special emphasis on cleanliness. It is preferable to keep special tools recommended by OEM for limited maintenance operations to be carried out at field or else similar indigenized tools must always be made available in the machine.

Use only recommended brand of Locktites, i.e.:-

270 No. For nuts & bolts.
574 No. for Sealant (Liquid Gasket).
641 No. for Bearing surface.
Replace oil ULTRA-10 / SAE 15-W (as the case may be) after every 500 hrs. of working. During oil replacement, strainer should be checked for any accumulation of impurities over magnetic rod. 'O' Ring over strainer must be replaced at the time of oil change.

Check the oil level weekly:

(a) While the machine is in horizontal plain.
(b) Keep transmission in neutral position.
(c) Cold level at 40°C & 1000 RPM - Lower mark
(d) Hot level at 80°C & 1000 PM - Upper mark

Where 80°C is not achieved, checking at 40oC for lower mark will serve the purpose.

Replacement of pressure filter (25 micron) at the interval of 250 hours of working.
Replace the filter along with oil in case of buzzer alarm heard for choking of filters.
Check external connections at regular interval for their tightness.
Operation of gear shifting should not be done below:-

1200 r.p.m. of the engine:

Towing speed restriction of 10 Kmph should be followed: otherwise it may lead to the damage of gearbox. Connecting two machines for block operation should not be done.
Shifting of gear should be carried out at the proper time. Any delay or early shifting will reduce the gearbox life in long run.

Proper Time for Lockup indication:

Indicator is not provided in operating panel, gears are being shifted only based on experience and assumptions.A LED connection may be provided in cabins as has been provided in SPURT Car. CPOH can provided circuit diagram if desired. Frequent variation of speed should be avoided. ZF key should be put off only after stopping of machine as two clutches out of seven clutches remain engaged even in neutral position and counter speed of the wheel through cardon shaft will affect those clutches which may damage the frictional bearings and slippage of clutch may occur. If for any reason external impurities enter the gearbox, working of machine should be stopped and after rectification of defect complete oil should be replaced. In that case clean the gearbox as much as possible including torque converter.

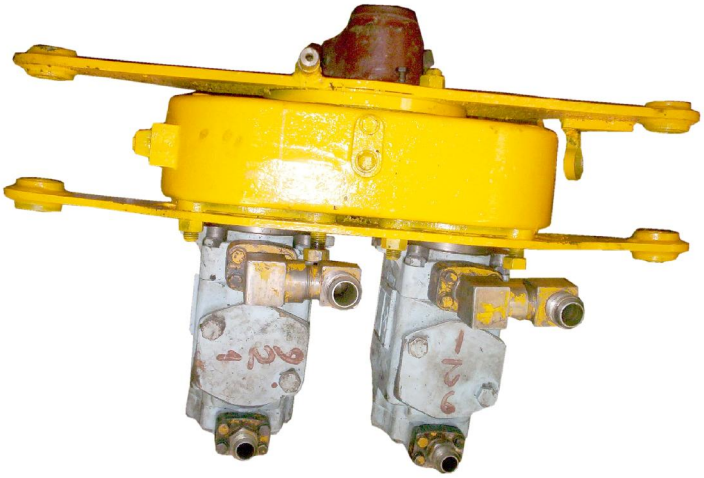
Pressure cut off switch should be checked for its functioning at 2.5 bars. Early or late cut off may reduce the life of the costly ZF gearbox.
In case of any obstruction while moving, r.p.m. should be reduced and brakes should be applied below the cut off pressure I.e. 2.5 bars.

Avoid the excessive application of brake above 2.5 bars.1-MAIN PRESSURE HAS GONE TO ZERO AND MOVEMENT F THE MACHINE STOPPED

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VI: Funk Gear Box **Session-9:** Working, Construction and Maintenance practices. .

FUNK GEAR BOX



Funk gear box is a mechanical gear box used for the purpose of power transmission. This has got the gear arrangement in such manner that with the help of a common shaft input power is taken and the power is transmitted in to two opposite directions. For example hydraulic pumps being in two opposite directions get power from one common input and pumps (LHS & RHS) can be driven in to two different directions.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VII: Reduction Gear Box **Session-10:** Working, Construction and Maintenance practices.

REDUCTION GEAR BOX:

It is a mechanical gear box use for power transmission in Track Machine. This gear box is used whenever we want to run the working unit at lower speed. Gear trains are selected as according to match the speed of the working unit. This gear box is used mainly in the working mode when the machine works during sleeper to sleeper movement.

Maintenance practices for the maintenance of reduction gear box there is a need of oil changing as per the prescribed manual. This should also be ensured that dust and dirt should not entrapped in the gear box as otherwise it will damaged the gear box and their will be no smooth operation of the gear box.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VIII: Satellite Axle Gear Box **Session-11:** Working, Construction and Maintenance practices

---

WORKING AND CONSTRUCTION OF SATELLITE AXLE GEAR BOX:

In 09-CSM machine, Plasser and Theurer provide a Continuous machine movement along with tamping for achieving more out put. For this purpose, tamping and lifting unit has been provided on Satellite frame which moves independent of machine movement. While tamping, main Machine moves continuously and the Satellite unit Stops for each tamping cycle and go distantly again and again. For the movement of Satellite frame, we use a satellite gear box which takes mechanical Energy through a hyd. Motor. Satellite gear box is a very sophisticated gear box and engaging of two big and small Spur gear depends upon Pneumatic Pressure. If Pneumatic Pressure is less than 2.5 bar then it will affect gear box as well as out put. In order to avoid long idling and long life of Satellite gear box. Following points are to be help in mind during operation.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VIII: Satellite Axle Gear Box **Session-12:** Precautionary steps to avoid failure.

PRECAUTIONARY STEPS TO AVOID FAILURE.

i) It is to be ensured that Pneumatic Pressure should not be less then 2.5 bar.
ii) Engaging and disengaging of both Spur Gears should be 100%.
iii) Satellite brake of 5 bars should act properly while tamping.
iv) Longitudinal Transducer limit switch should be in working order, limit switch connection should be in NO Position.
v) 32mm, 25mm pin Rocker Bearing GE-25, link plate, torque plate, Gear Box top housing must not any play.
vi) Proximatic Switch (1422k) should be set properly according to fork Position after ensuring 100% engaging and disengaging of both spur gears.
vii) There should not be any play between fork hole and guide rod. Pneumatic cylinder and shifter rod should be tightened along with the check nut.
viii) Pneumatic cylinder and valve should work properly and get it cleaned periodically.
ix) Rubbing block and brake gap should not be more than 3mm.
x) The seal of satellite brake cylinder should be checked regularly and replaced after every 1000hrs if required.
xi) Booster cylinder should be in working condition and pressure should not be less than 40 bar(40-60 bar)
xii) According to Track condition Machine speed should co-inside with satellite movement.(Machine Speed 1.2km/hr)

TAMPING UNIT FUNCTIONS & PARTS

Tamping Units/Bank:

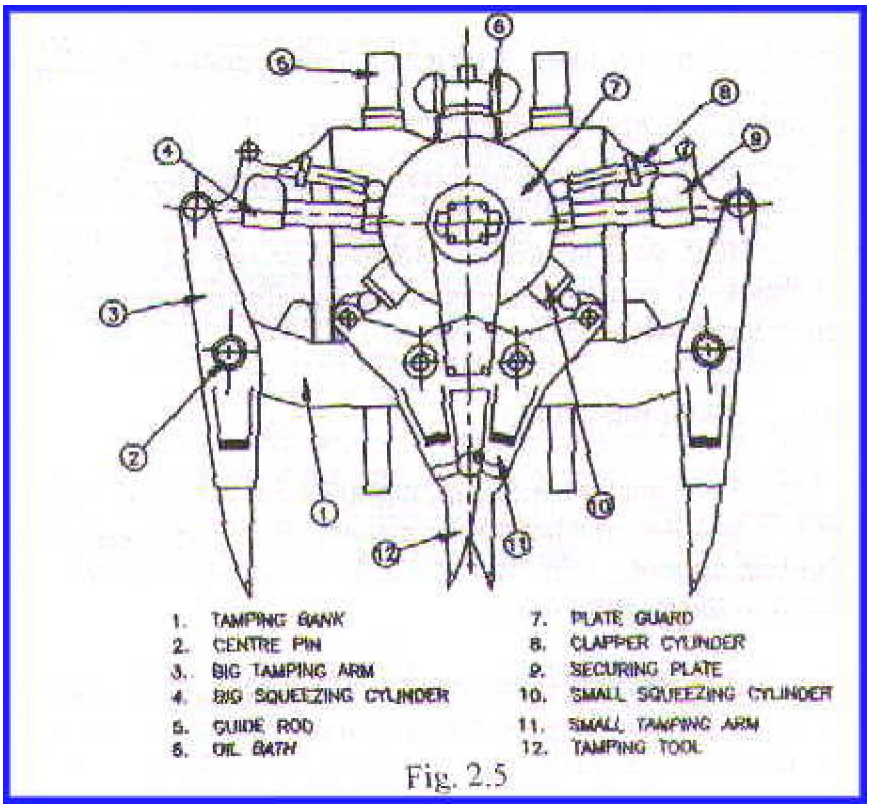
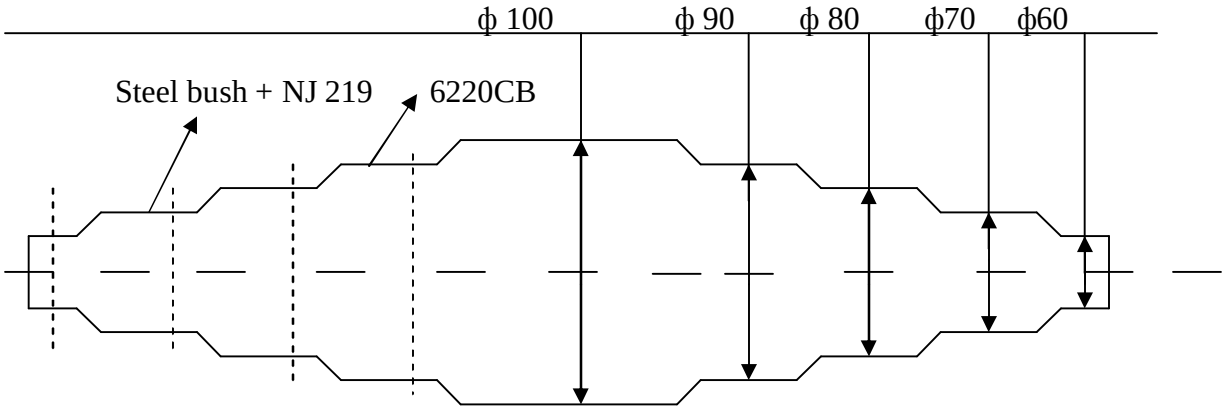


Fig. 2.5

The tamping unit is the most important mechanical assembly of the machine in addition to the Diesel Engine (which has been dealt separately). There are various designs of tamping banks suiting different types of machines and track requirements e.g. single sleeper tamping. Double sleeper tamping, switches and crossing etc., whatever type of machine it may be, M/s plasser & Theurer has world wide patent for its non-synchronous design of tamping banks. Which are discussed one by one.

Vibration Shaft:



NJP28.6 NJ29

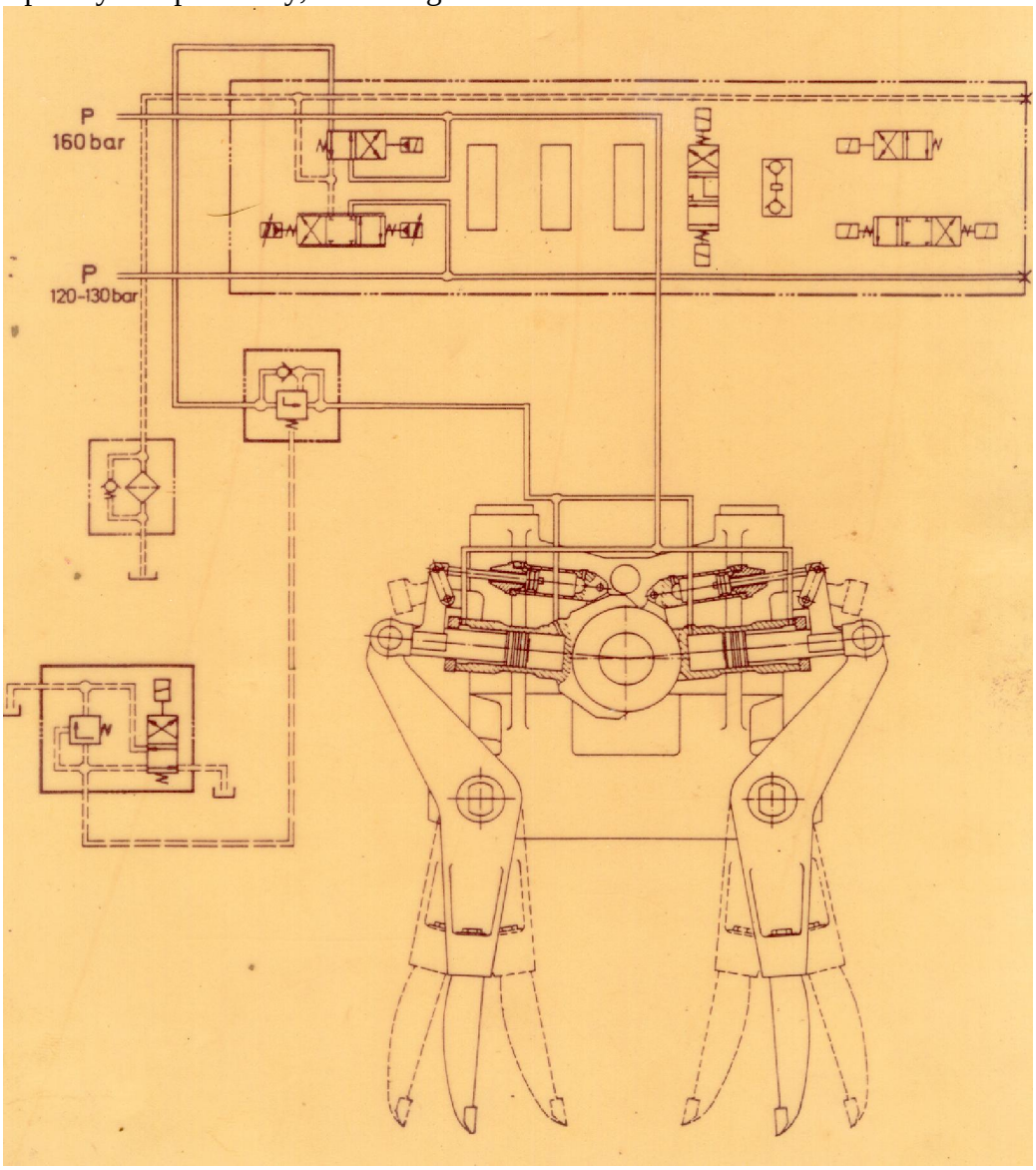
NU2220

All Dimensions ARE in MM

1.1 Tamping Bank For Tamping Single Sleeper

The mainliner universal machines having this tamping bank are designated 06-16 type. Non-synchronous constant pressure-vibration tamping is achieved by 8 tamping tools on each bank, arranged in pairs, in side and outside the rails, on both sides of the sleepers. The machine operates with a total of 16 tamping tools.

Non-synchronous feed adjustment results in all tamping tools exerting the same pressure on the ballast bed, regardless of the in-feed movement. There is complete force equilibrium between tool pairs, and uniform specific surface pressure on all **tamping tools. The pairs of tamping** tools move completely independently, according to the resistance encountered in the ballast bed.



During the in-feed action of the tamping tools, resistance builds up in front of each individual tool pair. When the resistance has reached the level of the chosed tool in-feed force, the tool pairs concerned come to rest. The other tamping tools continue to work until they too exert the same force on the ballast bed.

The plasser & Theurer non- synchronous constant pressure tamping system therefore guarantees completely uniform tamping of the sleeper bearing surface.

The tool blades are corrugated and have a spade shaped edge. This means that they adapt more more easily to the grain of the ballast, and deal with a wider tamping zone. Due to the spade-shape of the blades the tools encounter less penetration **resistance.**

The vibration is generated by a hydraulically driven eccentric shaft. Connecting rods (hydraulic cylinders) are supported on the shaft conveying the eccentric movement to the swing arms, which in turn vibrate the tamping tools.

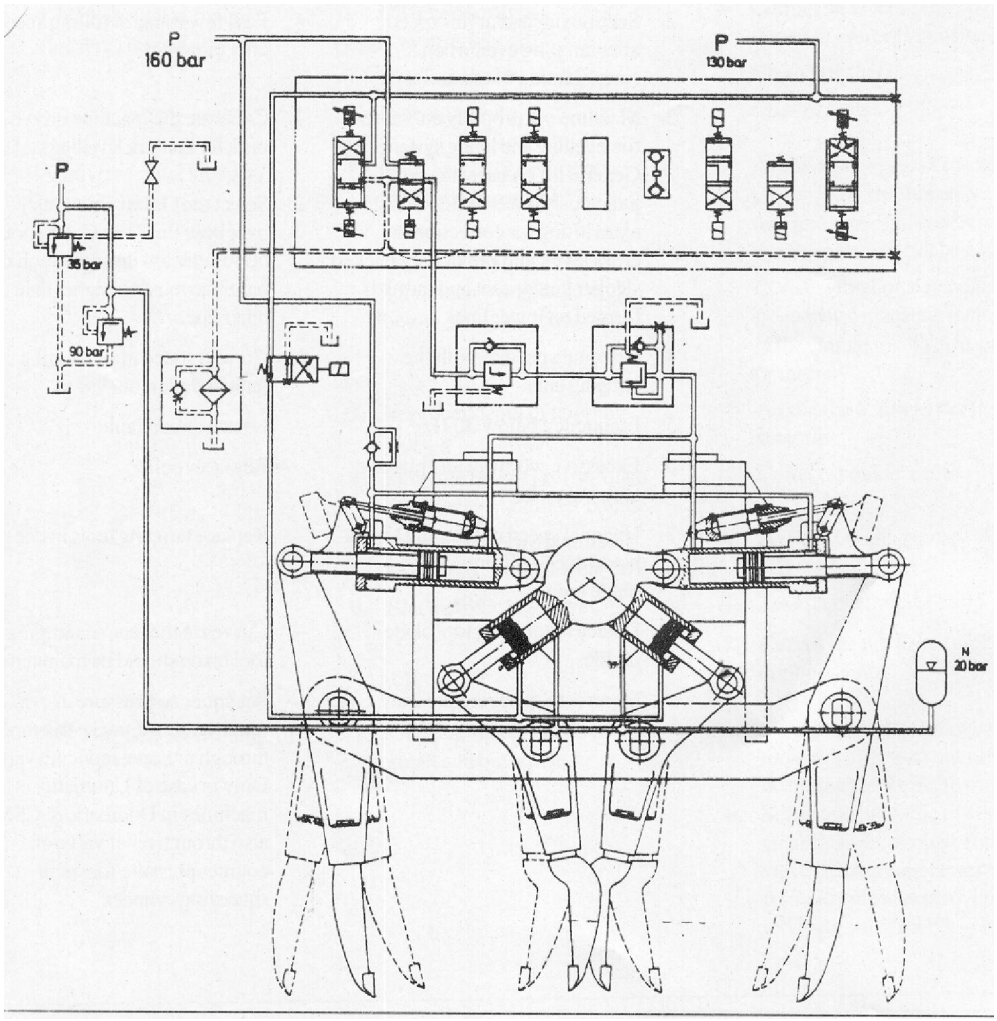
Speed of rotation of
Vibration shaft approx : 2,100 rev/min.
Vibration of tamping
Tools approx : 35 cycles.
Amplitude of vibration : 10 mm.

1.2 Tamping Bank For Tamping Two Adjacent Sleepers

The double headed tamping machines are of the type mainliner Duomatic 06-32 series.

Two independent tamping banks are laterally movable on horizontal guide columns for automatic centering above the rails, allowing a perfect tamping even on curves. Each machine has 32 tamping tools arranged in pairs for the simultaneous tamping of two adjacent sleepers.

A uniform compaction of the sleeper bearing surface is achieved by non-synchronous constant pressure vibration tamping. The design of the tool plates vibration frequency, etc., are similar to that of the 06-16 tampers.

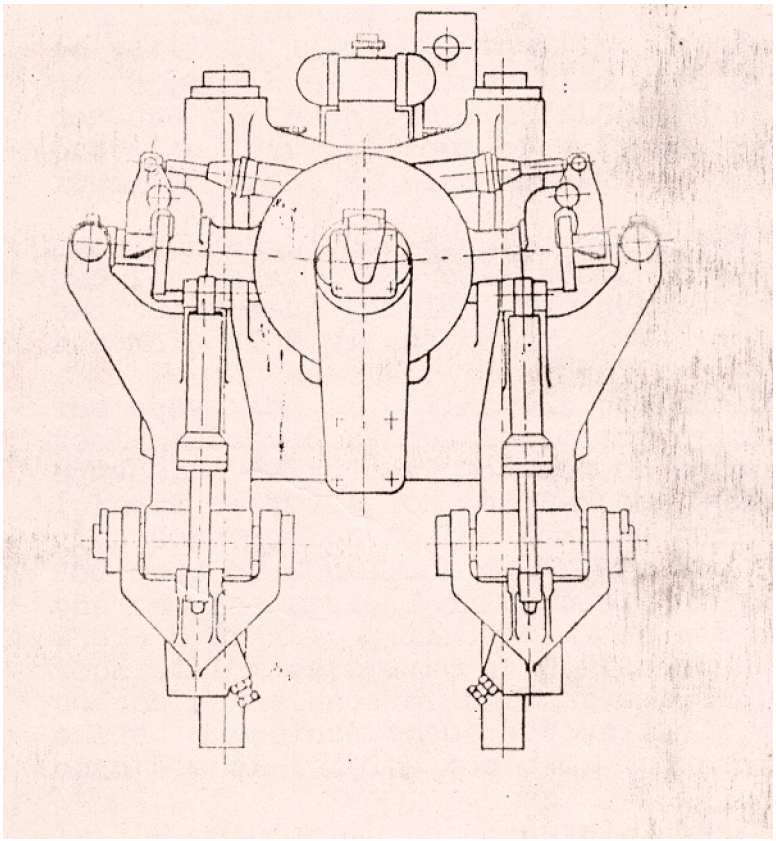


The simultaneous tamping of two adjacent sleepers increases the output., as compared to that of machines with a single tamping bank. Tamping machines with double-sleeper tamping banks are therefore considerably more economic in operation than those with single tamping banks. The generally track layout achieved with these machines is better than achieved tamping for individual sleepers. The output of double-headed tamping machines being greater, they are preferred by railway administrations even when used by contractors, as traffic restrictions and expenditure on personnel is lower than that which would be used for double the number of single-headed tamping machines.

Speed of rotation of vibration shaft : 2,100 rev/min.
Vibration of vibration : 10 mm.

1.3 Tamping Bank for Switches and Crossing

The tamping machines with these banks have the type designation mainliner unviers al 2 W 75.



One tamping bank per rails is equipped with 4 titable tamping tools. This disposition allow the tamping of all parts of the 5 & C layout. Even such parts as frogs, switch blades, etc. can be under-gripped by swinging in the tools. The non-synchronous feed adjustment of the tamping tools is by hydraulically produced vibrations.

For tamping double sleepers the opening width of the tamping clamps is increased. The tamping tools have a large surface and are manufactured of wear resistant manganese steel. Tamping tools with extra wide plates can be used for tamping plan track. The tamping banks are raised and lowered by hydraulic cylinders. The tamping banks can work independently.

The tamping banks can also be equipped with tool spades to apply on a larger area. The sleeper can then be tamped once with vertical tools and once with tools slightly tited outward so.

Rotations of vibration shaft : Appox 2, 100 rev/mins.
Vibration of tamping tools : Approx 35 cycles.
Amplitude of vibrations : Approx 10 mm.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-14:** Precautions during working & repairing. Maintenance schedule.

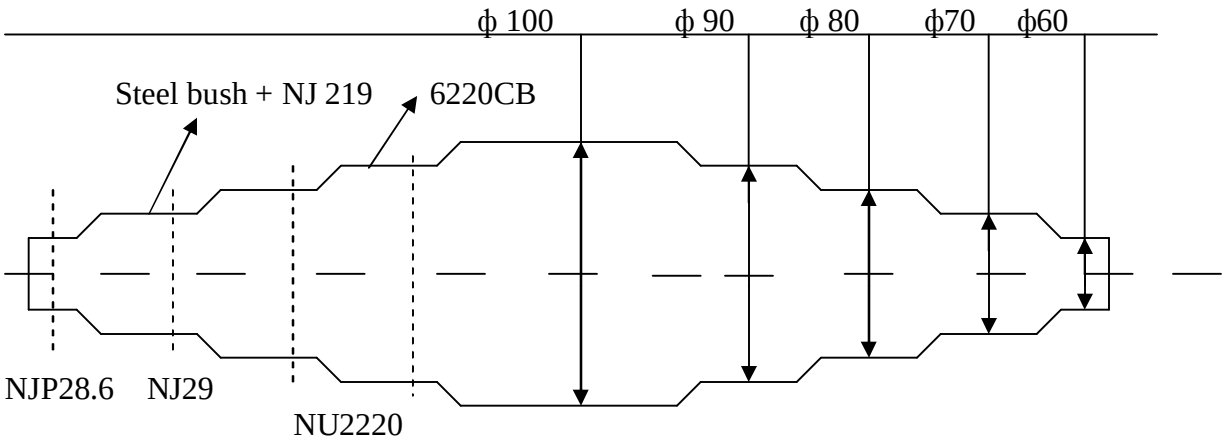
Trouble Shooting and Failure Analysis:

Trouble in Tamping Unit	Solution
1. Wear and tear of tamping tools.	1. Repair, welding and replacement of tamping Tools
2. Play developed in the Tamping Arm.	2. Requirement of Replacement of Tamping after certain specified time.
3. Leakage in the radial seal of tamping arm (955mm pin)	3. Replacement of Radial Seal of tamping arm (955m pin)
4. Breakage of Cover bolt 16 x 35 of small squeezing cylinder.	4. Replacement of cover bolt of 16 x 35 of small squeezing cylinder.
5 Shearing of piston screw of squeezing cylinder.	5. Replacement of bearings of Tamping Unit.
6. Seizure of bearings of Tamping unit.	6. Replacement of bearings of Tamping Unit.
7. Breakage of Vibration shaft of Tamping clip.	7. Replacement of vibration shaft of tamping unit.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-15:** Dimensions of different Parts and Tolerances, setting of bearings and spacers on vibration shaft.

Vibration Shaft:



All Dimensions ARE in MM

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-16:** Failure Analysis and Troubleshooting.

Trouble Shooting and Failure Analysis:

Trouble in Tamping Unit	Solution
2. Wear and tear of tamping tools.	1. Repair, welding and replacement of tamping Tools
2. Play developed in the Tamping Arm.	2. Requirement of Replacement of Tamping after certain specified time.
3. Leakage in the radial seal of tamping arm (955mm pin)	3. Replacement of Radial Seal of tamping arm (955m pin)
4. Breakage of Cover bolt 16 x 35 of small squeezing cylinder.	4. Replacement of cover bolt of 16 x 35 of small squeezing cylinder.
5 Shearing of piston screw of squeezing cylinder.	5. Replacement of bearings of Tamping Unit.
6. Seizure of bearings of Tamping unit.	6. Replacement of bearings of Tamping Unit.
7. Breakage of Vibration shaft of Tamping clip.	7. Replacement of vibration shaft of tamping unit.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-X: Lifting and Lining Unit **Session-17:** Function, assembly and maintenance aspects. .

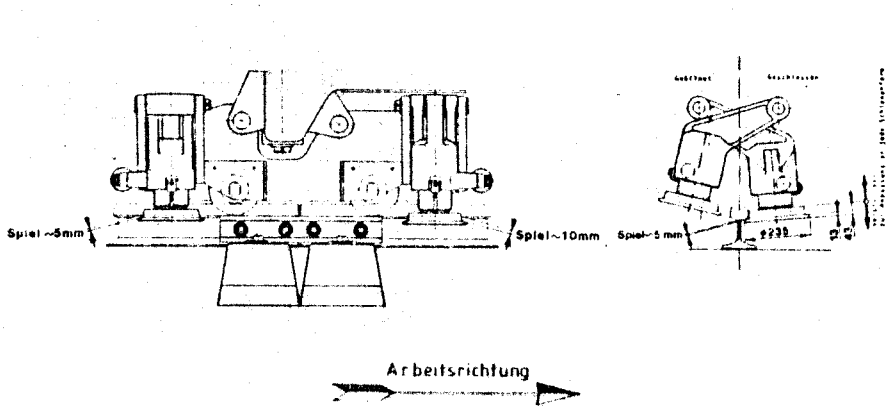
Lifting and Lining Unit

The track lining equipment and the roller lifting unit are complied. Two double-flanged rollers and one horizontal hydraulic cylinder on each unit line the track. When the combined lifting and lining unit have been lowered the 8 lifting rollers as well as the 4 lining rollers roll along holding the rails.

The track is lined by the lining cylinders moving the two tool carriers in the required direction. The lining force acts on the track on four points by the flanges of the ling rollers. The track is moved into the correct piston without impact. As lifting and lining are also carried out simultaneously and the combined unit is arranged immediately in front of the tamping bank, the track is is tamped in its corrected position.

The Leveling, tamping and lining machines of the mainline universal series are equipped with the combined unit for simultaneous lifting and lining of the track.

The lifting force is applied centrally over each rail without support on the ballast. Two pairs of rollers grip each rails under the head from inside and out side. This means that the track is lifted on four points. Because of the clamp like arrangement of the lifting rollers, and of the vertical lifting roller of the vertical lifting roller of the vertical lifting force, no tilting moment is conveyed to the rail and therefore no excessive loads exacted on the rail and therefore no excessive loads exacted on rail fastenings. In moving forward, the clamps remain closed, rolling under the rail top without touching the fastenings. The clamps also over-roll joints, fish-plates, welds, etc., without having to open. For tracks where the closed roller clamps cannot roll clear (e.g. bull head track) a special automatic control device is provided, which opens the clamps when the machine moves forward to close them again when the machines reaches the next tamping spot.



GENERAL INFORMATION

The sequence of dismantling the lifting and lining unit is basically the versed sequence of its assembling.

Utmost cleanliness is to be observed all through out the dismantling, repair and reassembling. Before repair the lifting and lining unit is to be cleaned with an adequate cleansing agent.

When repair is carried out on a unit which is mounted to the machine the site is to be protected against dropping dirt.

Before reassembling thoroughly clean all parts, replace used washers and remove sealing from sealing surfaces trim all burr and similar roughness. Replace by new ones damaged and worn parts.
A competent machine is to assess which of the parts submitted to normal wear are to be re-used. Washers, sealing rings, locking plates split pins and the like are to be replaced in case they were damaged during dismounting.
No clips, or splinters or other foreign matters are to be left in the housing.
Observe during reassembling the indicated torque and adjusting date. Screws and nuts for which no torque is indicated are tighghtended according to standard charts.
The numbers indicated in these instructions (e.g. 1/A,B) mean.

1 = number of figure
A,B = position

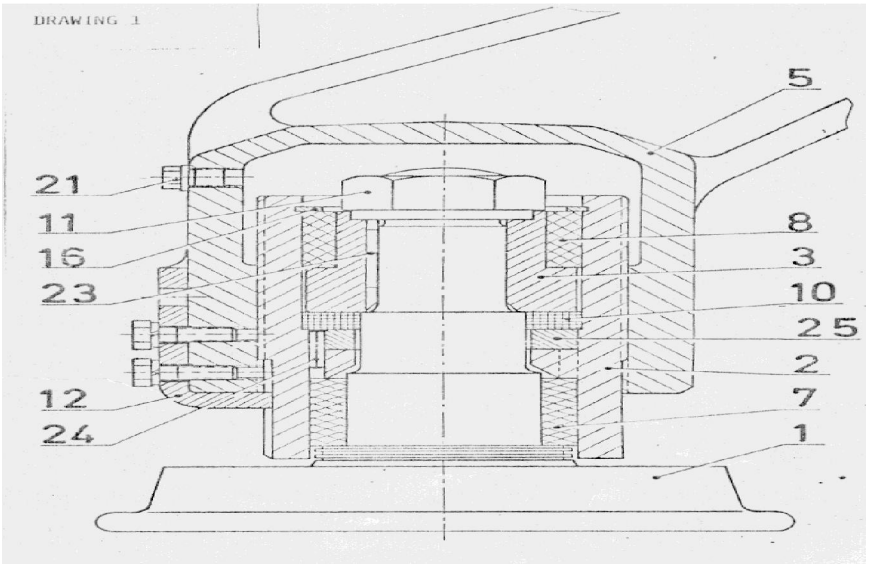
Numbers not followed by letters refer to the illustration as a whole.
V.B. = Numbers of devices used.

13.0 ASSEMBLING THE LIFTING ROLLER CLAMP ASSEMBLY

Hold lifting disc (1/1) in vice and insert adjusting spring (1/23) into shaft using a hammer of plastic material or of aluminum.
Drive to the bushing of plastic material (1/7) into the clamp sleeve (1/2) by means of device (VB 815) insert the intermediate ring (1/25) and secure against torsion by means of the clamping sleeve (1/24).
Grease the plastic bushing (1/7) and drive pre assembled clamp sleeve (1/2) in the shaft of the lifting disc (1/1)
Subsequently insert the greased axial pressure plate (1/10), the pressure bushing (1/3) and the plastic bushing (1/8), in using device (VB815)
Secure plastic bushing (1/8) by seeger ring (1/16).

Degrease nut (1/11) and thread of lifting disc shaft (1/1) coat them with loctite and tighten the nut.

1.	Lift disc	2.	Clamp sleeve
3.	Pressure bushing	5.	Clamp lever
7.	Bushing of plastic	8.	Material
10.	Axial pressure plate	11.	Nut
12.	Protector	16.	Seeger ring
21.	Plug screw	23.	Adjusting spring
24.	Clamping sleeve	25.	Intermediate ring.



Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XI: Bearings **Session-18:** Functions, Types, Bearing Clearance and Maintenance aspects. .

Functions, types, bearing clearances and maintenance aspects

Bearings are required while transmitting rotary power from the source to the points of its usages through various linkages to reduce friction, undue power losses, to give even support to the rotating unit and to avoid setting up of undue vibrations in the rotating member thus increasing life of the unit, by reducing wear.

Various types of bearings have been developed by bearing industries in the world for use on various machines and working units to suit to various loads, RPM, condition of working like vibration, jerks, etc. Various weathering condition like sun, dry wet, hot, cold or chemically contaminating atmosphere. There are generally the following types of bearings available.

Bush bearings.
Ball bearings.
Roller bearings
Needle roller bearings.
Thrust bearings.
Spherical bearings
Tapper roller bearings.
Special bearings (Rocker bearings)

Use of Bearings on Track Machines:

On track machines use of various types of bearings on their working units like tamping units lifting units, scrapping chains, ballast regulating units etc. is made e.g. besides this bearings are used in the following assemblies.

Wheels and axles.
Gear boxes.
Axle gear bogies.
Various bogies.
Pumps & Motors.
Radiator fans.
Engines, etc.

Numbering of Bearings:
Each bearing is given certain No. as per International standardization organizations ISO as per their diameters Plan for ball and roller bearings for other bearings different methods are used.

Bearing Number with series: (Example Of 62 Series)
Bearing up to 17 mm dia, bore the number are given as under:

SEREIS NO.	DIA	SERIES NO.	DIA
3 mm	623	9 mm	629
4 mm	624	10 mm	6200
5 mm	625	12 mm	6201
6 mm	626	15 mm	6202
7 mm	627	17 mm	6203
8 mm	628	20 mm	6204 From 20 mm on wards.

Last Nos. when multiplied by 5 given the bore dia of bearing..

Selection of Bearings:
Many factors have to be considered like.
1. Loads (Radial and axial)
2. RPM
3. Vibration
4. Shocks
5. Reversal of directions.
6. Atmospheric conditions (Clean dusty) full of chemicals.
7. Space to fit bearings.
8. Precision required in running.
9. Lubricating conditions
10. Quite running.
11. Temperatures while running.
12. Ease of mounting and dismounting
13. Clearance required in a bearing.

Bearing Clearance:
Bearing internal clearance is defined as the total clearance through which one bearing ring can be moved relative to the other this is indicated by shelters from C1 to C5.

Mounting and dismounting of bearings:
Before mounting any bearing the shaft or housing should be checked for proper tolerances for fits etc. if this is not observed the bearing may fail prematurely.
For providing bearings on a shaft interference fit the bearing should be heated in a oil bath tub and provided.
For providing bearing in a housing the bearing may be cooled in ice.
The bearing should be mounted square.
Lubrication paths should always be available if not these should be provided.
fixing of bearings should preferably be done in dust free atmosphere.
Axial location of bearings must be done as interference fit alone is generally not adequate for the axial location of bearing. As a rule therefore some suitable means of axially securing the ring is needed.

Bearing Technology

1. History Of Bearing

Bearing is a great invention of mankind. Even primitive man knew the use of balls and rollers for carrying heavy materials since when Egyptian pyramids were constructed . Recorded facts are available that in 1558,a Frenchman applied rollers to well bucket for drawing by reducing water the labour to great extent.

Pre-historic instances reveal that chariot was the most important asset of Assyrian Empire used for carrying weapons and soldiers in the war. The chariot axle used to get damaged by friction and hot axle trouble even with a load of four soldiers and a little weapons. The soldiers had an earnest desire to develop less friction chariots and their wish was granted in the later half of the nineteenth century when bearings were introduced.

In 19^{th} century a huge stone weighing 1000 tones and eight meters high used as a base of Russian czar peter I's statue was carried to its site by use of bronze balls.

Today this industry is so advanced that hundreds of bearings in thousands of sizes are available. Right from the simplest machinery like bicycle using balls for reducing friction to the most complicated rockets and satellites launched so far, utilize bearings for speed and service to the mankind and it is the best way to overcome friction.

2. Bearing Materials

The material for race ways and rolling elements have very small contact surface which are repeatedly subjected to stresses, must be such as to withstand wear and high elastic limits and high fatigue limits.

As a rule, high carbon chrome bearing steel Grade SAE 52100 or EN-31 is used for races and rolling material.

2.1 Chemical Composition

Grade	C	Cr	Mn	Si	P	S
SAE 52100	0.95 to 1.10	1.30 to 1.60	0.50	0.15 to 0.35	0.025	0.025

Other bearing steels depending upon the methods of heat treatment involved are as following.

S. No.	Group of Steel	Specification	Bearing Hardness
01.	Tool Steel	EN-31	HRC = 58-64
02.	Case Hardening	EN-32 & EM-207	HRC = 58-64
03.	Flame/Induction Hardening	EN-9K EN-43D EN-42E EN-43	HRC≥ 55

3. Bearing Life

The following relationship exists between the life in terms of millions of revolution and the load on rolling bearing.

$$L = (C/P)^P$$

Where

L = Rated life in millions of revolution

C = Dynamic Load capacity in Kgs.

P = Bearing Load in Kgs.

p = Constant i) For ball bearing = 3

ii) For Roller bearing = 10/3

If the speed n is constant, the life of rolling bearing can be determined in terms of operating hours (Lh) from the following formula.

$$L_h = \frac{16666}{n} (C/P)^P$$

$$= \frac{16666}{n} (Ca/Pa)^P$$

Example :- (Roller Bearing)

Given C = 1740 Kgs.
P = 415 Kgs.
n = 900 r.p.m.
For C/P = 4.2 and n = 900 r.p.m.
Read Nomograph for p = 10/3
L_h = 2200 hrs.

Example: (Ball Bearing)

Given C = 1850 Kgs.
P = 300 Kgs.
n = 2200 r.p.m.

For C/P = 6.16 and n = 2200 r.p.m.
Read Monograph for p = 3
L_h = 1800 Hrs.

4. Selection of Bearing

The bearings are selected keeping in view the equivalent load, desired life and operating speed or r.p.m. as discussed earlier. Tables showing load factor and r.p.m. are available for selection of bearing size for a desired life. The following table can be used as guide for calculating bearing. life of different machine.

5. Recommended Life Value

Type of machine	**Life L_h in Operating hrs.**
Infrequently operated machines Apparatus, devices, Demonstration gear.	500
Machine intended for brief operation lifting gear, Domestic equipment, hand tools.	4,000……8,000
Machines on intermittent operation: conveying Equipment, infrequently operated machine tools, Agricultural machinery.	8,000……15,000
Machines for I-shift operation: Machines tools, ventilators, countershafts, general Production machinery, extruders.	15,000….30,000
Machines on continuous operation: Pumps, compressors.	30,000…60,000
Machines on continuous operation with high production Capacity: Paper machines, textile machinery	100,000

NOTE: It will be seen from above table that the Track Machines fall in the Category of Machines on intermittent operation having life L_h = 8000 – 15000 operating hrs.

6. **Bearing Construction:**

Every Bearing has four main constructional features:
Inner race
Outer race

Balls/Roller/Needle.

Cage

The race (Outer & inner) provide the path for rolling elements for their smooth and frictionless motion that is why the bearings are termed as antifriction bearings also. The rolling elements (Ball/Roller/Needle) are sometimes mounted on the inner race where as in some cases on outer race. The rolling elements are kept intact, equally spaced and in one plane by a cage which can be pressed or fabricated type depending upon the manufacturer's design.

6.1 **Specification Of Cage:**

The cages are specified as follows and find their asses in industry/machinery as per requirement. The cage not only keep the rolling elements in position but also retain grease for their lubrication which if lost, the bearing is damaged and or results in over heating and caesura

S. No.	**Code**	**Cage Material.**
1.	F	Steel cage
2.	L	Light alloy cage
3.	M	Brass cage
4.	TM	Plastic cage
5.	J	Sheet Steel cage.

These days even Aluminum cages are also provided by the manufacturers.

7. RADIAL AND AXIAL CLEARANCES:

The radial or axial clearance ofa bearing is the amount by which the two races may be moved from one end position to the other radialy or axially.

7.1 RUNNING CLEARANCE:

Running clearance may be defined as the clearance of the mounted bearing produced as a result of fitting conditions and operating temperature. In other words:

Radial clearance > Running clearance

Radial clearance - Mounting tolerance = Running clearance

In order that the running clearance of a radial bearing always has the correct value to ensure an efficient function bearings are available with reduced or enlarged radial clearance for special conditions.

7.2 CLEARANCE SYMBOL:

Symbol	**Clearance Classification**
C2	Radial clearance smaller than normal

Radial clearance normal

C3	Radial clearance larger than normal
C4	Radial clearance larger than C_3
C5	Radial clearance larger than C_4

7.3 Radial Clearance of Deep Groove Ball Bearing With Cylindrical Bore:

Bored (mm)	**Radial clearance (In units of 0.001mm)**

		C 2		Normal		C 3		C 4	
Over	**Incl**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
2.5	10	-	7	2	13	8	23	-	-
10	18	-	9	5	18	11	25	18	33
18	24	-	10	5	20	13	28	20	36
24	30	-	11	5	20	13	28	23	41
30	40	-	11	6	20	15	33	28	46
40	50	-	11	6	23	18	36	30	51
50	65	-	15	8	28	23	43	38	61
65	80	-	15	10	30	25	51	46	71
80	100	-	18	12	36	30	58	53	84
100	120	-	20	15	41	36	66	61	97
120	140	-	23	18	48	41	81	71	114
140	160	-	23	18	63	46	91	81	130
160	180	-	25	20	61	53	102	91	147
180	200	-	30	25	71	63	117	107	163

Radial Clearance of Cylindrical Roller Bearings With Cylindrical Bore and Interchangeable Components:

Bored (mm)		**Radial clearance**									
		C 2		**Normal**		**C 3**		**C 4**		**C 5**	
Over	**Incl**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
18	24	0	30	10	40	25	55	35	65	55	85
24	30	0	30	10	45	30	65	40	70	60	90
30	40	0	35	15	50	35	70	45	80	70	105
40	50	5	40	20	55	40	75	55	90	85	120
50	65	5	45	25	70	45	90	65	105	100	140
65	80	5	55	30	80	55	105	75	125	115	165
80	100	10	60	35	85	65	115	90	140	145	195
100	120	10	65	35	90	80	135	105	160	165	220
120	140	10	75	40	105	90	155	115	180	185	250
140	160	15	80	50	115	100	165	130	195	-	-
160	180	20	85	60	125	110	175	150	215	-	-
180	200	25	95	65	135	125	195	165	235	-	-

7.5 **Radial Clearance Specified for High Temperature:**

Operating temperature	120-150^{0}C	150-180^{0}C	Over 180^{0}C
Radial clearance	C_3	C_4	Greater than C_4

8. **Classification of Bearings:**

There are three main classification of bearings e.g.
Ball bearing
Roller bearing
Needle bearing

They are further classified as follows:

I. **Ball bearings:**

Rigid Ball Bearings
Deep groove ball bearings
Angular contact
Double row-self aligning

Thrust Ball bearings
Single Thrust
Double/Duplex thrust.

II. **Roller Bearing:**
Cylindrical roller bearing
Spherical roller bearing
Taper roller bearing

III. **Needle Bearing:**
Needle cage
Inner Race
Shell type needle bearing
Needle bearing with hard shoulder.
Needle bearing without shoulder
Adjustable needle bearing
Self aligning
Cam follower type needle bearing
Roller follower needle bearing
Thrust Needle roller bearing
Flat cages.

Maintenance Aspects of Bearing:

9. **Lubrication of Bearings:**

Rolling bearing generally require a minimum of lubrication as the load is transferred under rolling friction. Primarily sliding friction occur only on the guide surfaces of the cages, but the quality of lubrication is never-the-less a decisive factor in the life of an antifriction bearing as the main function of lubricant is to prevent corrosion, wear and over heating.

9.1 **Importance of Lubrication:**

The lubrication plays very important role in antifriction bearings and serve various purposes as below:
It reduces friction and wear.
It prevents corrosion
It acts as coolant
It works as noise damper
It acts as dirt remover
It acts as seal/sealent also
It acts as retainer for rolling element.
NOTE: Lack of lubrication is one of the most common reasons for premature bearing death.

9.2 **Type of Lubrications:**

There are three types of lubrications commonly in use for antifriction bearings.

9.3 **Grease Lubrication:**

Properties of various types of greases are reproduced below for guidance of the users.

Type of Grease	**Calcium**	**Sodium**	**Aluminum**	**Barium**	**Lithium**	**Benton**	**Silica gel**
Name of Grease	Cup Grease	Fiber Grease	Mobile Grease	Multi purposes Greases	Non soap base greases.		
Outward appearance	Evenly butter	Fiber out or	Evenly thread like	Evenly fiber out	Evenly butter	Evenly butter	Evenly butter

	like	butter like			like	like	like
Dropping point ^{0}C	85	160-	85	175	175	More than 200	More than 200
Maximum Temp. Recommended ^{0}C	70	125	80	135	135	125	125
Water resistance	Good	Poor	Good	Good	Good	Fair	Poor
Mechanical stability	Fair to good	Fair to good	Poor to fair	Poor to fair	Excellent	Fair	Poor
When heated above 120^{0}C and then cooled	Bleeding	No Change	Jelly like	No Change	No Change	No Change	No Change

9.4 **Dry Lubricants:**

Dry lubricants are recommended for operating temperatures above 250^{0}C under normal operating conditions there is no advantage in using them even when used in conjunction with grease or oil.

10. **Maintenance of Roller Bearings Axle Boxes:**

Normally we do not require any maintenance except inspection and re-lubrication which is done at 6000-10000 miles (or 96000-160000 Kms). However depending upon the dynamitic conditions, if it is necessary lubricate the bearing earlier. Provision for grease nipple should be kept if possible.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson- XII BCM Assemblies **Session-19:** Working, Construction and Maintenance practices of Excavation Chain.

BCM Assemblies:

1. Excavating Chain

Shovel or main link	-	82 Nos.
Intermediate link	-	82 Nos.
Chain finger	-	5 Nos. in each shovel total 410 Nos.
Chain bolt	-	2 Nos.
Cutter Bar	-	1 No.
Dredger drum	-	1 No.
Wear Plates	-	56 Nos.
Corner Roller	-	5 Nos.
Chain Speed	-	1.8mmt
	-	2.4 mt/mt
	-	2.7 mt/mt
	-	3.4 mt/mt
Length of cutter bar	-	2.0 meter
Height of Cutter bar	-	250mm

Screening Unit:

1st	80mm size
2nd	50 mm size
3rd	32 mm size

Screening Drum:

This is responsible for creating vibration. Vibration is done through hydraulic motor. It is a bi-directional motor which gives bi-directional movement to the cutting chain.

Track Lifting & Lining Unit:

This is used for the purpose of lifting and lining. Lifting is through a centralized hydraulic cylinder. Track can also be slewed as per requirement.

Maintenance Practices of Excavating Unit:

As excavating unit consists of shovel, intermediate link round shaft chisel. 'T' head bolt, chain bolt etc. due to vibration bolt may shear up so proper attention to be done with respect to the taper and ovality. In addition to this worn out round shaft chisels should be replaced.

The teeth of dredger drum may get worn out. So it should be replaced after a certain period say 25 Km. or so.

Originally the cutting chain is provided with carbide tip as it is much more wear resistant. So these are to be replaced after 60 Km. progress and so on.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson- XII BCM Assemblies **Session-20:** Working, Construction and Maintenance practices of Conveyor Belts and Screens.

There are following conveyor belts provided on machine.

1.	Main conveyor belt	-	1 No.
2.	Distributor conveyor belt	-	2 Nos.
3.	Waste conveyor belt	-	1 No.

Above are rubber – materials, so due to their movement they are subjected to wear and tear. While working it must be ensured that there is no wear or tear or damaged occurred to the belts. So they need to be replaced. Some times the belts are joined through vulcanization process.

Screen Maintenance – Following are the Various: Screens provided on BCM.

1.	80mm	-	9 pieces
2.	50 mm	-	9 pieces
3.	32mm	-	9 pieces

Due to excessive vibration at 380 bar, the screen get damaged. For this, there is need of welding of these screens. Screens are welded through welding plant and 'U' clamp is also done for the purpose of proper fastening. The maintenance of screen is very much important from machine point of view for smooth working of BCM.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XIII- Lubrication **Session-21:** Oil and Lubricants used in different gear boxes, Tamping unit, Lifting unit, Screen -drum etc., types and their capacities.

Lubrication:

Oil and lubricants used in different gear boxes, Tamping Unit, Lifting Unit Screen drum and their capacity. Following are the various oil & lubricants used in machines.

Gear Box	-	C90 – 20 lts.	
Tamping Unit	-	SS-100 Hyd. Oil	
Grease for Tamping Unit	-	RR3	
Grease for Axle	-	Bearing grease	
Main gear box of BCM	-	Hyd. Oil HLP68	
Screen drum for BCM	-	Hyd. Oil HLP68	70 lts.
Axle Gear Box	-	Hyd. Oil HLP 68	45 Lts (each axle)
Dredger drum	-	Amola 100	25 lts.
Turn table	-	Hyd, oil	15 lts.

Turn

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XIV: Maintenance Schedules **Session-22& 23:** Maintenance Schedules of machines.

Maintenance Schedules of Track Machines

Following are the various schedule maintenance of different machines given as under:

Schedules	**UNO/DUO**	**CSM/09-3X Unimat/MPT DSG/BRM**	**BCM**	**FRM-80**
	Engine Running Hours	Duration	Engine Running Hours	Duration
Schedules- I	Daily	1hr.	Daily	1hr.
Schedules-II	50hrs.	2hrs.	50hrs.	2hrs.
Schedules-III	100hrs.	1 Day	100hrs.	1 Day
Schedules-IV	200, 400, 600, 800hrs.	2 Days	200, 400, 600, 800hrs.	2 Days
Schedules-V	1000, 3000, 5000hrs.	7 Days	1000, 3000, 5000hrs.	7 Days
Schedules-VI	2000, 4000hrs.	45 Days	2000, 4000hrs.	45 Days
Schedules-VII	6000hrs. (POH)	90 Days	6000hrs. (POH)	90 Days
Schedules-VIII	-	-	-	-

	PQRS		**TRT**		**T-28**	
Schedules	Engine Running Hours	Duration	Engine Running Hours	Duration	Engine Running Hours	Duration
	Daily	1hrs.	Daily	1hrs.	Daily	-
Schedules- I	50hrs.	2hrs.	50hrs.	5hrs.	50hrs.	-
Schedules-II	100hrs.	1 Day	200hrs.	1 Day	100hrs.	-
Schedules-III	200hrs.	2 Days	500hrs.	7 Days	150hrs.	-
Schedules-IV	1000hrs.	7 Days	1000hrs. (IOH)	7 Days	200hrs.	-
Schedules-V	2000hrs. (IOH)	45 Days	6000hrs. (POH)	-	300hrs.	-
Schedules-VI	4000hrs. ((POH)	60 Days	-	-	500hrs.	-
Schedules-VII	-	-	-	-	1500hrs.	-
Schedules-VIII						

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XIV: Overhauling of Machine **Session-24:** IOH/POH of machines.

OVERHAULING OF MACHINES

This can be said without any fear of contradiction that lot of wear and tear takes place on account of machine working and as machines are subjected to wear and tear, failures are bound to take place, so in order to prevent the failures of machines, schedules have been framed which are followed and then chances of failures are reduced. The various schedules have been incorporated in the track machine manual-2000 depending upon the type of machine which reduces down time of machines and this are known as preventive maintaining but this is not sufficient to meet the requirement of machines and accordingly with the certain passage of time and specified working hours of machines after which, other than schedules, machine are taken to zonal or central periodical overhauling workshop for conveying out IOH/POH of machines which are given as under for good health of machine. Yard stick of IOH/POH of machines.

POH of machines.

Overhauling of tamping Units, Gear Assembly, axle assembly and lifting lining assembly for unit change either at shop floor or field.

Post POH service to zonal railway and performance monitoring of overhauled.

Development of Expertise, Standardization/documentations and dissemination of knowledge with respect to overhauling of assemblies.

Study of Interchangeability of components and subassemblies.

Study of failures, finding out remedial measures, troubleshooting and development of maintenance practices.

Procurement of stores and equipments required for POH and their inspection.

Inspection and testing of machines/assemblies received prior to and after POH.

Study of new imported machines and preparations of inventory list with complete series of machines. (machine wise) and checking for changes with reference to old series of machines.

Development of drawings and material specification for manufacturer of spares.

Providing shop floor training regarding maintenance of machines.

SUB: INTERNAL COMBUSTION ENGINE & WORKSHOP TECHNOLOGY
Duration: 80 Sessions = 160 Periods

Sub-discipline:- Internal Combustion Engine (Lessons: X Sessions: 49)
Lesson-I: General. Session-1: History and Development of Engine, I.C. and E.C. Engine, Advantages and disadvantages

---

HISTORY AND DEVELOPMENT OF I.C ENGINES.

In the year of 1860 a French engineer J.J.E. LEVOSIER made first I. C. engine. In the working of this engine, the mixture of gas and air was sucked in the half stroke inside the cylinder, and then spark was given. The mixture burns and gives energy and by this energy piston moves forward and reaches to the other end of its stroke. But in this time the gas becomes cool and there is a vacuum inside the cylinder. Due to this vacuum piston starts returning back. In this engine consumption of gas was much and also there were many defects due to which this engine was not successful.

Another modified I. C. Engine was represented by Doctor N.A. Otto in 1876.In this engine mixture of air and petrol was compressed. Then electric spark was given to the compressed mixture due to which there was explosion in the mixture. Pressure rises and pushes the piston downward, thus rotating the crank shaft. This engine completes its cycle of operation in four strokes. This cycle is called Otto cycle. The limitation of this engine was that not much compression was developed inside the cylinder due to which power production was less. To increase power more cylinders were needed and engine takes more space. Consumption of petrol was also very much.

In the year 1892 Doctor Rudolf diesel made a diesel engine. This engine was similar to Otto engine having semi modifications. In this engine the pressure of compression was so much that the mixture burns itself. There was no need of spark. In this way Doctor Rudolf diesel is father of diesel engine. This engine became in use for the industries in the year 1900. This engine was further modified in 1920 and again modified in 1928. Now this engine started to be used in the buses.

ENGINE: - Engine is a device which converts one form of energy in to another form.

HEAT ENGINE: - Converts heat energy in to mechanical energy. Heat energy is obtained from combustion of fuel. Chemical energy in fuel is converted in to heat.

INTERNAL COMBUSTION ENGINE: - Those heat engines in which fuel is burnt inside the engine cylinder is called internal combustion engine.

EX :- Diesel engine, Petrol engine, Gas engine.

EXTERNAL COMBUSTION ENGINE: - Those heat engines in which fuel is burnt out side the engine cylinder is called external combustion engine.

EX: - Steam engine, Steam turbine.

ADVANTAGES OF I.C. ENGINE:

1. Compact.
2. Easy Starting
3. Less Maintenance Cost.
4. Very high thermal efficiency.
5. Weight-power ratio is very less.
6. Can generate much more r.p.m. then E.C. Engine.
7. Suitable for motive power due to their light weight.

DISADVANTAGES OF I.C. ENGINE:

1. I.C Engine creates more pollution as compared to E.C. Engine.
2. E.C. Engines are double acting engines while I. C. engines are single acting engines.
3. I.C. Engines can not develop as much power as compared to steam engines (E.C. Engines)

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)

Lesson-I: General Session-2: Classification of I.C. Engine and Main systems of I.C. Engine

---

CLASSIFICATION OF I.C. ENGINES:-

Engines may be classified as given below:-

1. On the basis of fuel used:-
   - (i) Petrol Engine
   - (ii) Diesel Engine
   - (iii) Gaseous Engines.

2. On the basis of no. of strokes per working cycle:-
   - (i) 2- Stroke Engines.
   - (ii) 4- Stroke Engines

3. On the basis of working Cycle:-
   - (i) OTTO- Cycle Engines.
   - (ii) Diesel cycle Engines
   - (iii) Dual cycle Engine.

4. On the basis of Method of ignition of fuel:
   - (i) Spark ignition engine
   - (ii) Compression ignition engines.

5. On the basis of method of cooling:
   - (i) Air Cooled engine
   - (ii) Water cooled engine.

6. On the basis of no. of cylinders:-
   - (i) Single cylinder engine
   - (ii) Multi-cylinder engine.

MAIN SYSTEMS OF AN I.C ENGINE:-Followings are the main systems of an I.C engine:-

1. Air supply system.
2. Fuel supply system.
3. Lubricating system.
4. Cooling system.

1. Air Supply System:- In this system we shall study about requirement of air, Air cleaner, drawbacks of choking of air cleaner, Turbocharger, After cooler and importance of after cooling etc.

2. Fuel Supply System:-In this system we shall study about functions of the system, classification, fuel injection pumps, injectors, Mico-Bosch and Cummins P.T. fuel supply system, cetane no., knocking of fuel etc.

3. Lubricating System: - In this system we shall study about properties of lubricating oil, oil additives, viscosity rating, lubricating circuit, components of lubrication system, Blow bye, reasons of low lubricating oil pressure and high oil consumption etc.

4. Cooling System:-In this system we shall study about different methods of cooling, Drawbacks of overcooling and reasons of over heating etc.

Cummins NTA 855 C – 380
N= 4 Valve head
T= Turbocharged
A= Aftercooled
855= Cubic Inch Displacement
C= Construction
380= Maximum rated H.P.

Cummins KTA 1150 L
K= Engine Family
L= Locomotive

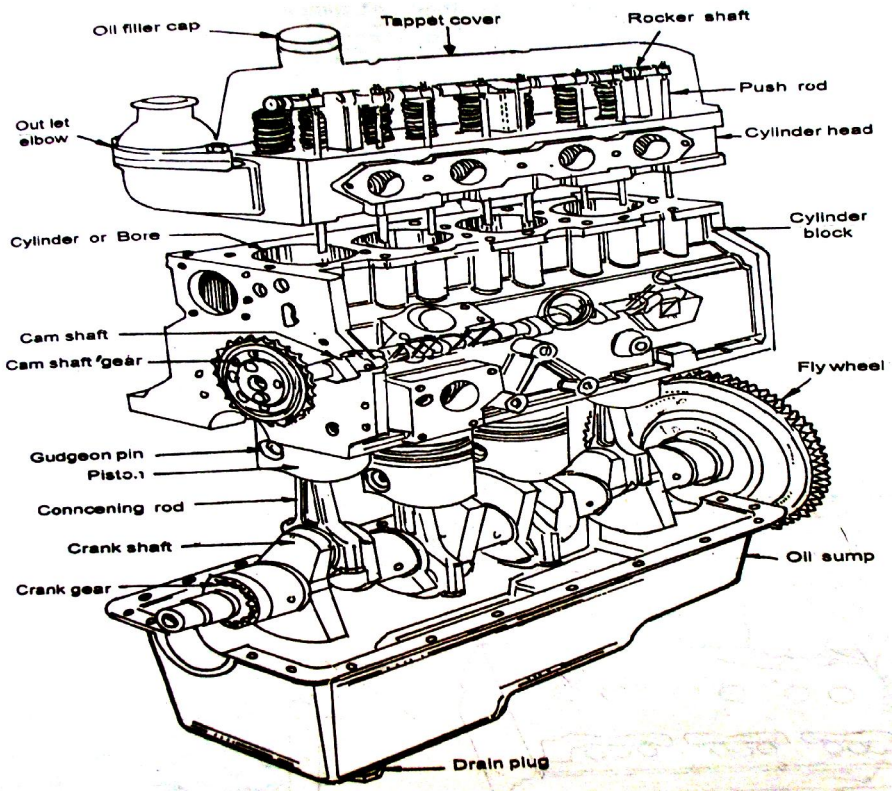
Deutz BF 12 L 513 C
B= Turbocharged
F= 4- Stroke
12= Twelve Cylinders
L= Air cooled
5= Series
13= Stroke length in cm.
C= Charge air cooler

KHD= Klockner Humbolt Deutz

MWM TBD 232 V 12
MWM= Motoren Werke Mannhem
T= Turbocharged
B= Aftercooled
D = Diesel Engine
232= Series
V= V- Type
12= Twelve Cylinders

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-II: Constructional Details of Engine. Session-3: Cylinder, Cylinder head, Piston and Piston Rings

Engine Construction



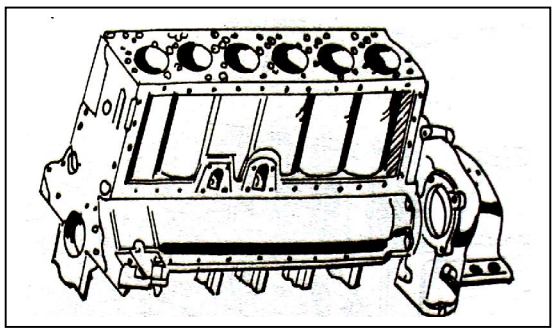
The main parts of the engine are as follows: -

1. Cylinder block and crankcase
2. Cylinder head
3. Oil sump
4. Piston
5. Piston Rings
6. Piston Pin or Gudgeon Pin
7. Connecting Rod
8. Crankshaft
9. Flywheel
10. Camshaft
11. Valve and valve mechanism
12. Accessories: - Air cleaner, Oil filter, Fuel filter, Oil pump.
13. Other parts: - Fuel pump, injector, and vibration damper.

Now we shall study these parts one by one in detail.

1. Cylinder Block and Crankcase

It forms the basic framework of the engine. Cylinder block houses the engine cylinders and crank case supports crankshaft and camshaft. Most engines have cylinder block and crankcase as a single casting. Some big engines have separate crankcase and cylinders are fitted (bolted) separately with the crankcase.



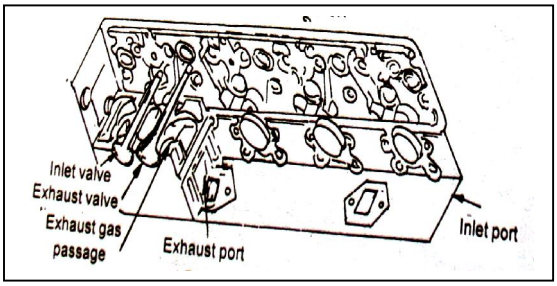
- Ø There are inbuilt oil galleries for circulation of lubricating oil.
- Ø Water-cooled engines have inbuilt passages for flow of cooling water. Air cooled engines have fins outside of the cylinders for cooling.
- Ø Big engines have separate liners placed inside the cylinder bores, which are replaced when

2. Cylinder Head

The top of the cylinder block is covered by cylinder head. It has combustion chamber and holes for fitting injector and valves. There are inbuilt passages for flow of lubricating oil. In water-cooled engines, there are also passages for flow of water. Bottom holes of cylinder head for lubricating oil and water, matches with the top holes of cylinder block for the same.

In air-cooled engines, there are fins outside the head for cooling. The cylinder head is bolted to the top of the cylinder block with a gasket in between them.

Material: Cast Iron.



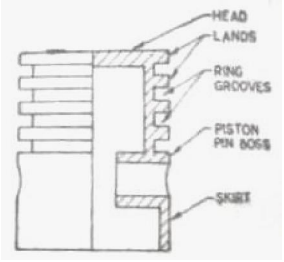
3. Oil Sump

It is the lowest part of the engine. It is attached to the crankcase through setscrews with a gasket in between them. It stores oil for engine lubrication system. There is a drain plug at the bottom of the oil sump. **Material: - Steel sheet or Aluminum.**

4. Piston

Piston transfers the power obtained from expansion of gases to the crankshaft via connecting rod. It is equipped with rings

.

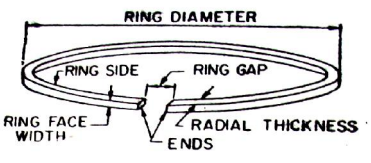


Material: - Aluminum Alloy

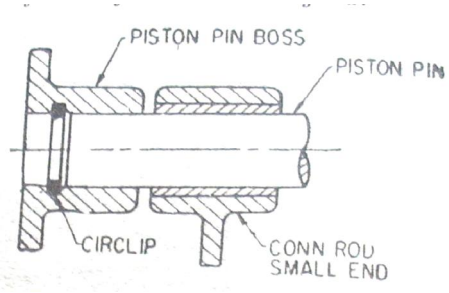
5. Piston Rings

Piston rings are fitted into the grooves of the piston.
There are two types of piston rings-

a. Compression ring
b. Oil Control rings



6. Piston Pin or Gudgeon Pin



It connects the piston and the small end of the connecting rod. Piston pin is generally hollow. In most of the engines, piston pin floats in both the piston bosses and small end of the connecting rod. Piston pin axial movement is prevented by fitting circlips in grooves at the outer end of piston bosses.

Material: Steel Alloy (Case hardened)

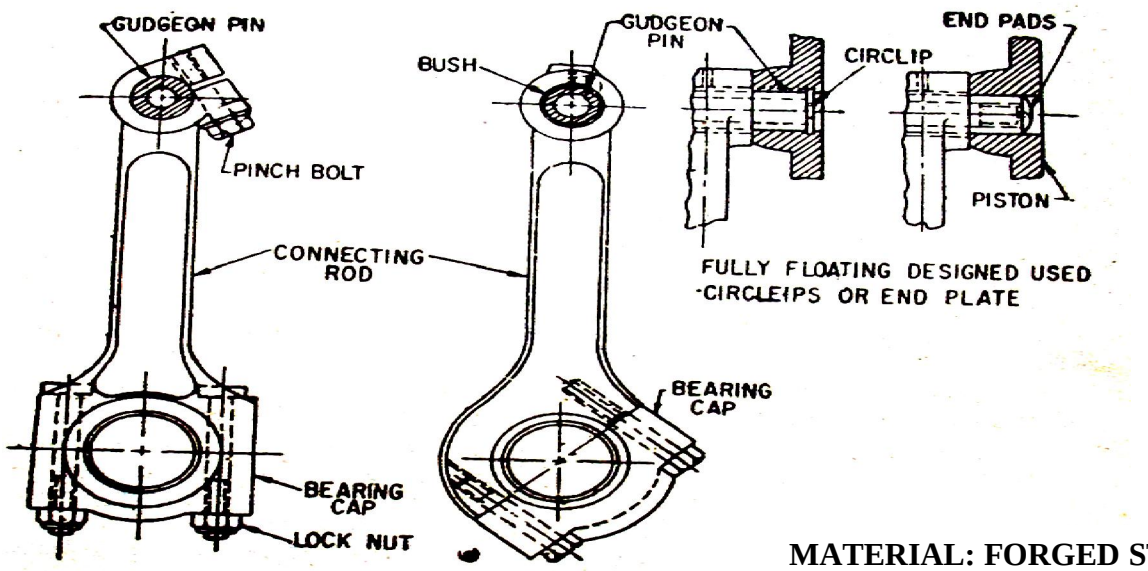
SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-II: Constructional Details of Engine.Session-4: Connecting rod, Crankshaft, Flywheel, Camshaft

---

7. Connecting Rod

It joins the piston pin with the crank pin of the crankshaft. Small end of the connecting rod is connected to the piston pin and the big end to the crank pin. Connecting rod converts the linear motion of piston into rotary motion of the crankshaft.

Connecting rod usually has I- beam cross-section. There is a drill passage from small end to the big end for flow of lubricating oil. The big end may be split at right angle to its length or at another angle. The small end is usually a solid eye fitted with a phosphor bronze bush, or a split eye and a pinching screw to close the eye round the pin.



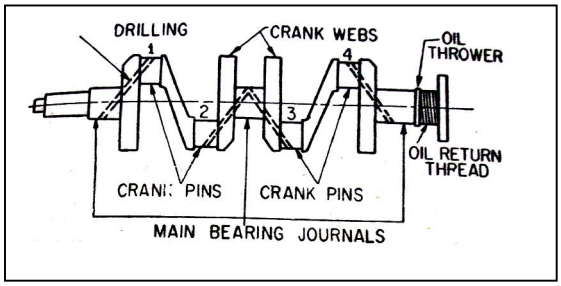
MATERIAL: FORGED STEEL.

All the connecting rods in an engine must be of equal weight. In original assembly, the connecting rods and caps are individually matched to each other and numbered to avoid interchange.

Crankshaft

Crankshaft is the part on to which reciprocating motion of the piston is converted into rotary motion. A crankshaft consists of

i. Crank Pins
ii. Webs
iii. Balancing Weight and
iv. Main Journal



Crankshaft has drilled oil passages though which oil can flow from the main bearing to connecting rod (C.R) bearing. The rear end of the crankshaft carries flywheel and the front end carries a gear, vibration damper and fan belt pulley.

Center to center distance between the crank pin and main journal is half of the piston stroke. Thus, one complete revolution of the crankshaft makes two strokes of the piston.

Material: - Steel Alloy

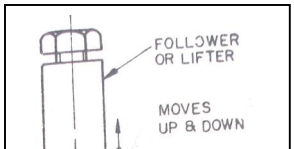
9. Flywheel

Flywheel is a heavy steel wheel attached to the rear end of crankshaft. During power stroke the engine tends to speed up and during other three strokes it tends to slow down. The Flywheel stores power during power stroke and releases during other three strokes to keep the engine running at the constant speed.

Flywheel is also used as a part of clutch mechanism. Flywheel also has teeth to mesh with self-starter during starting.

10. Camshaft

Camshaft is a shaft on which cams are mounted. Cam is a device, which changes rotary motion of the camshaft into linear motion of the follower or lifter. A camshaft has a number of cams along the length. There are two cams for each cylinder, one to operate the inlet valve and the other to operate the exhaust valve.



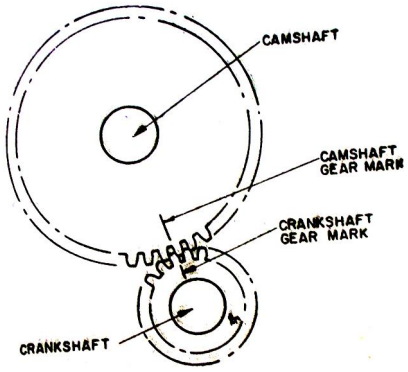
In addition, the camshaft has an eccentric to operate the fuel feed pump and a gear to drive the oil pump.

The crankshaft drives the camshaft. The camshaft gear has teeth twice of crankshaft gear teeth.

Gear ratio = No. of teeth on crankshaft gear.
No. of teeth on camshaft gear
= **1:2**

Thus camshaft turns at half the speed of the crankshaft.

There should be a definite relationship between crankshaft and camshaft. There are marks on crankshaft gear and camshaft gear, which are matched during assembly to maintain the definite relationship between the two.



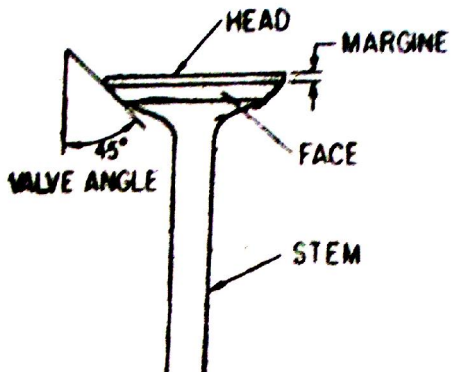
Note: - In Cummins Engines, there are three cams for each cylinder on camshaft. One cam operates inlet valve, second operates injector and third operates exhaust valve. Also there is no eccentric, because these engines have no fuel feed pump.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-II: Constructional Details of Engine. Session-5: Inlet and Exhaust valve, Push rod, Rocker arm, Valve clearance, Valve operating mechanism

---

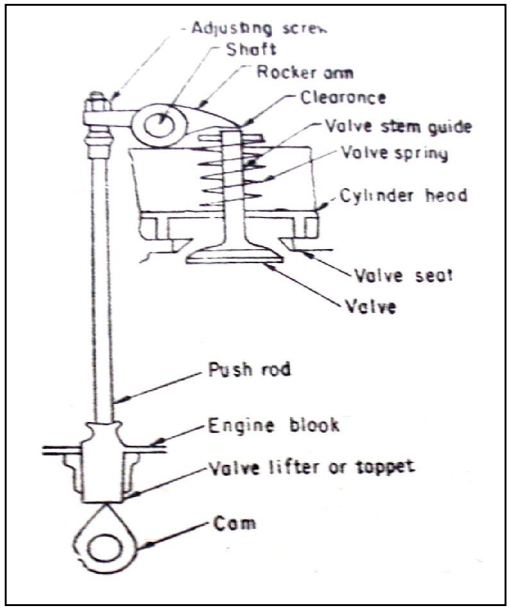
Valve And Valve Operating Mechanism

Valve: - Valve is a device to open and close a passage. There are two valves for each cylinder – an inlet valve and another exhaust valve. Air enters to the cylinder through the **inlet valve** and the burnt gases escape through the **exhaust valve**. When closed, the valve must seal the combustion space tightly.
Inlet valve is subjected to less heat and is made of **nickel chromium alloy steel.** Exhaust valve is subjected to severe heat and is made of **silicon chromium alloy steel.** Silchrome steel has very high



Valve Operating Mechanism:

Cams mounted on a camshaft operate valves. The crankshaft drives the camshaft. As the cam rotates it lifts the valve tappet, which actuates the push rod. The **push rod** rotates the **rocker arm** about a shaft called rocker arm shaft. The rocker arm pushes down the valve to open the passage.



Valve - Tappet Clearance:

A slight clearance is kept between the valve stem and rocker arm called valve tappet clearance. This clearance allows for expansion of the valve stem as the engine becomes heated. If sufficient clearance is not given, the valve will not seat properly, when the engine becomes heated, which will cause power loss. The exhaust valve has more clearance then the inlet valve due to more heating. Valve-tappet clearance is adjusted by means of an adjusting screw on the rocker arm.

12. Accessories: These are the parts, which are used for better working of the engine.

Air cleaner: It is used to allow clean air entrance into cylinders for fuel combustion.

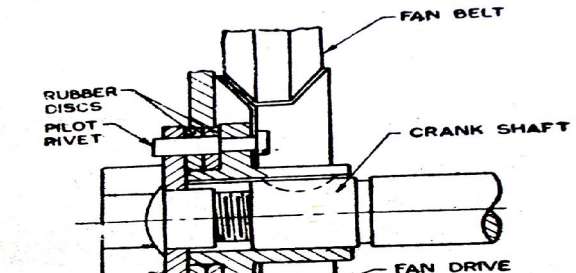
Oil filter: It screens impurities from the lubricating oil so that only clean oil will circulate throughout the engine.

Fuel filter: It screens impurities from fuel *i.e.* HSD so that clean fuel will flow through fuel pump and will go for combustion inside the cylinder.
Oil pump: It is used to supply pressurized oil into the lubricating circuit for engine lubrication.

13. Other Parts
Fuel pump: It supplies pressurized fuel to the fuel circuit.
Injector: It is fitted into the cylinder to supply fuel in atomized and vaporized form.

Vibration damper:

While engine is running, winding and unwinding effect comes on crankshaft during power stroke. This winding – unwinding effect develops torsional vibration due to which crankshaft may break. To damp down



It is simply a small flywheel. It is mounted at the front end of the crank shaft.

ENGINE REMOVAL:

1. Drain the cooling system by opening the drain cocks.
2. Disconnect the battery at the positive terminal to avoid the possibility of short circuit.
3. Remove the air cleaner horn from the carburetor and disconnect the breather hose at the oil filler pipe.
4. Disconnect the carburetor choke and throttle controls by loosening the clamp bolts and set screws.
5. Disconnect the fuel tank to fuel pump line by unscrewing the connecting nut.
6. Plug the fuel line to prevent fuel leakage.
7. Remove the radiator stay bar.
8. Remove upper and lower radiator hoses by loosening the hose clamp and slipping the clamps back on the hose.
9. Remove the four bolts from the fan hub and remove the fan hub and fan blades.
10. Remove the radiator attaching screws and remove the radiator.
11. Remove the starting motor cables. Remove the starting motor.
12. Disconnect the wires from the generator /alternator .Disconnect the ignition primary wire at the ignition coil.
13. Disconnect the oil pressure and temperature sending unit wires at the units.
14. Disconnect the exhaust pipe at the exhaust manifold by removing the stud nuts.
15. Remove the two nuts and bolts from each front engine support. Disconnect the engine ground strap. Remove the engine supports. This will allow the engine to drop slightly and will permit excess to the two top bolts on the flywheel housing.
16. Remove the rocker arm cover by removing the two holding nuts.
17. Remove two cylinder heads bolts. Fit a suitable engine lifting bracket in place and retighten the cylinder head bolts previously removed. Attach the engine lifting bracket to a chain hoist or other lifting device. Take up all slacks.
18. Remove the bolts which attach the flywheel housing to the engine.
19. Pull the engine forward or roll the vehicle backwards until the clutch clears the flywheel housing. Lift the engine from the vehicle.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-II: Constructional Details of Engine. Session-6: Demonstration of Engine components in I.C. Engine Model Room

---

1. Identification of Cylinder, Cylinder head, Sump, Piston, Piston rings, Connecting rod, Crank shaft, Flywheel, Camshaft, Inlet & Exhaust valve, Push rod, Rocker arm, Valve operating mechanism, Injector, Air cleaner, Oil filter, Fuel Filter, Oil Pump, Fuel Pump, Injector, Vibration damper etc.

2. To locate the Valve clearance position.

3. To count Nos. of teeth on Crankshaft gear & camshaft gear and to verify speed ratio.

4. To count Nos. of teeth on Crankshaft gear & P.T. pump gear or Mico-Bosch fuel pump **Sub-**

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-III: Basic Terminology. Session-7: T.D.C., B.D.C., Swept volume, Clearance volume, Compression ratio, Stroke length, Cylinder bore.

BASIC TERMINOLOGY:

Top Dead Centre (TDC): The upper most extreme point beyond which piston can not go in upward directions.

Bottom Dead Centre (BDC): The bottom most extreme point beyond which can not go in down word direction.

Stroke: The complete movement of piston in one direction i.e. either from TDC to BDC or from BDC to TDC is known as stroke.

Stroke Length (L): Distance between TDC & BDC.

Bore (d): The diameter of engine cylinder. It is measured in mm or inches.

Clearance Volume (Vc): The volume of cylinder above TDC.

Swept Volume (Vs): The volume of cylinder between TDC and BDC is called swept volume.

Compression Ratio: It is the ratio between the volume when piston is at BDC (Vs + Vc) and volume when piston is at TDC (Vc)

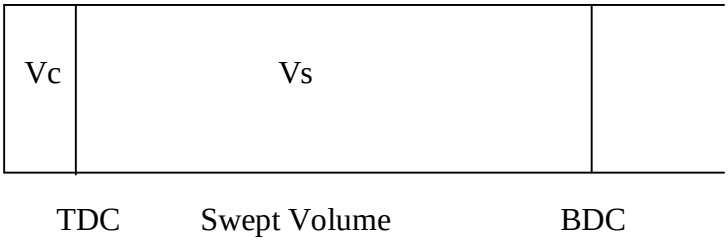
$$\text{Or,} \qquad \text{C.R (r)} = \frac{Vc + Vs}{Vc}$$

Vs = Swept volume = $\frac{\pi}{4} d^2 L$ (Volume between TDC & BDC)

Vc = Clearance volume. (Volume inside the cylinder when piston is at TDC)

d = Bore

L = Stroke Length



SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-8: Working Principle of 4-stroke Diesel Engine (Diesel cycle).

WORKING PRINCIPLE OF 4-STROKE DIESEL ENGINES

In our track machines, 4 stroke diesel engines are used. In 4 stroke diesel engine one working cycle completes in 4 strokes of piston or 2 revolutions of crank shaft. Working Principle of 4 stroke diesel engine can be explained as follows:-

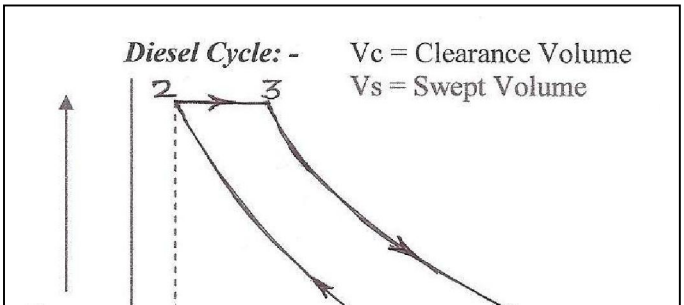
Suction Stroke: - In suction stroke, suction or inlet valve opens. Piston moves from TDC to BDC and vacuum is created inside the engine cylinder. In this process, fresh air will enter inside the engine cylinder at atmospheric pressure. At the end of suction stroke inlet valve is closed.

Compression Stroke: - In this stroke both valves remain closed. Piston moves from BDC to TDC compressing the air. Compression of air takes place according to adiabatic process, PV^{γ} = constant. In this process pressure and temperature will increase gradually up to 28 bars and 550^0C respectively. At the end of compression stroke, fuel is injected through injector in the combustion chamber.

Power Stroke: - The self ignition temperature of diesel is 440^0C. The diesel in the combustion chamber burns and burning gases expand. The burning gases push down the piston from TDC to BDC. Thus power is delivered at the crank shaft.

Exhaust Stroke: - Exhaust valve opens. Burnt gases go out by self pressure through the exhaust valve. Piston moves from BDC to TDC and pushes out the remaining gases. At the end of the stroke, exhaust valve gets closed.

Thus one working cycle gets completed in 4-strokes of piston or two revolutions of crank shaft or one revolution of camshaft.



From Graph:
Suction Stroke:
At point 0 à Inlet valve opens.
Process 0-1 à Piston moves from TDC to BDC. Due to piston movement, vacuum is created inside the engine cylinder. Due to this vacuum, fresh air

Power Stroke:

At Point 2	à	Injection of fuel starts. Fuel injection pr. = 180 bar. Self ignition temperature of diesel is 440°c, so it starts burning.
Point 2-3	à	It is known as "Heat addition process at constant pressure". Fuel is injected in the cylinder. Piston moves from TDC towards BDC.
Point 3	à	Fuel cut off point.
Point 3-4	à	Adiabatic expansion of flue gases takes place. Piston moves to the BDC due to the force exerted by the expanding flue gases.

Exhaust Stroke:

At point 4	à	Exhaust valve opens.
Process 4- 1	à	Exhaust gases go out (Heat rejection at constant volume). Pressure drops inside the engine cylinder up to atmospheric pressure.
Process 1- 0	à	Piston moves from BDC to TDC. Exhaust of flue gases takes place at atmospheric pressure.
At Point 0	à	Exhaust valve closes.

DIFFERENCE BETWEEN DIESEL AND PETROL ENGINE

(1) Both use battery for initial starting, but it is not required by the Diesel Engine to continue further working whereas petrol Engine needs electricity for ignition

(2) Diesel Engine utilizes fuel pump and injector nozzles for fine spray of fuel in to the cylinders whereas petrol Engine uses Carburetor.

(3) Diesel is less volatile and heavier than gasoline and hence cheaper. It ignites at a high temperature in comparison to petrol.

(4) Diesel engine uses greater compression ratio (1:16) the petrol engine whose compression ration is usually 1:7.

(5) Diesel engine needs sturdy structure in comparison to gasoline engine.

(6) Diesel engine sucks air alone during suction stroke and fuel at the end of the compression stroke is injected. The petrol engine sucks mixture of petrol and air through carburetor during suction stoke.

(7) Diesel Engine is heavier than petrol Engine.
(8) Diesel engine is compression ignition whereas petrol engine needs H.T. electricity from distributor spark coil and timer etc. These accessories are not needed in Diesel Engine.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 9)
Lesson-IV: Working Principle of I.C. Engine. Session-9: Working Principle of 2-stroke Diesel Engine and 2 & 4-Stroke Petrol Engine (Otto cycle)

WORKING PRINCIPLE OF 4- STROKE PETROL ENGINE (OTTO CYCLE)

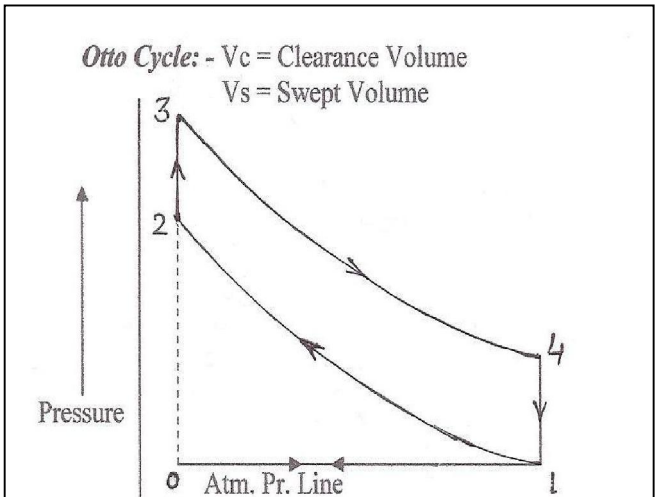
Suction Stroke: In suction stroke, suction or inlet valve opens. Piston moves from TDC to BDC and vacuum is created inside the engine cylinder. In this, Air and petrol mixture from carburetor enters inside the engine cylinder at atmospheric pressure. At the end of suction stroke inlet valve is closed.

Compression Stroke:- In this stroke both valves remain closed. Piston moves from BDC to TDC compressing the air-petrol mixture (charge). Compression of the air-petrol mixture (charge) takes place according to adiabatic process, PV^{γ} = constant. In this process, pressure will increase gradually up to 8 to 13 bars. At the end of compression stroke, an electric spark is given to the compressed charge in the combustion chamber. The charge starts burning.

Power Stroke: - The burning gases expand and push down the piston from TDC to BDC. Thus power is delivered at the crank shaft.

Exhaust Stroke: - Exhaust valve opens. Burnt gases go out by self pressure through the exhaust valve. Piston moves from BDC to TDC and pushes out the remaining gases. At the end of the stroke, exhaust valve gets closed.

Thus one working cycle gets completed in 4-strokes of piston or two revolutions of crank shaft or one revolution of camshaft.



From Graph:

Suction Stroke:

At point 0 à Inlet valve opens.

Process 0-1 à Piston moves from TDC to BDC. Due to piston movement, vacuum is created inside the engine cylinder. Due to this vacuum, fresh air and petrol mixture (charge) enters inside the engine cylinder. Theoretically it is assumed that

Power Stroke:

At Point 2 à Spark is given through spark plug.

Point 2-3 à It is known as "Heat addition process at constant volume". Burning of charge takes place at constant volume.

At Point 3 à Burning completes.

Point 3-4 à Adiabatic expansion of flue gases takes place. Piston moves from TDC to the BDC due to the force exerted by the expanding flue gases.

Exhaust Stroke:

At point 4 à Exhaust valve opens.

Process 4-1 à Exhaust gases go out (Heat rejection at constant volume). Pressure drops inside the engine cylinder up to atmospheric pressure.

Process 1- 0 à Piston moves from BDC to TDC. Exhaust of flue gases takes place at atmospheric pressure.

At Point 0 à Exhaust valve closes.

WORKING PRINCIPLE OF 2 – STROKE PETROL ENGINE:

In 2-stroke petrol engine one working cycle gets completed in 2-strokes of piston.

Upward Stroke: - As piston moves from BDC to TDC vacuum is created in the crank case chamber. Due to this vacuum air-petrol mixture will enter in the crankcase chamber through inlet port.

Up ward moving piston first covers transfer port and then covers outlet port. After that, air-petrol mixture entrapped in the combustion chamber will be compressed. At the end of upward stroke piston will be at TDC. At this point, sparking takes place. Petrol burns and burning gases expand applying thrust on the piston.

Downward Stroke: - Due to thrust of expanding gases piston moves from TDC to BDC. During this stroke the inlet port is covered by the piston and new charge is compressed in the crankcase. Further downward movement of the piston opens outlet port first; and high pressure burnt gases go out. Then transfer port opens and air-petrol mixture being compressed in the crankcase chamber, starts entering through the transfer port. This air-petrol mixture entering through transfer port strikes with the deflector on piston and rises upward and pushes out the remaining burnt gases. The cylinder is completely filled with the fresh charge, although it is some what diluted with the exhaust gases. Piston reaches BDC and again starts upward stroke.

In this way one working cycle is completed in 2-strokes piston or one revolution of crankshaft.

Note: - 1. Lubrication of engine components is performed by mixing lube oil in the petrol.

2. Due to no oil in the sump, there is no requirement of oil control rings in two stroke petrol engine.

WORKING PRINCIPLE OF 2 - STROKE DIESEL ENGINE: In a 2- stroke diesel engine one working cycle gets completed in 2- stroke of piston.

Upward Stroke: - As piston moves from BDC to TDC vacuum is created in the crank case chamber. Due to this vacuum, fresh air will enter in the crankcase chamber through inlet port.

Upward moving piston first covers transfer port and then covers outlet port. After that, fresh air entrapped in the combustion chamber will be compressed. At the end of upward stroke piston will be at TDC. At this point, diesel is injected through injector in the combustion chamber. Diesel burns and burning gases expand applying thrust on the piston.

Down Ward Stroke: - Due to thrust of expanding gases piston moves from TDC to BDC. During this stroke the inlet port is covered by the piston and fresh air is compressed in the crankcase. Further downward movement of the piston opens outlet port first; and high pressure burnt gases go out. Then transfer port opens and fresh air being compressed in the crankcase chamber, starts entering through the transfer port. This air entering through transfer port strikes with the deflector on piston and rises upward and pushes out the remaining burnt gases. The cylinder is completely filled with the fresh air, although it is some what diluted with the exhaust gases. Piston reaches BDC and again starts upward stroke.

In this way one working cycle is completed in 2-strokes piston or one revolution of crankshaft.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-10: Demonstration in I. C. engine model room.

---

1. Demonstration of: (a) 4-stroke diesel engine model.
   (b) 4-stroke petrol engine model.
   (c) 2-stroke diesel engine model
   (d) 2-stroke petrol engine model.

2. To note down the components name of:
   (a) 4-stroke diesel engine model.
   (b) 4-stroke petrol engine model.
   (c) 2-stroke diesel engine model
   (d) 2-stroke petrol engine model.

COMERICAL MOTOR FUEL: The following three grades of fuel are available in the market for automotive uses:-

1. Super premium grade fuel
2. Premium grade fuel
3. Regular grade fuel

The main constituents of hydro – carbons are hydrogen and oxygen. In our track machine mostly we have diesel engine in which diesel fuel is used.

Properties of high speed diesel:-

Boiling range: 180°c to 300°c
Specific gravity: 0.82 to 0.92
Calorific value: 50 MJ/ kg
Minimum cetane no.: 45

As an impurity in high speed diesel, approximately 1% sulphur is available. This is considered high as per international standard.

LPG: There are two types of LPG- 1. Propane and 2. Butane

A mixture of propane & butane is also used. Its heat energy is less (about 80%) than gasoline, but its high octane value compensates the thermal efficiency of the engine.

CNG: Its main constituents are methane (90 to 95%). A marginal quantity of propane, iso-butane and butane is found. It is stored in a cylinder at high pressure of about 200 bar. CNG is available in earths crust.

COMBUSTION: Combustion is a chemical action which produces heat and light. In an I.C. engine, chemical reaction takes place between fuel and air inside the cylinder. The fuel burns in the presence of air. Oxygen is essential for burning.

$H + O_2 \rightarrow H_2O$

$C + O_2 \rightarrow CO_2$ + Large amount of heat

For combustion of 1 liter of HSD 12,500 to 14,000 liter of fresh air at N.T.P. is required. If less air is available inside the engine cylinder, fuel will not burn completely and instead of carbon di- oxide carbon mono-oxide will be produced.

$C + O_2 \rightarrow 2CO$

Carbon mono-oxide is colorless, taste less and poisonous. It is to be noted that 15 parts of carbon mono-oxide in 10,000 parts of air is dangerous to breath. Higher CO concentration may cause quick paralysis and death. If sufficient air is not delivered to the cylinders the mixture becomes reach and unburnt hydrocarbon will come out with the exhaust gases. It also results in carbon deposits in the combustion chamber. Also engine will give black smoke and out put of engine will decrease. Dilution of lubricating oil will also take place. Wear and tear of engine also increases.

Combustion in C.I. engine may be divided into four stages:-

Stage 1: Ignition Delay: -

The time elapsed between the start of fuel injection and first appearance of flame is called ignition delay. It consists of physical delay (when the fuel atomized, vaporized, mixed with air and heated) and chemical delay (when the chemical reaction starts and accelerates so as to start a flame of measurable pressure rise).

Stage 2: Rapid and Un-Controlled Combustion:-

At the end of delay period high temperature of order of about 450°c to 550°c exists in the combustion chamber. Therefore once the combustion starts, it proceeds very fast due to presence of multiple ignition points. This stage starts at the ends of ignition delay and continues till the maximum pressure is reached.

Stage 3: Controlled Combustion:-

This is a stage of slow combustion and continues till the maximum temperature in the combustion chamber is reached. In this the rate of combustion depends primarily on the rate of mixing of fuel vapours with the air.

Stage 4: After Burning:-

This stage occurs during the expansion stroke. During this stage unused oxygen gradually decreases and mixture is diluted by the combustion products. This stage continues from the point of maximum cycle temperature to about 70° to 80° after TDC.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-12: Actual Working Cycle of 4-stroke diesel engine

---

ACTUAL WORKING CYCLE OF 4-STROKE DIESEL ENGINE

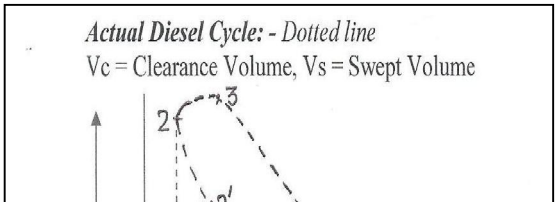
In a 4-stroke diesel engine, actual working cycle can be explained as given below:

Suction Stroke: Inlet valve opens five to ten degree of crank rotation before TDC in exhaust stroke and whenever piston moves from TDC to BDC, vacuum will be created inside the engine cylinder. Due to pressure difference, Fresh air will enter inside the engine cylinder at a pressure less than the atmospheric pressure. Inlet valve is closed 35^0 to 50^0 after BDC in compression stroke.

Compression Stroke: Whenever piston moves from BDC to TDC the air inside the engine cylinder gets compressed according to poly-tropic process. Pressure and temperature will increase and reaches above the burning point of fuel. Just before reaching the piston at TDC, diesel is injected by the injector inside the engine cylinder. Due to sufficient high temperature inside the engine cylinder the diesel catches fire and starts burning.

Power Stroke: Whenever fuel is injected inside the engine cylinder it burns due to high temperature and pressure of compressed air and converts into flue gases. These gases will expand inside the engine cylinder. This expansion of flue gases takes place according to poly-tropic process. Due to expansion of flue gases inside the engine cylinder, force is exerted on the piston and in this way power is generated. Piston moves from TDC to BDC.

Exhaust Stroke: In this stroke piston moves from BDC to TDC. Exhaust valve opens 35^0 to 50^0 before BDC in power stroke and pressure drops to about atmospheric pressure. A little force is exerted on the flue gases by the piston which further increases the pressure above the atmospheric pressure and flue gases are exhausted. Exhaust valve is closed approx. 5^0 to 10^0 after TDC in suction stroke.



From Graph:

Suction Stroke:
Before Point 0 à Inlet valve opens.
After Point 0 à Exhaust Valve closes.

Exhaust Stroke:
Process 1 -0 à Exhaust stroke at slightly more than atmospheric pressure
Before Point 0 à Exhaust valve closes

VALVE OVERLAP:-

At the end of exhaust stroke and start of suction stroke there is a certain time period during which inlet valve and exhaust valve both remains simultaneously open. This time period is called valve over lap.

Question: The stroke length of a cylinder is 152 mm and injection starts 18° before TDC. What will be the position of piston in respect to BDC?

ACTUAL WORKING CYCLE OF 4-STROKE PETROL ENGINE

In a 4-stroke petrol engine, actual working cycle can be explained as given below:

Suction Stroke: Inlet valve opens five to ten degree of crank rotation before TDC in exhaust stroke and whenever piston moves from TDC to BDC, vacuum will be created inside the engine cylinder. Due to pressure difference, fresh air and petrol mixture (charge) from carburetor will enter inside the engine cylinder at a pressure less than the atmospheric pressure. Inlet valve is closed 35^0 to 50^0 after BDC in compression stroke.

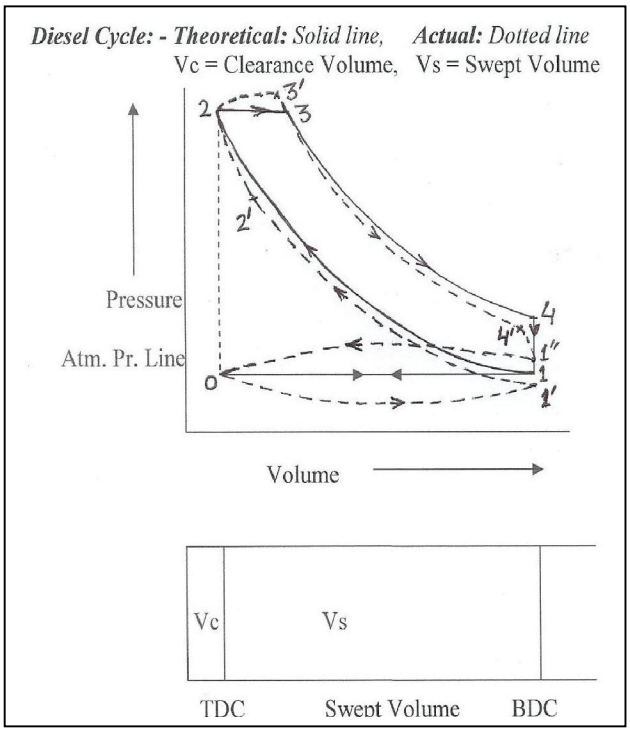
Compression Stroke: Whenever piston moves from BDC to TDC the fresh charge inside the engine cylinder gets compressed according to poly-tropic process. Pressure and temperature will increase. Just before reaching the piston at TDC, spark is produced by the spark plug inside the engine cylinder, by which the charge catches fire and starts burning.

Power Stroke: Burning charges convert into flue gases. These gases will expand inside the engine cylinder. This expansion of flue gases takes place according to poly-tropic process. Due to expansion of flue gases inside the engine cylinder, force is exerted on the piston and in this way power is generated. Piston moves from TDC to BDC.

Exhaust Stroke: In this stroke piston moves from BDC to TDC. Exhaust valve opens 35^0 to 50^0 before BDC in power stroke and pressure drops to about atmospheric pressure. A little force is exerted on the flue gases by the piston which further increases the pressure above the atmospheric pressure and flue gases are exhausted. Exhaust valve is closed approx. 5^0 to 10^0 after TDC in suction stroke.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-13: Deviations between actual Working Cycle & Theoretical Cycle

---



Deviations between theoretical & actual Working Cycle:

1. Theoretically inlet valve open at TDC in suction stroke. But actually it open 5^0 to 10^0 before TDC in exhaust stroke. Except MWM engine in which it open 1^0 after TDC in suction stroke.
2. Theoretically suction of air takes place at atmospheric pressure but actually it takes place at a pressure less than atmospheric pressure.

3. Theoretically inlet valve close at BDC in suction stroke. But actually it closes 35^0 to 50^0 after BDC in compression stroke.
4. Theoretically compression stroke takes place according to adiabatic process. But actually it takes place according to poly-tropic process.
5. Theoretically injection of fuel start at TDC in compression stroke, but actually it start approx. 14 to 18^0 before (some time 29^0 before) TDC in compression stroke.
6. Theoretically during burning of fuel (process 2-3) pressure remains constant, but actually pressure slightly increase.
7. Theoretically injection stops approx. 18^0 after TDC (Fuel cut off point) in power stroke, but actually injection stops at TDC in compression stroke.
8. Theoretically as soon as we inject the fuel, it burns but actually it takes some time to start burning after injection.
9. Theoretically expansion takes place according to adiabatic processes but actually it is according to poly-tropic process.
10. Theoretically exhaust valve opens at BDC in exhaust stroke but actually it open $35\text{-}50^0$ before BDC power stroke.
11. Theoretically it takes zero time to drop the pressure up to atmospheric pressure (Heat rejection at const. vol. process 4-1) but actually it takes some time.
12. Theoretically exhaust of fuel gases takes place at atmospheric pressure but actually it takes place at a pressure above the atmospheric pressure.
13. Theoretically exhaust valve closes at TDC in exhaust stroke. But actually it closes 5^0 to 10^0 after TDC in suction stroke. Except in MWM engine in which it closes 1^0 before TDC in exhaust stroke.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-14: Firing orders and VT diagram

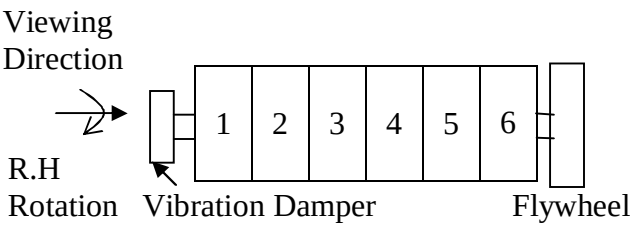
---

FIRING ORDER: - The sequence in which the power impulses occur in an engine is called the firing order. The firing order is selected as a part of the engine design to obtain the best engine performance.

(A) CUMMINS ENGINES

Cylinders are counted from vibration damper side. Direction of Rotation (DIR) is clockwise viewing from vibration damper side.

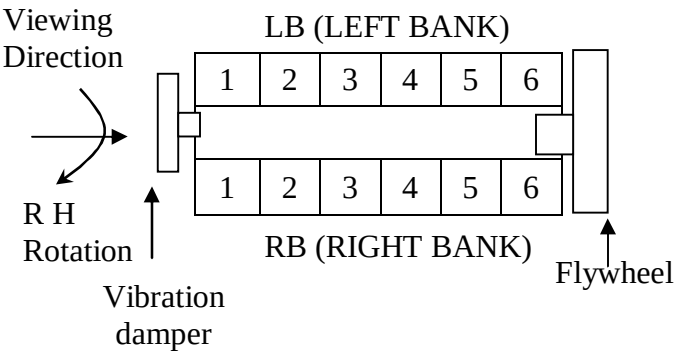
1. 6 Cylinder Engines



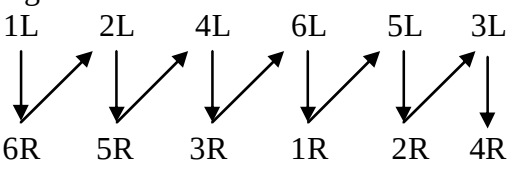
Firing Order:-

1 - 5 – 3 – 6 – 2 – 4

2. 12 Cylinder Engines



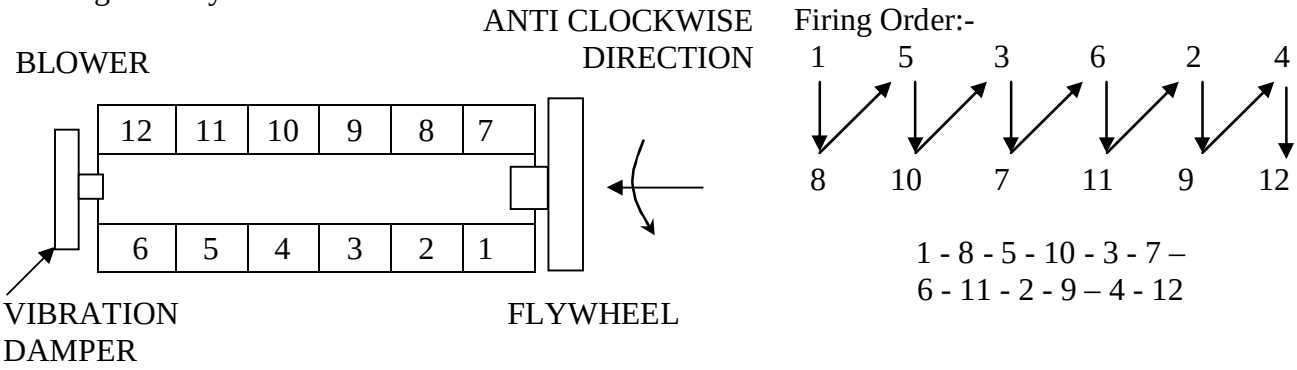
Firing Order:-



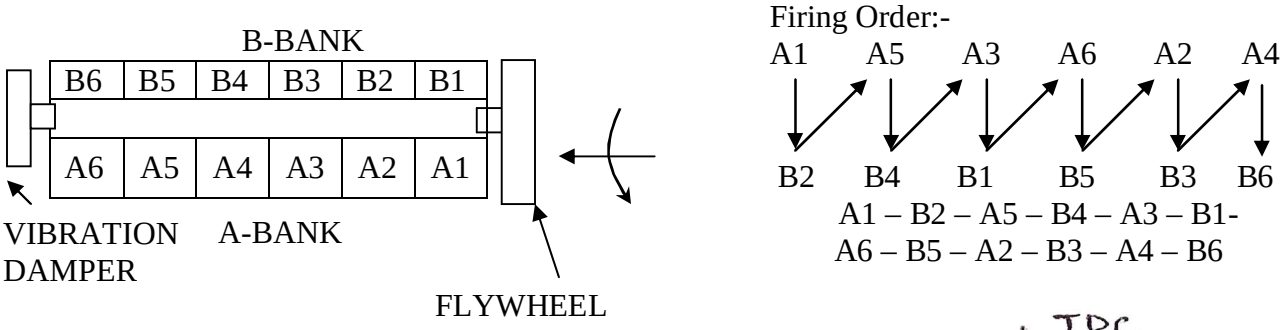
1L - 6R – 2L – 5R – 4L – 3R –
6L - 1R – 5L – 2R – 3L – 4R

(B) 12 CYLINDER DEUTZ ENGINE MODEL BF 12L 513 C (12 Cylinder Engines)

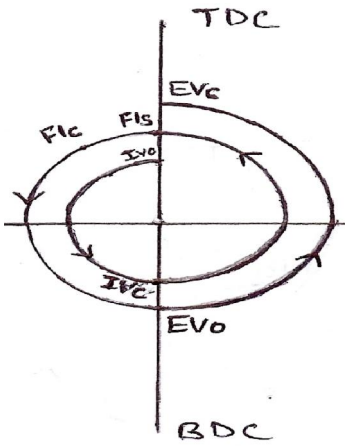
Cylinders are counted from flywheel side. Direction of Rotation (DIR) is anticlockwise viewing from flywheel side.



(C) MWM (GREAVES) ENGINE MODEL TBD 232/234 V 12 (12 Cylinder Engines)

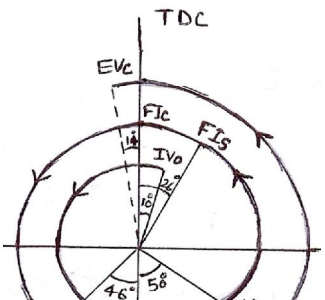


THEORITICAL VALVE TIMING DIAGRAM



Inlet Valve Opens (IVO) - at TDC
Inlet Valve Closes (IVC) - at BDC
Fuel Injection Starts (FIS) - at TDC
Fuel Injection Closes (FIC) - Some Degree after TDC
Exhaust Valve Opens (IVO) - at BDC
Exhaust Valve Closes (EVC) - at TDC

ACTUAL VALVE TIMING DIAGRAM OF ASHOK LEYLAND ALU – 680 ENGINES



Inlet Valve Opens (IVO) - 10^0 before BDC

Inlet Valve Closes (IVC) - 50^0 after BDC

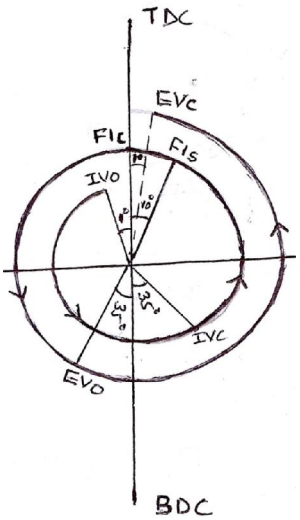
Fuel Injection Starts (FIS) - 26 ^{0} before TDC

Fuel Injection Closes (FIC) - At TDC

Exhaust Valve Opens (IVO) - 46 ^{0} before BDC

Exhaust Valve Closes (EVC) - 14^0 after TDC

ACTUAL VALVE TIMING DIGRAM OF MWM (GREAVES) ENGINE



Inlet Valve Opens (IVO) - 1^0 after TDC

Inlet Valve Closes (IVC) - 35^0 after BDC

Fuel Injection Closes (FIC) - At TDC

Exhaust Valve Opens (IVO) - 35^0 before BDC

Exhaust Valve Closes (EVC) - 1^0 before TDC

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-IV: Working Principle of I.C. Engine. Session-15: Power flow in Multi cylinder engine.

POWER FLOW IN MULTI CYLINDER ENGINE:

Multi cylinder engine runs smoother than single cylinder engine .The more cylinder in an engine the more continuous flow of power and more smoother will be its operation.

POWER FLOW CHART FOR 4 CYLINER ENGINE:-

In four stroke 4 cylinder engine, each power stroke begins at the end of previous power stroke. There is no over lap between power strokes in a four cylinder engine.

In a 4- cylinder engine number of cylinder = 4

Power flow gap = 720^0|4 =180^0

Crank rotation → / FIRING ORDER ↓	180^0			180^0			180^0			180^0		
	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}	60 ^{0}
1	P	P	P	E	E	E	S	S	S	C	C	C
3	C	C	C	P	P	P	E	E	E	S	S	S
4	S	S	S	C	C	C	P	P	P	E	E	E
2	S	E	E	S	S	S	C	C	C	P	P	P

POWER FLOW CHART FOR 6 CYLINER ENGINE:-

In a four stroke 6- cylinder engine number of cylinder = 6

Power flow gap = $720^0|6 = 120^0$

This provides a 60^0 power over lap between successive power strokes. It means that if a cylinder enters in the last 60^0 of its power stroke then the next cylinder as per firing order will enter in the first 60^0 of its power stroke.

Crank rotation → / FIRING ORDER ↓	180^0			180^0			180^0			180^0		
	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0	60^0
1	P	P	P	E	E	E	S	S	S	C	C	C
5	C	C	P	P	P	E	E	E	S	S	S	C
3	C	S	S	S	P	P	P	E	E	E	C	C
6	C	C	C	S	S	S	P	P	P	E	E	E
2	E	E	S	S	S	C	C	C	P	P	P	E
4	P	E	E	E	S	S	S	C	C	C	P	P

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-V: Air Supply system of Diesel Engine. Session-16: Requirement of Air, Types of Air cleaner.

REQUIREMENT OF AIR:

For Combustion of diesel inside the engine cylinders sufficient quantity of air should be available. For complete combustion of one liter HSD, 12,500 to 14000 liter fresh air at NTP is required. Only 22 – 23% O_2 is available in atmospheric air which is used for burning of fuel. If less air is available then burning of fuel will be incomplete and instead of CO_2, CO will form. To supply air of proper quality (dry, cool, clean & fresh) in sufficient quantity inside the engine cylinders is the function of air supply system.

Main components of the Air Supply System are as follows:

1. Air Cleaner
2. Hump Hose
3. Vacuum Indicator
4. Turbo Charger
5. After Cooler
6. Inlet Manifold
7. Exhaust Manifold
8. Silencer (Muffler)

AIR CLEANER:

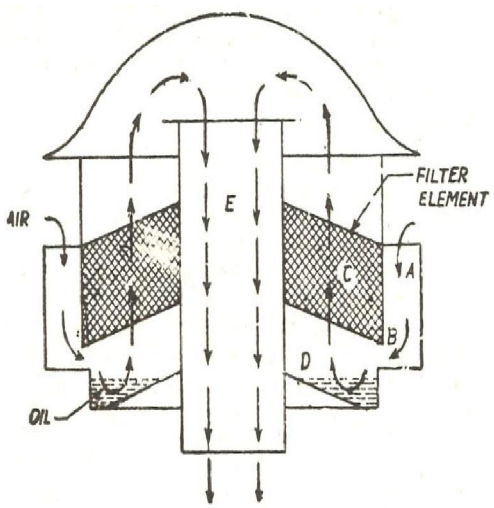
Air contains dust and dirt. If the air is not filtered before its entrance into the engine cylinders, the dust and dirt particles will seriously damage the engine. These dust and dirt will mix with the lubricating oil and form abrasive pastes, which will quickly wear the piston, rings, cylinder wall, bearings, valve guides and other relatively moving parts. This wear will cause high lubricating oil consumption, increased blow by and reduce engine components life. The purpose

of air cleaner is to remove these harm full dust and dirt particles from the air. It not only cleans the air but also muffles the noise resulting from air entrance to the inlet manifold and valve ports. It also arrests the flame in case the engine back fires.

TYPES OF AIR CLEANER: Two types of Air Cleaner

1. Oil bath type air cleaner
2. Dry (paper) type air cleaner

Oil Bath Type Air Cleaner: It is a heavy duty air cleaner. It consists of a wire-mesh filter element saturated with oil. At the bottom, there is an oil pan. the operation of air cleaning is carried out in two stages. In the first stage, the air strikes on the oil surface and then lift upward reveres into the filter element. The dust particles penetrate into the oil surface and get absorbed by it. In the second stage the partially cleaned air passes through the wire-mesh filter element, in which the remaining dust particles are retained.



Oil bath type air cleaner.

This type of air cleaner is cleaned periodically. The wire-mesh filter is removed, cleaned in petrol and dried by air. Oil in the pan is also replaced.

Dry Type Air Cleaner:

It consists of a specially pleated paper element over which a fine mesh screen is provided for strengthening. By placing the pleated element, a large filtering surface is provided and yet restriction to air flow is minimal. The element is enclosed in a silencing chamber.

The element should be cleaned periodically. With a dry type air cleaner, a filter restriction indicator (Vacuum Indicator) is often found mounted into the clean air side of the system. When an air cleaner is not chocked, it looks transparent and if becomes chocked then it will give red indication.

Pre-cleaner:

Pre-cleaner is fitted on the air cleaner to arrest the thick dust and soil particles. On the engine which work in very unsafe atmosphere (dusty atmosphere), Pre cleaners are essentially required. Pre-cleaner has screen which arrests the thick soil and straw. After filtering through the screen, the air enters in the pre-cleaner body and revolves by strips fitted on the angle. Due to revolving, thick dust and soil separates and settles down at the bottom. A glass bowl is fitted at the bottom of the pre-cleaner. The bowl is cleaned periodically after filling by dust.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-V: Air Supply system of Diesel Engine. Session-17: Cleaning and checking of dry type Air cleaner, Draw backs of choking of Air Cleaner.

CLEANING OF DRY TYPE AIR CLEANER:

1. Only outer element is cleaned and never clean inner element.
2. Air should be applied from inside to outside and not in reverse direction.
3. Pressure of air should be 3.5 bar to 4.5 bar.
4. Nozzle dia should not be less than 0.8mm
5. Nozzle should not come in touch with paper element. It should remain approx. 1" away.
6. Tapping of air cleaner on the rigid surface is not allowed.

CHECKING OF DRY TYPE AIR CLEANER:

1. Bring the air cleaner in dark room.
2. Glow a bulb of 100W inside the air cleaner.
3. Light rays should not come out through the side of air cleaner. It should work like a lamp shade; otherwise it is damage to be rejected.

DRAW-BACKS OF CHOCKING OF AIR CLEANER

Air cleaners are used to clean the air. If air cleaner is choked then following problems will arise:

1. Incomplete combustion of fuel

Fuel will not burn properly and instead of carbon-dioxide, carbon-monoxide will form and engine will give black smoke.

2. Dilution of Lubricating Oil:

As the fuel will not burn properly it will accumulate on piston. This accumulated fuel will leak through the piston rings and cylinder liner into the oil sump and mix with the lubricating oil causing dilution of it.

3. Increase Wear and Tear

Due to dilution of lubricating oil improper lubrication will take place and wear and tear of different engine parts increases.

4. Chocking of injector Holes

Due to un-burnt fuel and hence more carbon particles, injector holes may chock. Due to which the fuel cannot be injected in proper pattern.

5. Chocking of Silencer

Due to more carbon particles in exhaust, silencer also may choke.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-V: Air Supply system of Diesel Engine. Session-18: Supercharging, Turbocharger and after cooler, Importance of After cooling.

SUPER CHARGING: The process of supplying air to the engine cylinder above atmospheric pressure is called super charging. In a naturally aspirated engine, the piston-cylinder draws air equal to its stroke volume. The pressure inside the cylinder is less than the atmospheric pressure during the suction stroke. But in a supercharged engine, the air is forced into the cylinder at a pressure higher than atmospheric (at least 6 PSI).

TURBOCHARGER: Turbo charger is a device which is used to supply air inside the engine cylinders at more than atmospheric pressure. It is connected between air cleaner and inlet manifold. It is driven by the exhaust gases of the engine.

Construction and Working of Turbocharger: A turbo charger consists of a turbo wheel (turbine) and a centrifugal blower impeller (compressor wheel), separately enclosed in casings but mounted and rotating on a common shaft. It is mechanically independent of the engine except that its turbine is connected with exhaust manifold and the impeller with the after cooler or inlet manifold. The turbine portion should be made of heat resistance material.

The turbocharger is fitted between the air intake and exhaust system. Exhaust gases pass from the engine exhaust manifold to the turbine and rotates the wheel. The rotating motion of turbine is transferred through a common shaft to a compressor wheel. The compressor wheel then sucks air from the air cleaner and pushes it into the intake manifold under pressure. The actual pressure is measured in inches of mercury (Hg) and is dependant upon the engine, turbo design and power requirements.

Care: Turbo charger rotates by the exhaust gases at rpm of 1,25,000 to 1,40,000 approx. Bearing design and precise balancing of the whole rotating assembly are, therefore, of the greatest importance in ensuring a long useful life for the unit.

Turbo-compressor performance is sensitive to the presence of dirt and other harmful deposits. Special attention should be paid to air filtration when a turbocharger is fitted. Deposits should never be allowed to build up on the compressor as they would cause unbalance, and in most designs provision is made for cleaning the compressor without dismantling the turbocharger.

The main care with the turbocharger is that the engine should not be stopped at full rpm. Before stopping, it should be run 3 to 5 minutes at idle rpm. If we do not do so, the lubricating oil supply to the turbocharger shaft bearings stops with the engine stop, but the turbocharger shafts keeps on rotating for a considerable time at high rpm. Thus due to no lubrication, its bearings become red hot and the unit may get damaged. Also oil seal may get damaged due to overheating which will result in oil leakage to the impeller side.

Advantageous features of the turbocharger are:

1. By supplying more air more fuel can be injected for combustion inside the combustion chamber and therefore more power is obtained.
2. Better control over the air/fuel ratio at all engine speeds reduces the degree of smoke emission.
3. Having more air at lower speeds enables better fuel combustion and gives lower torque speeds.
4. A pressurized air manifold helps reduce combustion noise.
5. Turbocharger speed is controlled by the exhaust system and atmospheric back pressure. Engine working at high altitudes would normally suffer from lack of oxygen due to less air density. As the atmospheric pressure is less at altitude the back pressure in the exhaust system is less and the resistance to turbine shaft rotation is less. This results in the turbocharger shaft rotating at a faster speed forcing more air into the combustion chamber and thereby compensating for the lack of oxygen.

AFTER COOLER (INTERCOOLER): After cooler is a device, which is used to cool the air coming out from turbocharger before entering into the engine cylinders.

After cooler are of two types:

(i) Air to Air type – Used in Deutz Engine (BCM machine) model BF 12L 513C.

(ii) Air to water type – Used in MWM & Cummins engines.

IMPORTANCE OF AFTER COOLING: In turbocharged engine, air coming from the turbocharger gets heated due to which its density decreases. Due to increase in temperature the density of air will decrease which is not desirable. In we cool the air in after cooler before it enters in to the engine cylinder, the density will increase. For limited vol. inside the engine cylinder, we can supply more air inside due to which more fuel will burn and we get more power. In this way output of the engine will increase.

INLET MANIFOLD: The inlet manifold is used to carry air into the engine cylinders through inlet valves. It is made of Al or C.I and its inside surfaces are smooth, so that there should not be obstruction to the passing air. It is bolted with cylinder head with a gasket at each joint to prevent air leakage.

EXHAUST MANIFOLD: It is similar to inlet manifold. It is made of C.I. It is fitted with cylinder head with asbestos gasket in between them. It collects the exhaust gases from the cylinder and sends to the silencer (muffler).

SILECER (MUFFLER): Muffler is used

1. To reduce the noise of exhaust gases.
2. To reduce the temperature of the exhaust gases.
3. To trap the unburnt gases and burning gases.
4. To arrest spark.

Mufflers maintain some back pressure in the exhaust gases. This is necessary for the engine. At the start of suction stroke, Exhaust valves are open along with inlet valve for some time. If inlet gases have no restriction then they will enter rapidly and cool the exhaust valve very fast. Due to this rapid cooling exhaust valve may get bent. So this pressure is required to prevent the exhaust valve from rapid cooling.

Silencer Types: Straight Flow: In this silencer exhaust gases come out through the holes of a pipe and re-enter into the holes of another pipe and then go out.
Reverse Flow Type: In this type of silencer there are three or four segments connected by pipes with each other. These pipes are not in a line. Exhaust gases move forward and reverse inside the silencer.

Flexible Pipe: Exhaust manifold is connected with the engine and vibrates with it. Exhaust silencer is hanging with the chassis. A flexible pipe is fitted in between muffler and exhaust manifold to prevent the vibrations from reaching to the muffler.

Rain Cap: The engine in which exhaust pipe is fitted vertically; the rain drops may enter the cylinder head and combustion chamber through the pipe. If it is not prevented it will rust the valves and piston rings. In such engines rain cap is fitted over the exhaust pipe. If rain cap is damaged then exhaust pipe should be covered by a jar while the machine is stable.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)

Lesson-V: Air Supply system of Diesel Engine. Session-19: Demonstration in I. C. engine model room

---

1. To demonstrate the air system components: Dry type air filter, Wet type air filter, Turbocharger, Inlet manifold, After cooler, Exhaust manifold, Silencer (Muffler) etc.

2. To explain the working of turbocharger and its components.

3. To sketch the block diagram of air flow circuit.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine. Session-20: Functions and classification of Fuel supply system, Mico-Bosch fuel supply system, Block diagram.

FUNCTIONS OF FUEL SUPPLY SYSTEM

1. Storing of fuel.
2. Filtering the fuel
3. Delivering the fuel to pump
4. Injecting fuel into engine cylinder
5. Regulating the engine speed.

CLASSIFICATION OF FUEL SUPPLY SYSTEM

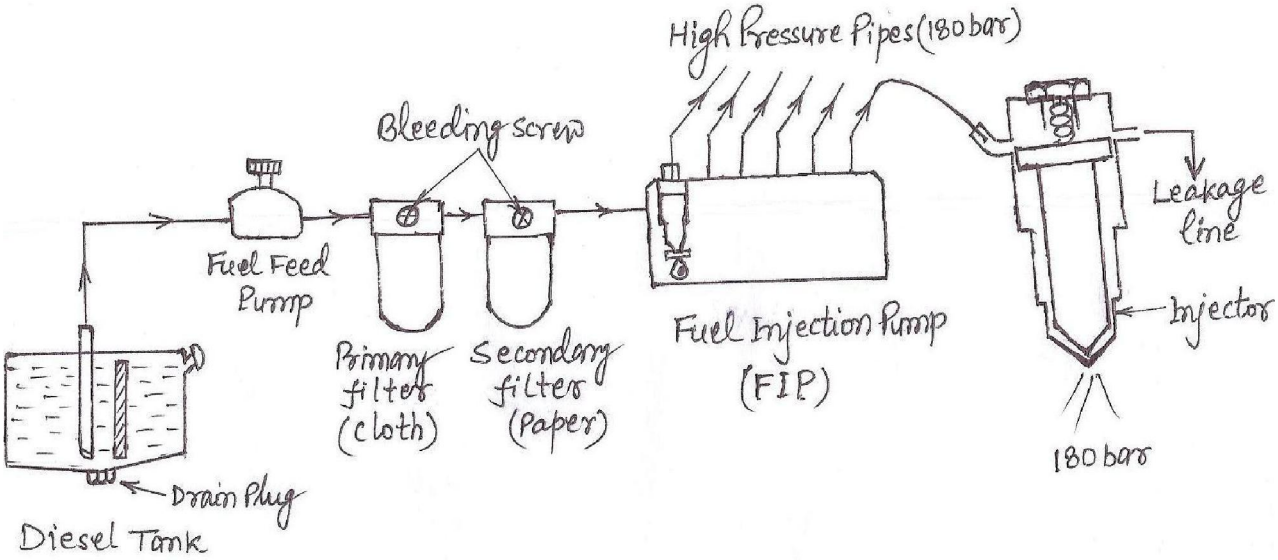
1. Air Injection System: In this system liquid fuel is injected with compressed air. This system is less reliable, less efficient and requires an air compressor. Due to this reason the system has become obsolete.
2. Solid Injection System: In this system only the liquid fuel is injected and there is no need of compressed air. There are two types of solid injection system in use:
a) Individual pump system (Mico-Bosch fuel supply system)
b) Common rail fuel injection system (Cummins P.T. fuel supply system)

a) **Individual Pump System (Mico-Bosch fuel supply system)**

Working Principle: In this system fuel is drawn from the tank by a fuel feed pump and send to the fuel injection pump through fuel filters. The fuel injection pump (FIP) will pressurize the fuel individually for each cylinder and send to the corresponding injectors through high pressure pipes. The high pressure fuel goes to the injector at the time of injection. The injector injects fuel at approx. 180 bar to the engine cylinder in atomized and vaporized form. Extra fuel is returned by the fuel injection pump to the diesel tank. Also a leakage line from the injector goes to the diesel tank.

The system contains following components:

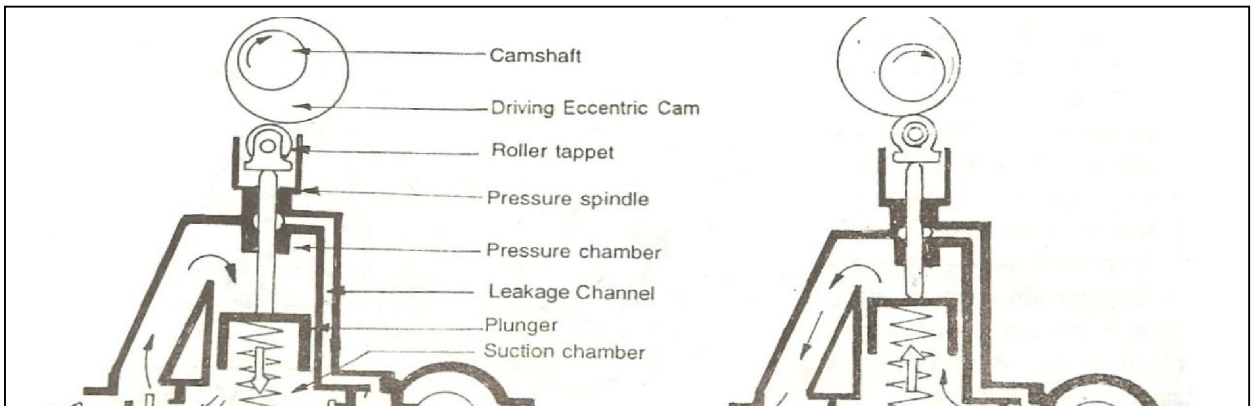
1. Diesel Tank
2. Fuel feed pump
3. Fuel filter
4. FIP
5. Injector
6. Leakage Line



SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine. Session-21: Fuel feed pump, Fuel filters, Fuel injection pump.

Fuel Feed Pump: Plunger type fuel feed pump is used in Mico-Bosch fuel system.

Working: There is a spring on the plunger of the pump. This spring forces the plunger against the tappet. There is an inlet and outlet valve. When plunger lifts due to spring force a vacuum is created in the suction chamber and diesel is sucked, simultaneously the diesel is forced out from the pressure chamber. When the tappet presses the plunger due to eccentric movement, the fuel is forced to the pressure chamber. In this way diesel is sucked from the tank and send to injection pump. If the tank level is lower than the engine level, this pump is used to suck the diesel from the tank and send to the fuel injection pump.

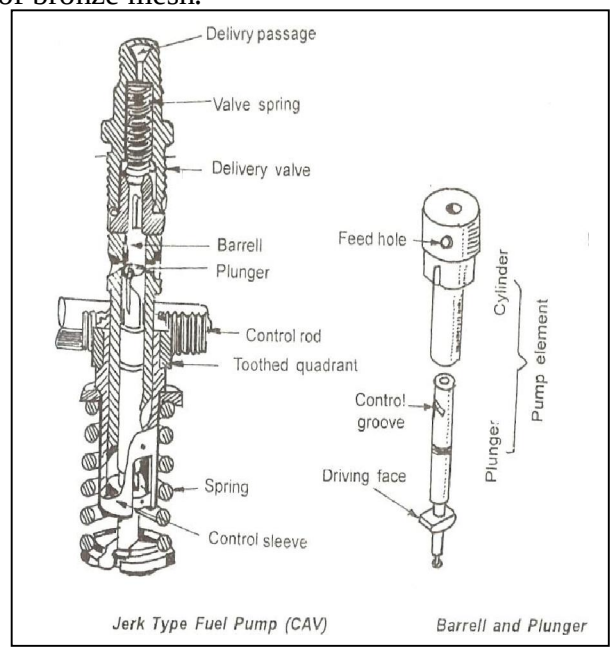


Fuel Filter: In Mico-Bosch fuel system mainly two filters are used.
a) Primary filter and b) Secondary filter

Primary filter is made up of felt or cloth and the secondary filter is made up of paper. In many cases a pre-filter is also used. This is made of bronze mesh.

Fuel Injection Pump:

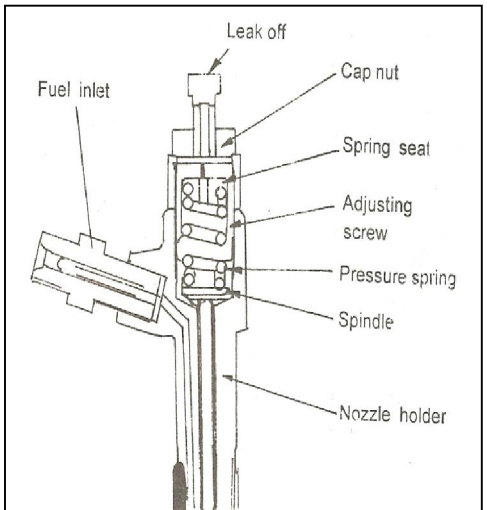
This is used in Mico-Bosch fuel system to build up a high pressure in fuel for injection. FIP also meters the correct quantity of fuel according to varying load and speed requirements and delivers it at the correct time to the engine cylinder. Injection sequence is produced in FIP. There are individual plungers driven by cams of a camshaft in the FIP. The plunger reciprocates in the barrel. The plunger has a rectangular vertical groove and helical groove. The delivery valve is lifted off its seat under the pressure of the fuel against the spring. The fuel from the delivery valve goes to injector.



When the plunger is at the bottom of its stroke the supply port and spill port are uncovered, the fuel from fuel feed pump after filtration is forced into the barrel. Now the plunger is pushed up by the cam movement and both the ports are closed. On further movement of plunger, the fuel above it is compressed which lifts the delivery valve and fuel goes to the injector. The plunger raises up still further and at a particular moment, the helical groove connects the fuel on the upper part of the plunger to the spill port. Consequently the fuel goes out and there is a sudden pressure drop due to which the delivery valve falls back on its seat under the spring force. Thus pressure in the delivery pipe drops and discharge from the injector gets cut off. The cycle is repeated again and again.

Injector:

The fuel injector is used to inject a small volume fuel in a fine spray to the combustion chamber. It consists of needle valve which is pressed on its seat in the nozzle by a spindle or plunger. The pressurized fuel enters in the injector body from the high pressure pipe. The fuel passes through drillings to a point just about the nozzle seat. The needle valve is lifted from its seat by pressure of the fuel and the injection takes place. When the injection pressure falls below the spring pressure the valve gets closed. This action sets of an oscillation in the valve which consequently



SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine. Session-22: Cummins P.T. Fuel Supply System, Block diagram, Difference between Mico-Bosch and Cummins P.T. Fuel Supply System.

---

b) Common rail fuel injection system (Cummins P.T. fuel supply system)

Operating Principle:

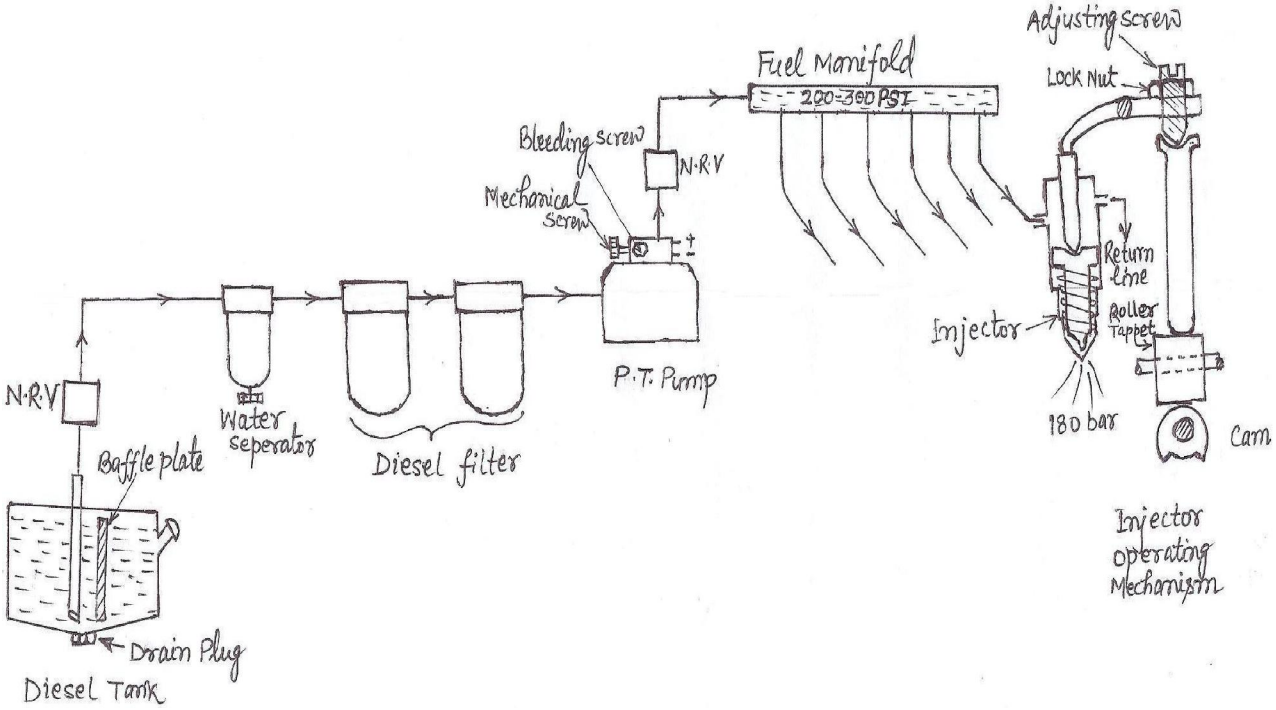
This system was designed by Cummins engineers for Cummins diesels. The identifying letter P.T. is abbreviation for 'Pressure-Time'. The operation is based on the principle that amount of fuel injected depends upon pressure of fuel and time available for the filling diesel into injector cup.

The PT pump is driven by cam shaft gear at crank shaft speed. The 'PT' pump draws fuel from the diesel tank through water separator and fuel fitter. The PT pump delivers fuel to the fuel manifold through shutdown valve at a pressure of 200 – 300 PSI. From fuel manifold, fuel goes to the injector and returns to the tank. The injector plunger is actuated by cam mechanism at the time of injection. Travel of plunger opens path for the diesel to the injector cup for a few degree rotation of cam shaft. Fuel pressure and the length of time the metering orifice is exposed to the fuel inlet, determines the quantity of fuel which fills in the injector cup. Then the cam

mechanism pushes down the injector, resulting in injection at the pressure of approximately 180 bar.

The Cummins PT Fuel system consists of following components.

1. Diesel Tank
2. Water separator
3. Fuel Filters
4. P.T. Pump
5. Fuel Manifold
6. Injector
7. Return Line



P.T. Pump:

Now, PTG Fuel pump is used. It is called a governor control pump because, governor assembly controls pressure regulation and engine RPM. Fuel flow through the P.T pump is as under:

The gear pump transfers fuel from the fuel tank through the filter screen into the pressure regulator plunger cavity. The fuel further divides into two directions:

a) By one path the fuel acts on the *pressure regulator by pass plunger* and returns to the gear pump suction.

b) In the second path the fuel flows through throttle, where it can proceed through two paths

i) Idle fuel path and ii) Manual controlled path

At idle speed, the manual controlled fuel path is closed and the fuel flows through the idle fuel path from the idle port in the governor. At intermediate speed and full speed fuel passes through both the paths. The PT pump governor exercises final control over engine speed. The fuel coming through throttle flows through the open shutdown valve to the fuel manifold.

Injector: The PT Injector performs to important functions:

i) It meters the right quantity of fuel into the injector cup.

ii) It injects the metered amount of fuel through the spray holes in the combustion chamber.

There are two types of Cummins injector. The flanged injectors are used in engines equipped with fuel manifold. The cylindrical injectors are used in engines, equipped with drilled fuel passages.

DIFFERENCE BETWEEN MICO BOSCH AND PT PUMP SYSTEM:

SL. No.	MICO BOSCH	CUMMINS PT PUMP SYSTEM
1.	Separate reciprocating pump(plunger and barrel type) is used for each engine cylinder.	A low pressure gear pump is used for all engine cylinders.
2.	Fuel injection pump will supply fuel to the injector only at that particular movement when the cylinder is ready to receive fuel.	Gear pump will continuously supply fuel to the injectors.
3.	As soon as the injector receives fuel, it injects into the engine cylinders.	Injectors receive fuel continuously, but it is injected at the particular moment, when the cylinder is ready to receive fuel. For remaining time it is returned back to the tank.
4.	Final fuel injection pressure is built in the fuel pump and injector only injects the fuel in the form of fine spray.	Injectors receives fuel at very low pressure (200-300 PSI) at which it is not possible to inject into the engine cylinder. The pressure of fuel is increased up to final injection pressure in injectors and it breaks the fuel in fine particles for injection. Hence the injector of Cummins PT fuel supply system is also called unit injector.
5.	The opening and closing of injector takes place by the high pressure of fuel to be injected.	The opening and closing of injector takes place in the same fashion as that of valves (inlet and outlet).
6.	No need to provide push rod and rocker arm for operation of injectors.	Push rod and rocker arm are provided for opening and closing of valves.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine. Session-23: Demonstration in I.C. Engine Model Room.

---

1. To demonstrate the components of Mico-Bosch fuel supply system.

2. To draw the fuel flow circuit of Mico-Bosch fuel supply system.

3. To demonstrate the components of Cummins PT fuel supply system.

4. To draw the fuel flow circuit of Cummins PT fuel supply system.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine. Session-24: Cetane number, Octane No., delay Period and Knocking of fuel.

CETANE NUMBER:

In a diesel fuel it is the percentage of Cetane in a mixture of Cetane and α-methyl Naphthalene, which has the same diesel knock characteristics as the fuel under test. Cetane number expresses the auto ignition quality of the diesel fuel. A fuel with shorter ignitions delay period will hare higher Cetane numbers and vice versa. Most diesel fuels have Cetane numbers from 40 to 50.

OCTANE NUMBER:

The octane no. of any fuel is the percentage of iso Octane by volume in the mixture of iso octane and normal heptane which gives the same anti knocks characteristics as the fuel under standard test conditions. There were given arbitrary values. Zero for normal heptane and 100 for iso octane.

IGNITION DELAY:
The time between the fuel injection in the combustion chamber and its actual burning is called the ignition delay or ignition lag.

KNOCKING OF FUEL:

Diesel Knock:
If delay is long, much larger quantity of the fuel is injected before the first droplets burn and this may result in too high rate of combustion, giving rise to very high rates of pressure rise and also higher peak pressures, causing a peculiar thudding sound, known as diesel knock.

Detonation:
Detonation is caused by the sudden instantaneous ignition of the unburnt charge, when the rise in temperature exceeds, the rate of heat dissipation, thus subjecting the un-burnt charge to the temperature and pressure sufficient to cause its ignition

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-VI: Fuel Supply system of Diesel Engine: Session-25: Draw backs of keeping low HSD Oil level in tank, removing of Air Lock.

DRAWBACKS OF LOW HSD OIL LEVEL IN DIESEL TANK:

If always we work with low HSD oil level in the tank then following problems will arise.

1. The water present in air of the vacant tank will condense at low temperature and will mix with lubricating substance of fuel. This mixing will form sludge (greasy mix of lubricating

substance and water) which is heavier than HSD oil due to presence of water. It will accumulate at the bottom of the tank and frequently cleaning of the tank will be required.

2. Some amount of these water particles will go into the engine cylinders along with fuel. There these will burn which will require heat energy for burning. The part of the heat energy which is to be converted into mechanical power will waste for burning of fuel resulting in decreased output of the engine.

3. Due to too much low oil level, air will enter into the fuel system due to which it becomes impossible to start the engine. Hence, air from the system is required to be removed. If air will enter into the system in block section then it takes about 15 -20 minutes to remove the air which is lost of the valuable working time.

4. Due to mixing of water particles with lubricating substance of fuel lubricating quality of fuel will decrease due to which rapid wear and tear of fuel pump and injectors takes place.

5. Down time of machine will increase as tank will require frequently cleaning.

REMOVING AIR LOCK:

If due to any reason air enters into the fuel system lines then it becomes impossible to start the engine. The air present in the fuel lines blocks the passage and the fuel can't be delivered to the engine cylinders. Air may enter into the engine cylinder due to low HSD oil level in the tank, when the machine negotiates over a curve and the level of HSD oil falls below the opening of suction pipe in the tank. It may also enter due to loose connections or any small hole in the fuel lines in between the tank and fuel pump.

Also the air may enter into the fuel supply system while changing the filters. This air is to be removed for proper functioning of fuel supply system. For removing the air from the fuel supply system, following method is adopted:

In Mico-Bosch fuel supply system –

1. Loose vent-screw provided on the body of the fuel filters and fuel injection pump.
2. Do hand priming by fuel feed pump hand operated lever.
3. Priming will be done till oil free form air bubbles starts to come through the first vent screw in the fuel flow direction.
4. As soon as the fuel free from air bubbles starts coming out through the first vent screw in the fuel flow direction, tighten the vent screw.
5. Repeat the step 3 & 4 for the remaining vent screws facing the fuel flow direction in sequence.

In this way air is removed from the system.

In Cummins P. T. fuel supply system

1. Loosen/ remove the bleeding screw provided on the shutdown valve.
2. Prime the engine by self starter to force out the entrapped air until the fuel free from air starts flowing trough the bleeding screw.
3. As soon as the fuel free from air bubbles starts coming out through the bleeding screw, tighten the screw.
4. Sometimes if it is suspected that fuel filter has become empty, it is filled by H.S.D. by loosing and taking out the output pipe and simultaneously loosing the input pipe for air removal. Then P.T. pump suction line is filled by H.S.D. and connection is restored to normal. Now steps 1, 2 and 3 are done.
5. Sometimes in place of priming the engine, P.T. pump suction line after filling by H.S.D. is blown by mouth to force out the entrapped air.

In this way air is removed from the system

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VII: Lubricating System of Diesel Engine. Session-26: Concept of lubrication and functions of lubricating oil, Properties of Lubricant.

CONCEPT OF LUBRICATION: Whenever two metallic surfaces move over each other, irregularities on the two surfaces interlock with each other due to which friction is produced. When metal surfaces are in direct contact to each other the friction produced in between them is called solid friction. When a film of lubricating oil is interposed between the two surfaces, the friction produced is called fluid friction. If the lubricants between the two surfaces do not cause complete separation, the friction produced is called boundary friction.

To supply lubricating oil between the moving parts is called lubrication and the system used is called lubrication system.

FUNCTIONS OF LUBRICATING OIL:-

1. To reduce friction between moving parts.
2. To reduce wear and tear of moving parts.
3. To provide cooling effect.
4. To provide cushioning effect. It absorbs shocks, between bearings and other moving parts.
5. To produce cleaning action, during its circulation.
6. To provide a sealing action. It helps the piston rings to maintain an effective sealing in the cylinder against high-pressure gases.

PROPERTIES OF LUBRICATING OIL:-

1.Viscosity: Viscosity means resistance of lubricating oil to flow. The viscosity of oil is specified as the time in seconds that it takes for a given amount of oil to flow by gravity through a standard size orifice at a given temperature. The viscosity of the oil varies inversely with temperature. The oil with minimum variation is preferred.

2.Flash Point: The lowest temperature at which the lube oil will flash when a small flame is passed across its surface is called flash point. The flash point of the oil should be sufficient high to avoid flashing of oil vapors at temperatures occurring in common use.

3.Pour Point: The minimum temperature at which the oil flow starts is called pour point. The oil cannot be used for lubrication below this temperature .So the pour point of the oil should be less than the lowest temperature encountered in the engine.

4.Corrosion Resistance: Corrosion means destruction of a solid body by chemical action. The oil should not have any tendency to corrode to engine parts.

5.Cleanliness: Lubricating oil must be clean. It should not contain any dust/dirt particles so that the crankcase and oil lines are kept clean.

6.Physical Stability: The lubricating oil must be stable physically at the lowest and highest temperatures prevailing in the engine.

7.Chemical Stability: At high temperatures the oil should remain chemically stable. There should not be any tendency for oxide formation. The oil should not decompose to form carbon particles.

8.Adhesiveness: The property due to which the oil particles stick with metal surfaces is called adhesiveness. Oil should have good adhesiveness.

9.Film Strength: It is the property due to which the oil retains a film between two surfaces even at high speed and temperature. The film between moving parts should not break.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VII: Lubricating System of Diesel Engine. Session-27: Oil Additives, Viscosity rating and lubricating circuit

---

LUBE OIL ADDITIVES: -

Additives are mixed in the oil to impart those desired properties. These additives are as follows: -

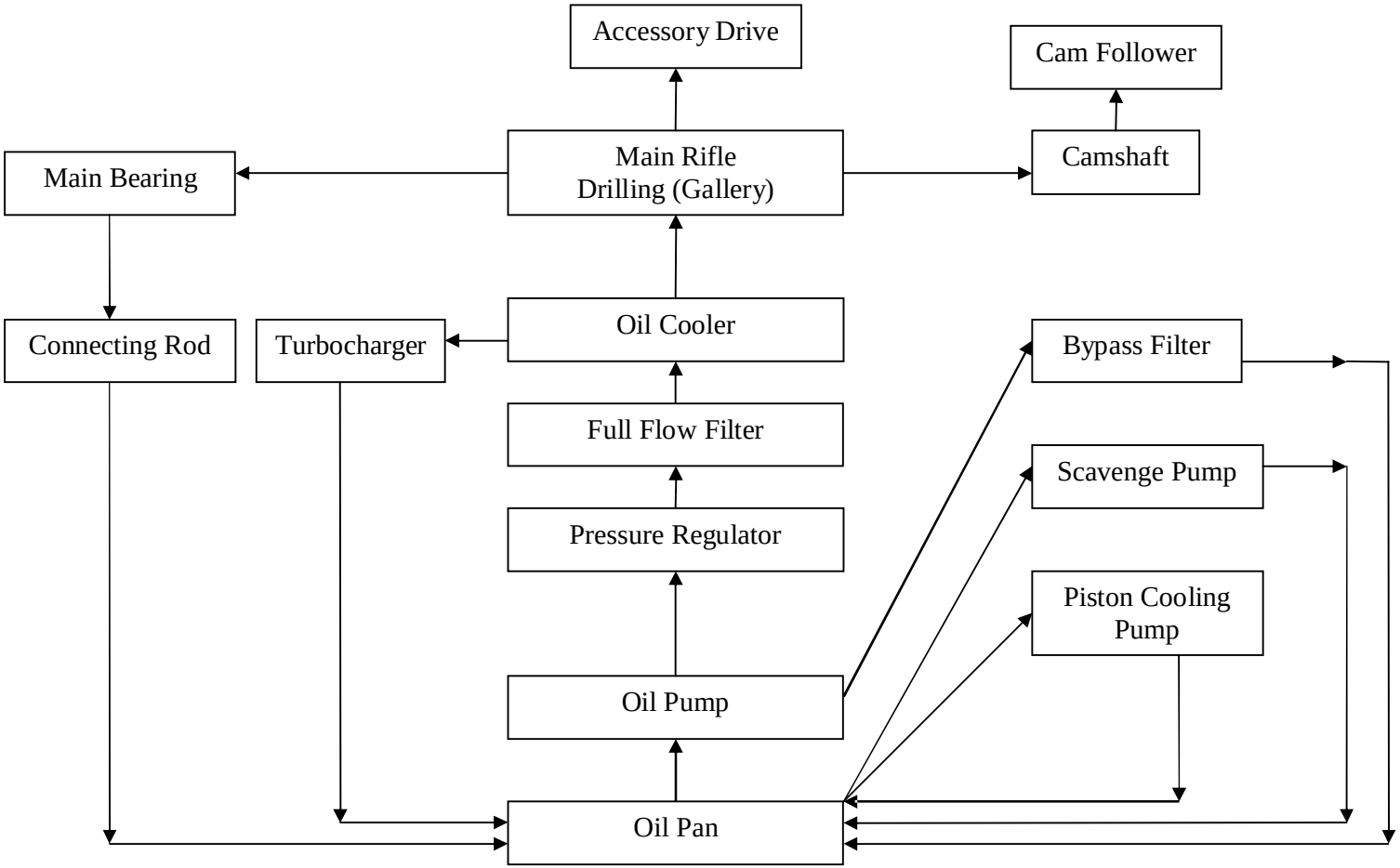
1. Viscosity-index improver: - To maintain a more uniform viscosity over the wide range of operating temperatures.
2. Pour point depressant: - To reduce the pour point of the oil.
3. Oxidation inhibitors: - To reduce oxidation of the oil caused by high temperatures.
4. Corrosion inhibitors: - To inhibit corrosion due to the formation of acid at high temperatures.
5. Anti Rust: - To prevent rust formation on internal parts during shutdown periods.
6. Antifoam: - To control foaming and prevent air bubbles from entering the oil pump.
7. Detergent/Dispersants: - To prevent the formation of deposits of Carbon, gum and dirt, detergent additives are used. Like ordinary hand soap, it losses and detach the deposits. The oil then carries the loosened material away. The larger particles drop to the bottom of the crankcase, but smaller particles tend to remain suspended in the oil. These impurities are flushed out when the oil is changed.
A dispersant is added to the oil to prevent the particles from clotting, and to keep them in finely divided state. Without dispersant, the small particles will tend to form large particles which might block the oil filter and passages.
8. Extreme pressure additives: - Lubricating oil may be subjected to very high pressures in bearings and valve trains. To prevent the oil from squeezing out, extreme pressure additives are put into the oil. They react chemically with metal surfaces to form very strong, thin and slippery film. Thus they help the oil by providing protection during moments of extreme pressure.

Viscosity rating (SAE NUMBER) :
SAE stands for "Society of Automotive Engineers". The oils which are used for winter have suffix 'W' (Ex.- SAE 15 W) and their viscosity test is made at 0° Fahrenheit (-18° Celsius). The oils without suffix 'W' (Ex. - SAE 40) are used for summer and their viscosity test is made at 210° Fahrenheit (99˚C).
These day's multigrade oils are available. These oils undergo minimum change in viscosity with temperature.
Example: SAE 15 W 40: This oil has the same viscosity as SAE 15W at 0˚F and as SAE 40 at 210˚F.

SAE No.	Viscosity at 0˚F (Say bolt-seconds)	Viscosity at 210˚F (Say bolt-seconds)
10 W	12″	-
20 W	48″	-

20	-	45″ to 58″
30	-	58″ to70″

Oil grade	**Temperature range**
15 W 40	-10˚C and above
20 W 40	0˚C and above



LUBRICATING CIRCUIT (Lubricating oil flow schematic)

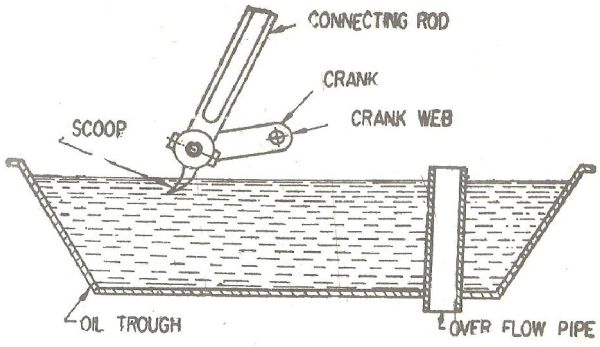
DIFFERENT TYPES OF LUBRICATING SYSTEMS:-

1. Petroil system
2. Splash system
3. Pressure system
4. Semi pressure system
5. Dry sump system

1. Petroil System: In this system lubricating oil is mixed into the petrol, while filling in the petrol tank. When the fuel goes into the crank chamber during the engine operation, the oil particles go deep in to the bearing surfaces and lubricate them. The cylinder wall, piston rings, piston pin and crankshaft are lubricated in the same way. This system is adapted in 2-stroke petrol engine.

2. Splash System:

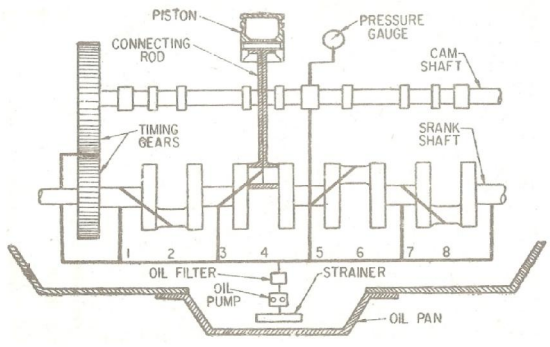
In this system oil is stored in a sump. A scoop is made in the lowest part of the connecting rod. When the engine runs the scoop dips in the oil once in every revolution of crankshaft and causes the oil to splash on the cylinder walls. This action effects the lubrication of cylinder



4. Semi Pressure System: It is the combination of splash system and pressure system. Some parts are lubricated by splash system and some parts are lubricated by pressure system.
5. Dry Sump System: In this system the oil is stored in a separate tank from where it is fed to the engine. This system is used in aircrafts because its engine position keeps on changing.

3. Pressure Lubricating System:

In this system engine parts are lubricated under pressure feed. Lube oil is stored in a sump. Oil pump draws oil through a strainer and delivers it to the main gallery through a filter at a pressure of 1.0Kg/cm^2 – 4.0 Kg/cm^2. The oil from the main gallery goes to the main bearings. After lubricating them, some of the oil falls back to the sump, some is splashed to lubricate cylinder walls and the remaining goes through a drilled hole to the crankpins. From crankpin it goes to the piston pin through a hole in the connecting rod web, where it lubricates the piston rings



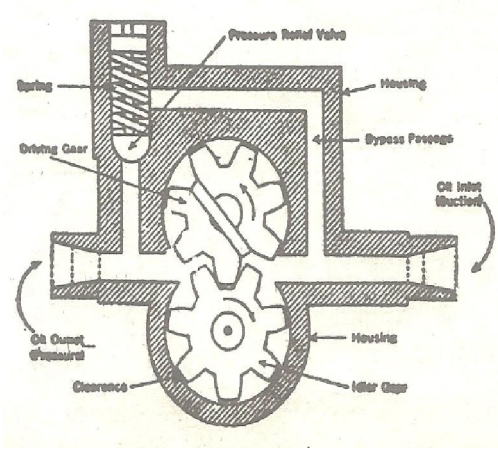
A separate oil line goes from the oil gallery for lubrication of camshaft and timing gears. The valve tappets are lubricated through a hole from the main gallery to the tappet guide surfaces. An oil pressure gauge at the panel indicates the oil pressure in the system.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VII: Lubricating System of Diesel Engine. Session-29: Oil pump, Relief Valve, Filters, Oil Cooler, Strainer, Oil Pressure Gauge, Oil Pressure Indicating Light

PARTS OF LUBRICATING SYSTEM

1. Oil Sump: Oil sump is the bottom most part of the crank chamber. It provides a covering for the crankshaft and stores oil in it. It contains a drain plug at its bottom to drain out the oil.
2. Strainer: Oil strainer is simply a wire mesh screen. It is attached to the inlet of the oil pump. The strainer retains dirt or grit in the oil.
3. Oil Pump: It supplies oil under pressure to the engine parts for lubrication. It is generally located out side the crankcase. Different types of the oil pumps used for engine lubrication are as follows: - 1. Gear pump 2. Plungers pump 3. Rotors pump 4. Vane pump.

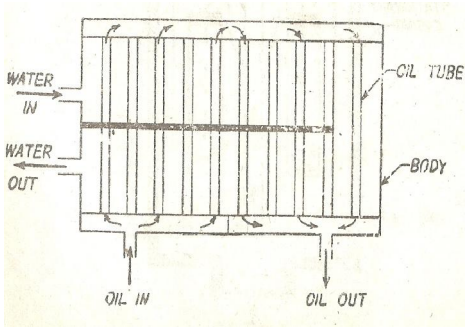
Gear Pump: It consists of two meshed spur gears enclosed in housing. There is very little clearance between the gear teeth and housing. One gear is drive gear getting power through its shaft from camshaft or crankshaft. The other gear is free to revolve on its own bearing. When the pump is in action, the oil enters between the gear teeth from the inlet side, carried around between the gears and pump housing and forced out through the outlet side.



This type of pump is used almost universally due to simplicity in construction. It can deliver oil at a pressure about 1.0 – 4.0 Kg/cm^2. A pressure **relief valve** is also provided in many oil pumps to relieve the excess pressure.

4. Oil Filter: Oil filter is used to filter out the dirt/grit particles from the engine oil. There are two types of lube oil filters: i) Full flow type and ii) Super bypass type
5. Oil Cooler: Oil cooler is provided to cool the lube oil in heavy-duty engines, where oil temperature becomes quite high. The viscosity of oil decreases with the temperature raise and oil film may break at high temperature.

The oil may be cooled either by cold water or by air stream. Water type oil cooler contains tubes in which oil circulates. The water circulates out side the tubes in the casing of the cooler. The heat of the oil is carried away by the circulating water. In air type cooler there are fins around the tubes to increase the cooling surface area. Air stream passes around the tubes and takes away the heat from the tubes and fins.



6. Oil Level Indicator: The level of the oil in the sump is checked by a dipstick. Before starting the engine, oil level should be checked. The oil level should be between "H" and "L" mark of the dipstick.
7. Oil Pressure Gauge: Oil pressure gauge indicates the oil pressure during engine operation. Normally one electrical type oil pressure gauge is fitted on the driving panel and another mechanical type oil pressure gauge is fitted near the engine at instrument panel.
8. Oil Pressure Indicating Light: There is an oil pressure indicating light (Red LED/ Yellow LED) provided at the driving panel. This light glows when oil pressure becomes down from the minimum setting. It gives warning about decreased oil pressure.
Oil Pressure Rating: -1. At idle speed: - Min. 1.5 kg/cm^2 2. At rated speed: - Min 2.5 kg/cm^2.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VII: Lubricating System of Diesel Engine. Session-30: Blow bye, Crankcase ventilation, Reasons for low lubricating oil pressure and high oil consumption

---

BLOW BYE: - The escaping of burnt gases (combustion products) from combustion chambers to the crank case chamber through cylinder walls is known as blow bye.

CRANKCASE VENTILATION

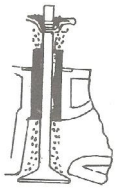
The products of combustion contain manly nitrogen, water and carbon dioxide. Sulphuric acid may also be present due to sulphur content in the fuel. The product of combustion may leak into the crankcase. The crankcase ventilation removes all these unwanted gases and sulphuric acid particles. It prevents the lubricating oil from being dilute and corrosion of crankcase metals due to acid formation.

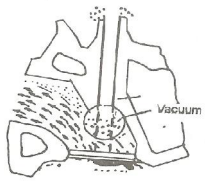
REASONS FOR LOW LUBRICATING OIL PRESSURE

1. Less oil in the sump.
2. Loose connections in the oil lines.
3. Too weak relief valve spring.
4. Excessive clearance in the bearing due to which oil may leak rapidly from bearing ends.
5. Oil filter may be clogged.
6. Oil pump may be worn.
7. Faulty pressure gauge.

REASONS FOR HIGH LUBE OIL CONSUMPTION

1. Loose connections in oil filter lines.
2. Worn oil seal at front or rear main bearings.
3. Worn rear oil seal of camshaft.
4. Broken or improperly installed oil pan, valve cover and timing gear cover gaskets.
5. Cylinder and head distortion due to improper tightening of the cylinder head bolts.
6. Worn out oil control rings.
7. Out of round cylinders.
8. Loose bearings.
9. Excessive clearance in intake valve guides.
10. Excessive oil pressure.
11. Clogged oil breather.
12. High speed and high temperatures of engine, which reduces oil viscosity causing more oil flow. Hence more oil leaks and more oil burns.





PRECAUTIONS WHILE CHANGING LUBRICATING OIL

1. Oil should be drained when engine is hot. In hot condition, oil becomes thin and flows easily resulting in complete drain.
2. Drain plug should be kept open for sufficient time to ensure complete drain.
3. Lube oil filters and filter sealing rings also should be replaced with oil change.
4. Oil grade to be replaced should be same. If oil grade/brand is different, flushing of engine should be done with same new oil.
5. Before filling oil, drain plug should be tightened.
6. Oil level should be kept at ‘H’ mark of dipstick.
7. Filter-cane should be filled with new oil.
8. After running of engine for few minutes, stop the engine and after 30 minutes, oil level should be checked and toped up.
9. Oil leakage should be checked and made fit.
10. If centrifuge is provided in the lube oil system (MWM, Deutz engines), it should be cleaned.
11. Torn the filter paper and check for any metal particles.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VII: Lubricating System of Diesel Engine. Session-31: Demonstration in I.C. Engine Model Room

---

1. To Demonstrate lubricating system components such as
    1. Strainer
    2. Oil pump
    3. Relief valve
    4. Inline Lube Oil filters
    5. Super bypass filter
    6. Oil Cooler etc.

2. To demonstrate lube oil flow circuit.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VIII: Cooling System of Diesel Engine. Session-32: Necessity of Cooling, Different methods of Engine Cooling, Air Cooling System.

Necessity of Cooling:-

During combustion of air-fuel mixture, enormous amount of heat is produced and the temperature of burning gases may be reached up to 2500˚c. The temperature is so high that it will cause: - a) Pre-ignition of the charge,

b) Break the lubricating film between the moving parts,

c) Weld the moving parts or

d) Any mechanical breakage of the engine parts.

So this temperature must be reduced to 200˚c -250˚c, at which the engine my work efficiently. However, too much reduction in temperature will lower thermal efficiency of the engine .Thus the purpose of the cooling system is to keep the engine at its most efficient operating temperature at all engine speeds and driving conditions.

The cooling system is so designed that it prevents cooling until the engine reaches to its normal operating temperature. When the engine warms up, the cooling system begins to function. It cools rapidly when the engine is to hot, and it cools slowly or not at all when the engine is cool or is warming up. Engines are designed to operate in a definite temperature range which will ensure correct clearances between parts, promote vaporization of the fuel, keep the oil at its best viscosity and prevent the condensation of harmful vapours.

DIFFERENT METHODS OF ENGINE COOLING:- The following methods are mainly employed for engine cooling: 1. Air cooling 2. Water cooling

AIR COOLING SYSTEM:- In this method, heat is dissipated directly to the air after being conducted through the cylinder walls. Fins and flanges on the outer surfaces of the cylinders and heads serve to increase the area exposed to the cooling air, and so raise the rate of cooling.

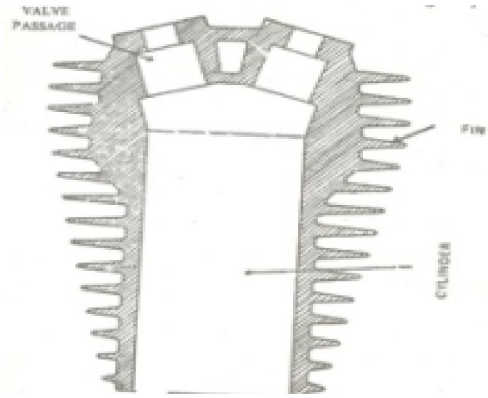
Advantages of air cooling:-

1. Lighter in weight due to absence of radiator, cooling jackets, and coolant.
2. No topping up the cooling system.
3. No leaks to guard against.
4. Antifreeze, corrosion resistance not required.
5. Engine warms up faster than the water –cooled engines.
6. Can be used in areas where there is scarcity of water.

Disadvantages: -

1. Less efficient cooling, because co-efficient of heat transfer for air is less than that of water.
2. Not easy to maintain even cooling all around the cylinder, distortion of the cylinder may take place.
3. More noisy operation.
4. It can be used only where the cylinders are exposed to air stream

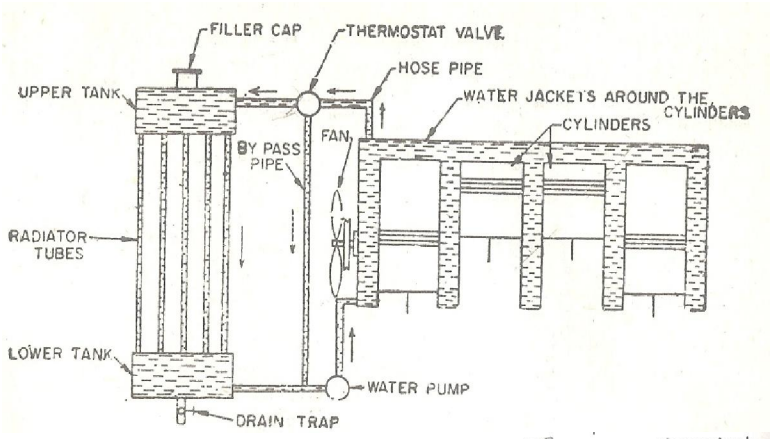
Cooling fins: The fins are usually made of about the cylinder wall thickness at their routes, tampering down to about one –half the root thickness. The length of fins varies from one quarter to one third of the cylinder diameter. The distance between the two fins centers is about one-quarter to one third of their length. The total length of finned cylinder barrel is from 1 to 1.5 times the cylinder bore. Another experimental consideration is to allow 1,400 to 2400 cm^2 of cooling fins area per horse-power.



2. WATER COOLING SYSTEM: - In this method water is circulated through water jackets around each of the combustion chambers, cylinders, valve seat and valve stems. The circulating water, when passes through the engine jackets in the block and cylinder head, takes heat of the combustion. When it passes through the radiator, it is cooled by air drawn through the radiator by a fan and by air flow developed by the forward motion of the vehicle. After passing through the radiator, the water again goes in the engine jackets. The normal operating water temperature of the engine should be 71°c to 88°c, but the most suitable temperature is assumed to be 82°c for water cooled engines.

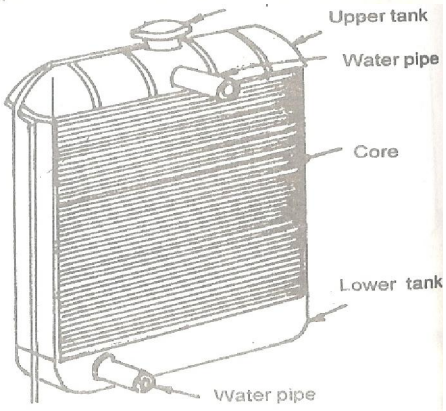
Components of the water cooling method: -

1. Radiator
2. Water Pump
3. Water Manifolds
4. Water jackets
5. Thermostat
6. Fan
7. Temperature indicator.



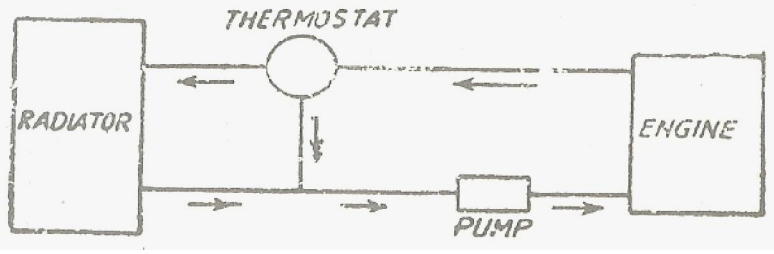
1. Radiator: -

Radiator is device to provide large amount of cooling surface to the large amount of air, so that the water circulating through it is cooled efficiently. It consist of an upper tank and a lower tank and between them a series of tubes. The upper tank is connected to the water outlets from the engine jacket by a hose pipe, and the lower tank is connected to the jacket inlet through the water pump. Water passes through the tubes. Fins are placed around the tubes to improve heat transfer. Air passes around the tubes, between the fins, absorbing heat from the water. If any tube is clogged the cooling effect of the tube is lost.



Radiator is usually made of copper and brass because of their high heat conductivity. The various sections of the radiator are almost completely joined together by soldering.

2. Thermostat: - Thermostat valve is used to regulate the circulation of water in system to maintain the normal working temperature of the engine parts. The thermostat valve automatically works in the cooling system. When the engine is started from cold, the thermostat valve prevents the flow of water from engine to radiator, so that the engine readily reaches to its normal working temperature. Generally it starts opening and allowing water to the radiator at 74 degree centigrade and opens completely and allows whole water through the radiator at 85° centigrade.



Thermostat works on the principle- a heat unit operating a valve.

Wax- element thermostat: -
A copper cover is filled with wax and sealed. When temperature rises, the wax expands and operates the valve. When temperature reduces wax contracts and spring closes the valve.

3. Water pump: - A pump is used to increase the velocity of the circulating water. An impeller type pump is fitted between the cylinder block and radiator. Pump is driven by the engine by a belt or gears. The impeller shaft is supported on one or more bearings. A seal prevents water from leaking out around the bearings.

4. Fan: - A fan is mounted behind the radiator. It is either fitted on the water pump shaft or separately driven by belts or hydraulic motors. The fan draws air through the radiator for cooling.

5. Water jackets: - Water jackets are cast into the cylinder blocks and heads. Jackets are the passages through which water circulates around the cylinders, valve ports and seats, combustion chambers and any other hot parts that require cooling.

6. Temperature Gauge: - A temperature gauge is mounted on the instrument panel. There are two types of temperature indicators:-

1. Mechanical type.
2. Electrical type.

Closed system: - The circulation of water is closed in the system under pressure. The boiling point of the water is raised by keeping it under pressure. A relief valve is provided in radiator filler cap to prevent excessive pressure causing leaks. A vacuum valve is also provided in the cap to admit air when the pressure in the system falls below that of the atmosphere due to the condensation of steam vapours on cooling.

The relief valve is generally set to open at pressure of 0.55 to 1.10 kg/cm^2. A 1.10 kg/cm^2 valve would provide a boiling point of about 125 degree Celsius. By raising the boiling point of the coolant, the cooling capacity of the system is raised.

Corrosion inhibitor: - A corrosion inhibitor should be used in the cooling system to prevent the formation of rust and scale. Nalcool-2000 is used in MWM (Greaves) engines and coolant additive concentrate (CAC) is used in Cummins engines as a corrosion inhibitor. The water and corrosion inhibitor ratio by volume is 30:1 for Nalcool-2000 and 15:1 for Coolant additive concentrate. Also premixed coolant is available for top-up in Cummins engines.

As much as possible distilled water should be used for cooling. Clean tap-water also may be used. But water from rivers, canals etc, which are mostly dirty, should not be used.

Draining cooling system: - A drain plug is provided at the bottom of the radiator and also a drain plug is provided on the right side of the cylinder block. Remove the radiator cap to break any vacuum that may have developed.

Note: - If the coolant is lost from the system and the engine becomes overheated, do not refill the system immediately. Allow the engine to cool or refill slowly while the engine is running, otherwise there is danger of cracking the cylinder block and head.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-VIII: Cooling System of Diesel Engine. Session-34: Drawbacks of overcooling and reasons for overheating

---

Troubles of cooling system: -

1. Loss of coolant due to leaks: - External leaks may be noted by inspection. Internal leaks are caused by faulty head gasket, loose cylinder head, cracked head or engine block.

Internal leak will rise the lubricating oil level in the oil pan. It may also produce clouds of white vapor in the exhaust gases.

2. Over heating:- It is caused by insufficient quantity of water in the cooling system, clogged radiator and water passages, belt slippage, inoperative thermostat, late ignition timing, incorrect valve timing, pre-ignition, too tight bearings, too low engine oil level, clogged exhaust system etc.

3. Over cooling: - An engine running below the normal operating temperature range is called over cooled. It is caused by a thermostat that opens too soon or remains open at al times.

The temperature gauge also may be faulty to give incorrect reading. If it is faulty, it should be replaced.

Noises: - Noises in the cooling system may occur due to dry bearings, a loose pulley on the pump or fan shaft, an impeller loose on the shaft or too much end play in the shaft.

DRAW BACKS OH OVER COOLING:-

1. Thermal efficiency is decreased because more heat losses through the cylinder walls.
2. Combustion efficiency is decreased due to poor vaporization of fuel which results in loss of power and black smoke.
3. Mechanical efficiency is decreased because viscosity of lub. Oil increases and hence more piston friction is encountered.
4. Engine runs noisy due to excess clearance between moving parts.
5. Lube oil is diluted because incomplete burnt fuel escapes through the cylinder walls to the sump.
6. Sludge develops in sump.

Though more cooling improves volumetric efficiency, but the overall efficiency is decreased.

SUMMARY OF COOLING SYSTEM TROUBLES:

Troubles	**Possible causes**
1. external leakage	a) Loose hose clips. b) Defective rubber hose. c) Damaged radiator seams. d) Loose core plugs. e) Damaged gaskets. f) Leak at the water temperature gauge.
2. Internal leakage	a) Defective cylinder head gasket. b) Cracked cylinder wall. c) Loose cylinder head bolt.
3. Poor circulation	a) Restriction in system. b) Insufficient coolant c) Inoperative water pump. d) Loose fan belt. e) Inoperative thermostat.

4. **OVER HEATING**	**a) Poor circulation due to any reason.** **b) Thermostat doesn't opens properly.** **c) Dirty oil sludge in the engine.** **d) Low lube oil level.** **e) Lube oil too thick. Low lube oil level.** **f) Lube oil too thick.** **g) Radiator fins chocked.** **h) Incorrect ignition timing.** **i) Incorrect valve timing** **j) Tight bearing.** **k) Clogged exhaust system.** **l) Dragging brakes.**
5. Over cooling	a) Defective thermostat. b) Faulty temperature gauge.
6. Corrosion	a) Excessive impurity in water. b) Incorrect quality / quantity of corrosion resistant additive.

For coolant to be used on Cummins Engines: pH value- 8.5 to 10.5

For coolant to be used on MWM Engines: pH value- 8.0 to 10.0

1. To demonstrate Air Cooling System components.
2. To demonstrate Water Cooling System components.
3. To study working of Thermostat.
4. To draw water flow circuit of the model engine.

MAINTENANCE SCHEDULES OF CUMMINS ENGINE (KTA 1150-L AND NTA 855-L) AS PER 09-3X CSM OF RDSO

SCHEDULE – I (TO BE DONE DAILY)

(i) Check the engine oil level for both engines and top up if required.
(ii) Check coolant level in radiator for both engines.
(iii) Check and prevent the water leaks, if any.
(iv) Check the air cleaner vacuum indicator for both engines. If indicator is red, the outer filter is to be cleaned.
(v) Check the tension of V-belts and correct it, if required for both engines.
(vi) Drain the air tanks after the day's work.
(vii) Drain the water separator before starting the engine.
(viii) Record the maximum engine temperature of the day's work.
(ix) Clean the engine and premises.
(x) Check fuel level in Diesel tank.
(xi) Check oil pressure of both the engines on load after two hours working.
(xii) Check the oil leakage from fuel line.
(xiii) Check the oil pressure at idle RPM.

SCHEDULE – II (TO BE DONE AFTER 50 HOURS OF ENGINE RUNNING)

(i) Check the condition of V- belts.
(ii) Check the condition of brake shoes.
(iii) Check electrolyte level and Specific Gravity of batteries.
(iv) Clean the outer air filter element.
(v) Drain the water bowl of diesel tank.

SCHEDULE – III (TO BE DONE AFTER 100 HOURS OF ENGINE RUNNING)

(i) Check high water temperature safety device.
(ii) Check low lube oil pressure safety device.
(iii) Check the throttle control linkage
(iv) Examine the mounting bolts of the engine.

SCHEDULE-IV (TO BE DONE AFTER 200 HOURS OF ENGINE RUNNING)

(i) Change the engine oil.
(ii) Change lube oil filter element.
(iii) Change fuel filter element.
(iv) Lubricate the bearings of all the engine pulleys with grease.
(v) Change super lube. oil by-pass filter element.
(vi) Clean crank case breather.
(vii) Clean the mesh of radiator by pressurized air.
(viii) Replace the outer and inner engine air cleaner element.

Note: Item no. (i), (ii), (iii) and (v) will be done after 250 engine hours.
Item no. (viii) will be done after 500 engine hours.

SCHEDULE-V

(TO BE DONE AFTER 1000, 3000 and 5000 HOURS OF ENGINE RUNNING)

(i) Change worn out water hoses.
(ii) Overhaul the self starter.
(iii) Overhaul the alternators.
(iv) Overhaul the injectors.
(v) Overhaul the fuel injection pumps.
(vi) Replace the rocker cover gaskets.
(vii) Clean the engine radiator externally.
(viii) Clean the diesel tank.
(ix) Clean the cooling coil.
(x) Replace the batteries on condition basis.
(xi) Check the water pump pulley.
(xii) Check coolant for PH value.
(xiii) Change the filter cartridge of air dryer

SCHEDULE-VI (IOH)

(TO BE DONE AFTER 2000 and 4000 HOURS OF ENGINE RUNNING)

(i) Top overhauls the engines, if required.
(ii) Overhaul the air compressor.
(iii) Replace all the water hoses.
(iv) Overhaul the water separator and air oiler.
(v) Overhaul the air unloader.

SCHEDULE-VII (POH)

(TO BE DONE AFTER 6000 HOURS OF ENGINE RUNNING)

(i) Overhaul or replace the engine.
(ii) Overhaul the radiator fan drive assembly.
(iii) Replace the engine mounting pads.
(iv) Check the engine damper for dynamic balance.
(v) Replace the water separator and air oiler.
(vi) Replace the air unloader.
(vii) Check and clean the cooling coil.
(viii) Test the air tank for rated air pressure

IMPORTANT

(i) Premixed CAC will be used for toping up the radiator.
(ii) API CF-4 15W40 lube oil to be used in engine.
(iii) Engine oil pressure should be minimum 1.5 kg/sq.cm at idle & 2.5 kg/sq.cm on load at rated RPM after two hours working.
(iv) RPM of engine radiator fan should not be less than 1600 for proper cooling.
(v) Radiator may be replaced if it is blocked more than 20% during service or badly leaking and not economical to repair.
(vi) Tension of V-belt will be checked at center of belt and it should not be more than 15mm.

MAINTENANCE SCHEDULES OF DEUTZ ENGINE MODEL BF 12 L 513 C AS PER BCM RM-80 OF R.D.S.O

Schedule – I (To be done daily)

1. Check level of the lube oil and top up, if required.
2. Check fuel level and top up if required.
3. Check for any oil leakage from the fuel pump, injectors, fuel supply, and return pipes.
4. Check engine oil pressure after warming up-
   (a) at idle speed (min. 1.5 kg/sq.cm)
   (b) on rated speed (min. 2.5 kg/sq.cm).
5. Check & correct the tension of alternator V-belt.
6. Check the contamination indicators (pilot lamps) for dry type air filter.
7. Record the maximum engine temperature of the day.
8. Clean engines and their premises.
9. Check the functioning of engine clutch.

Schedule II (To be done after 50 engine hours)

1. Clean air cleaner element (outer) with 1.5 bar pressure of dry air.
2. Change oil in the wet type air filter.
3. Clean the fins of engines and air charge cooler.
4. Clean batteries plug connections and apply petroleum jelly.
5. Check electrolyte level in batteries and specific gravity
   i. [Minimum specific gravity = 1.24].

Schedule III (To be done after 100 engine hours)

1. Clean fuel pre-filter (wire mesh).
2. Change the twin stage fuel filter element.

Schedule IV (To be done after 200 engine hours)

1. Change engine oil.
2. Change lube oil filters.
3. Check tappet clearances and adjust if required.
4. Check engine hoses for leakage and condition and do needful.
5. Grease clutch drive shaft bearings.
6. Check clutch fluid level in container.

Schedule V (To be done after1000, 3000, 5000 engine hours.)

1. Lubricate the accelerating mechanism with oil.
2. Check high pressure fuel pipes clamps.
3. Clean the diesel tanks.
4. Decarbonise cooling coil and check the fittings.
5. Replace the crank case breather element.
6. Change dry type air filter element.
7. Test engine temperature indicator.
8. Change batteries, if required.

Schedule VI (To be done after 2000, 4000 engine hours)

1. Check engine timing and do needful.
2. Check and clean air reservoir.
3. Check the air compressor. Overhaul if necessary.
4. Replace V-belts on condition basis.
5. Overhaul the alternator and starter.
6. Clean turbocharger and do needful.
7. Check anti vibration mountings of the engine and change, if required.
8. Calibrate the fuel injection pump.
9. Calibrate the fuel injectors.

Schedule VII (To be done after 6000 engine hours)

1. De-carbonise the engine heads.
2. Check crank shaft and cam shaft end play.
3. Overhaul the air compressor.
4. Change air inlet hoses.
5. Overhaul blower assembly.
6. Change all the high pressure fuel pipes, pipe clamp, flexible fuel hoses and rubber hoses.
7. Overhaul turbo charger.
8. Change shaft seals and bearings of the clutch drive shaft assembly.
9. Check the exhaust manifold for any defect and clean the same.
10. Change shut down valve on condition basis.
11. Replace twin filter body.
12. Replace cooling coil.
13. Change anti-vibration mountings of the engine.
14. Renew the engine wiring with temperature proof wires.
15. Change engine safety system, if required.

MAINTENANCE SCHEDULES OF MWM ENGINE AS PER OEM

Daily checks:

Prior to starting:

1. Check water level-top up to recommended level. (ref. instruction manual – ph value)
2. Check engine oil level.
3. Check air filter and dust bowl
4. Clean engine and surrounding

After starting

5. Check oil pressure at idling and maximum speed. Minimum oil pressure: 1.5 kg/cm^2 at idling speed and 2.5 kg/cm^2 at rated speed.
6. If oil pressure deviates substantially from recommended, stop the engine and check the trouble shooting chart or call your service representative.
7. Check coolant water temperature. recommended coolant working temperature – 75^0c to 85^0c. Maximum coolant temperature – 95^0 (engine shutting off)
8. Check engine for leakages.

Every 250 hours

1. Change engine oil.
2. Change oil filters.
3. Remove sump bottom cover and clean the lube. oil suction strainer.
4. Check rubber sleeves and hose pipes, replace if found defective.
5. Check zinc anodes.
6. Change fuel filter elements
7. Check coupling disc on injection pump.
8. Check ‘v’ belts and lubricate raw water pump.
9. Check and re-adjust valve tappet clearance 0.2 mm (cold)
10. Check speed governor and engine shutdown for proper functioning and lubricate linkages.
11. Check battery.

Every 2000 hours

1. Check bearings of water pump and pulley, replace ‘v’ belts.
2. Check flexible coupling and rubber engine mounts.
3. Check injectors.
4. Clean crankcase ventilation/breather.
5. Check and clean inlet ducts.
6. Remove and clean exhaust piping.
7. Check thermostats
8. Clean heat exchanger
9. Check monitoring functions (engine protection devices).
10. Clean intercooler

11. Renew anti-vibration mounting pads.
12. Clean cooling water passages
13. Check compression
14. Check and service starter & generator.
15. Check all bolts and nuts for specified torques
16. Clean engine and flush radiator.

Every 8000 hours

Further checks to be carried out in order to assess whether top overhauls are required on the engine, only if deterioration is noticed in the engine performance like:

a) Loss of power
b) Heavy smoke
c) Low oil pressure
d) High oil temperature
e) High water temperature
f) Unusual noise and vibration

In the event of any of the above deficiencies occurring in the engine, it is advised that the operator carry out the trouble tracing exercise to eliminate these individual deficiencies. However in case they remain un-rectified compression and injection pressure etc. will reveal whether it is necessary to carry out decarbonisation and/or other repairs.

SUB-DISCIPLINE:- INTERNAL COMBUSTION ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps. Session-39: Maintenance Steps to improve Performance

---

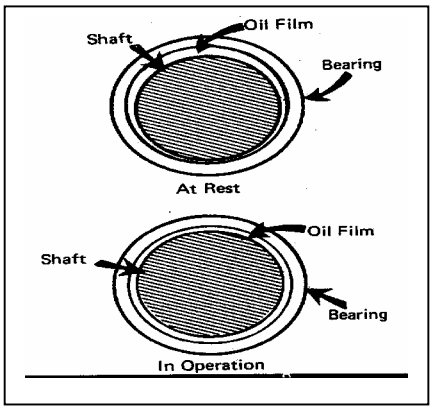
Cummins 10 maintenance Steps

1. Keep Dirt out of the engine

Dirt is the cause of most wear in an engine.
Dirt penetrates the oil film and grinds away the metal.
Valve stems, Guides, faces, Seats, Liner and Piston walls and Piston Rings suffers most from dirty intake air.
Bearings, Shaft Journal also suffer when dirt gets into lubricating oil.

Hence Keep Dirt / Dust out of your engine

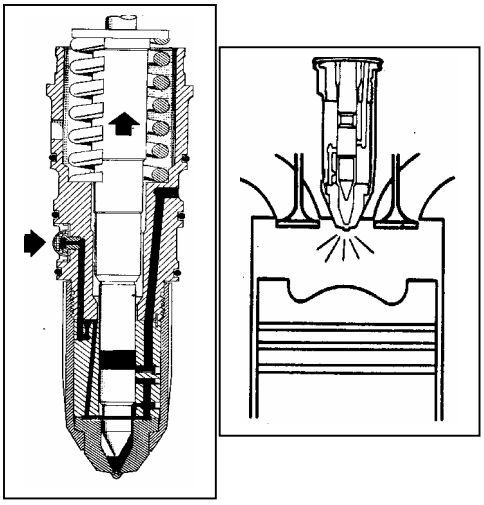
2. Maintain a Lubricating oil film on bearing surfaces.



- Prime the lubricating system as suggested.
- Bar the engine for 2 or 3 rotations while priming.
- Avoid poor lubrication due to low oil pressure, dilution, partially clogged oil passages / filters or improper clearances, incorrect oil level and incorrect grade of oil to eliminate Piston or bearing seizures.

Hence, ensure oil film on Bearing Surfaces is always present.

3. Regulate the Engine's Fuel.



- Violations of requirements such as uniform metered fuel for all cylinders and fine spray of fuel to mix with air would result in low power, smoky exhaust, dilution, hard starting etc.

  Ensure air supply is not restricted beyond limit.

  Hence, ensure the engine's fuel is regulated properly.

4. Control Operating Temperature.

- Water jackets lose ability to ABSORB heat when they become coated with scale, rust or dirt.
- Water pump CIRCULATE less coolant as impeller wear and Belt slip.
- Thermostat fails to CONTROL coolant flow after long period of service.
- Radiators lose ability to DISSIPATE heat as the core becomes choked internally / externally.

5. Guard Against Corrosion.

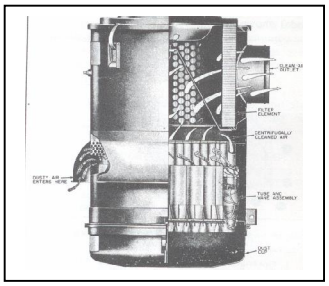
Acid, salt or airs in the coolant are the most causes of corrosion.

Corrosion even accelerates to the extent of Cylinder Block, Liners and Cylinder Head replacement.

Corrosion can be controlled or prevented entirely at little expense of time and money.

Hence, ensure the engine is protected against Corrosion.

6. Let the Engine Breathe.



- Diesel Engine requires about 12,500 gallons of Air to burn One gallon of Diesel completely.
- Inadequate air supply would result in power loss, wastage of fuel and bearing failure.
- The exhaust system must carry the exhaust gases with out restrictions.

Hence, ensure that intake and exhaust system meets the requirements.

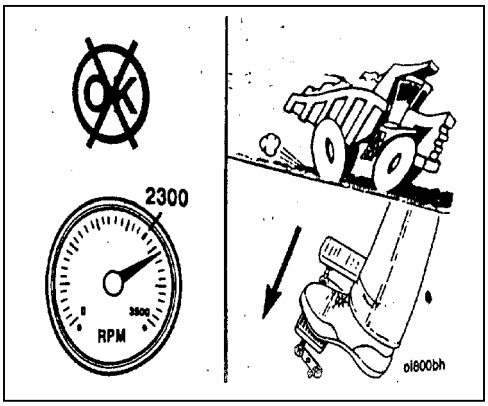
7. Prevent Overspeeding.

Cummins engines are protected against over-speeding during normal operations by Governors.

Over-speeding is possible allowing a vehicle on a down grade beyond its rated speed.

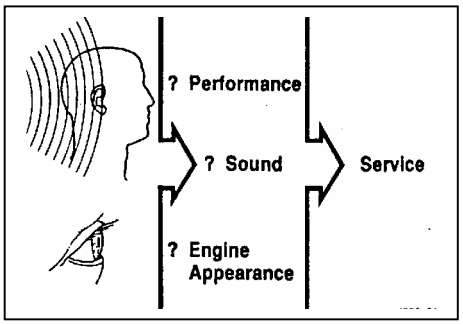
Over fuelling and lighter air density can cause failures to turbocharger.

Over-speeding causes piston to strike and break valves.



Hence, control on engine speed is must.

8. Know your Engine's condition.



- Engine gives symptoms and signs of its condition for the operator or technician to take corrective action.
- Delayed response may lead to serious damages.
- Would help to correct the problems when they are simple.
- Check lube filter element for particles during B checks.

Hence, carry out proactive checks to know your engines condition better.

9. Correct Troubles while they are simple.

Engine gives symptoms and signs of its condition for the operator or technician to take corrective action.

Delayed response may lead to serious damages.

It would help to correct the problems when they are simple.

Preventive measures on warnings would avert costly progressive damages.

Hence, prolonging a complaint must be avoided.

10. Schedule and control your maintenance.

Preventive maintenance is the easiest and least expensive maintenance.

Correct care of your engine would result in longer life, better performance and more economical operation.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps. Session-40: Precautions in providing Piston Rings on Piston and assembling in cylinder liner

---

PRECAUTIONS WHILE FITTING THE PISTON RINGS:

The following precautions must be adhered strictly while fitting the piston rings.

i) Do not fit new piston rings into excessive worn piston grooves.
ii) Do not file the piston ring ends. If is required, file only to a very fine finish so that the ends may seat squarely.
iii) Do not fit piston rings too tight.
iv) Do not fit an over size ring into a tapered piston.
v) Always fit the bottom most ring first.
vi) Do not fit the rings from piston skirt side.
vii) After fitting the rings into the respective grooves, tilt the piston horizontally. The rings should fall freely of its own weight.
viii) Check the side clearance in the grooves. It should be as per the manufacturer's specification.
ix) The end gap of piston ring is approximately 0.001" per inch of piston diameter.
x) Arrange the end gap of piston rings in a manner so that the gaps for all the rings should not fall in one line.
xi) While fitting the piston rings apply sufficient quantity of engine lubricating oil.
xii) After fitting the rings into the grooves, rotate the rings in the grooves so that it is free.
xiii) Make sure that the grooves in the piston are cleaned properly.

PRECAUTIONS IN FITTING PISTON RINGS ASSEMBLY INTO CYLINDER LINER:-

1. Before inserting the piston into the cylinder remove the ridge, which is formed on top of the cylinder. If it is not removed the piston rings may break.

2. Piston rings are compressed by ring compressor for easy and damaged free sliding of piston into liner.

3. Care should be taken to install the piston facing in the right direction. Many pistons have a notch or other making that must face to the front of the engine.

4. While inserting connecting rod into piston liner, take care that big end of C.R. do not scratch the liner or crankshaft main journal.

5. Push the piston into liner gently without applying excessive force.

6. In two stroke cylinders, the ring gaps should not face the port otherwise they may break.

7. To prevent rotation of rings, there are small pins in ring grooves of two-stroke pistons. This pin should be kept between ring gaps.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps. Session-41: Adjustment of valve (Tappet) clearance

---

Valve Clearance:
The intentional gap in between the Rocker arm & valve stem (or cross head in case of Cummins Engines) is known as valve clearance.

Position for valve Clearance adjustment
When both the valves are fully closed then there will be maximum gap in between the valve stem & Rocker Arm, at that time valve clearance is to be adjusted.

When the piston of any cylinder is at TDC or near TDC in compression stroke, at that time valve clearance should be adjusted because at that time there will be maximum gap in between valve stem & Rocker Arm.

We can identify the correct position of piston by the following method:
i) In case of engine fitted with Mico Bosch Fuel supply system.

(a) Remove Injector of cylinder no. (1) & insert a rod which will rest on the piston. Now rotate the fly wheel in the direction of rotation. With the movement of fly wheel & the piston, rod will also lift. There will be a point up to which the rod will lift & then it goes in down ward direction. The point, at which it happens, is TDC. Now check whether it is TDC of compression stroke or exhaust stroke. If it is at TDC of compression stroke then the rocker arm of inlet & exhaust valve will not press the valve stem & both the rocker arm will be loose. If it is TDC of exhaust stroke then both the rocker arm will be in contact with valve stems.

If piston is at TDC of exhaust stroke then rotate the fly wheel by one complete revolution. Now it will reach at TDC of compression stroke.

(b) There is another method to identify the correct position of piston. Loosen the delivery pipe of cylinder no. (1) from the fuel injection pumps and rotate the fly wheel in the direction of rotation. When the piston of that cylinder is about to reach at TDC in compression stroke, the fuel starts coming out from the delivery pipe. This is the correct position to adjust the valve clearance because at that time both the valves are fully closed.

(ii) In case of engines fitted with Cummins P.T. fuel supply system such as NT-743 C, NTA-855-L and KTA 1150-L engines, there are 3 push rods & 3 rocker arms for each cylinder, one for inlet valves, one for exhaust valves & middle one for the operation of injectors. Just before completing the compression stroke when cylinder is ready to receive the fuel, first of all the middle rocker arm, which is provided for injector, starts lifting & then it comes down words. During the movement of this rocker arm, both the valve will be fully closed & there will be maximum gap in between the rocker arm & cross head (valve clearance is the gap between the rocker arm & cross head). At that time we can adjust the valve clearance.

In few engines there are marking on the fly wheel or drive pulley, according to which we can adjust the valve clearance.
To adjust the valve clearances, after bringing the piston at correct position loosen the lock nut of adjusting screw which is provided on the push rod.

Place filler gauge of sufficient thickness in the gap & adjust the adjusting screw by screw driver. Now tighten the lock nut.
After adjusting the valve clearance of cylinder no. (1), rotate fly wheel in the direction of rotation by $720^0/n$ (n = No. of cylinders). If it is 6 cylinder engine then rotate by $720^0/6 = 120^0$ in the direction of rotation i.e. 1/3 rev. of crank shaft & get next cylinder, according to firing order, ready to adjust the valve clearance.

In this way adjust valve clearance one by one of all cylinder according to firing order by rotating the fly wheel by $1/3^{rd}$ revolution.

Valve Clearance:

	Inlet Valve	**Exhaust Valve**
Cummins engines	0.014"	0.027"
MWM Engine	0.2 mm	0.2 mm
Deutz Engine	0.2 mm	0.3 mm

ADJUSTMENT OF VALVE TAPPET CLEARANCE IN MWM 232 & 234 V-12 ENGINES:

FIRING ORDER OF MWM TBD-232 & 234, V-12 ENGINES:

A1,	B2,	A5,	B4,	A3,	B1
A6,	B5,	A2,	B3,	A4,	B6

Procedure – As per Operation & Maintenance Manual:

1. Remove rocker covers of all 'A' bank cylinders.
2. Check the condition of the rocker Lever adjusting screw threads and locknut threads. If the threads are damaged, replace respective adjusting screw or locknut.
3. Rotate the crankshaft in direction of rotation i.e., anti-clockwise viewed from flywheel side until intake valve of A1 cylinder is just closed. Mark the position and then rotate the crankshaft further by 180 degrees which signifies No. A1 piston is approximately at Top Dead Centre in compression stroke.
4. Set intake and exhaust valve clearance to 0.2mm (0.008"). Install rocker cover of A1 to indicate the completion of tappet setting.

NOTE:

a) While adjusting the valve clearance the right hand rocker lever is exhaust and left side is intake.
b) Rocker lever or valve which aligns with exhaust manifold exit is exhaust rocker lever or exhaust valve and the remaining is intake valve.

Continue to rotate the crankshaft in D. O. R. i.e. anti-clockwise until intake valve of A2 cylinder is just closed. Further rotate the crankshaft by ½ turn (180^0) and set valve clearance to 0.2mm (0.008")

Follow the same procedure:

For A3, A4, A5 & A6.

After the completion of ‘A’ bank tappet adjustment, move to ‘B’ bank and commence with B1 cylinder and follow the same procedure as followed in ‘A’ bank.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps Session-42: Adjustment of injection timing and testing of Nozzles

---

ADJUSTMENT OF INJECTION TIMING:-

(1) Place the pump on the foundation and tighten its foundation bolt by hand.
(2) Loose the bolts of pump coupling.
(3) Rotate the engine and bring the piston of one no. cylinder at T.D.C of compression stroke. Generally one no. cylinder is nearest to radiator. At this time, check the T.D.C mark on flywheel by inspection hole of flywheel housing.
(4) Rotate the engine a little in reverse direction and bring the ‘INJ’ mark on Flywheel in coincidence with the pointer of inspection hole, so that the injection will start before the T.D.C of piston.
(5) Open the inspection plate of fuel pump and rotate the pump in its direction of rotation till the one no. plunger starts lifting.
(6) In this position tight the engine coupling with pump coupling.

Now rough timing has been set and for fine adjustment, do the following works:-

(7) Remove delivery valve holder, delivery valve, spring peg seat and joint washer.
(8) Fit spill cut-off at the place of holder.
(9) Connect fuel inlet line with pump.
(10) Do hand priming and fill the fuel gallery of pump.
(11) When gallery becomes full, remove the air through vent screw till the clear diesel starts coming.
(12) Bring the control lever or control rack in full position.
(13) Loose the fine adjustment bolt on pump coupling.
(14) Rotate the coupling by hand as much as its movement for fine adjustment. Stop rotating when diesel stops coming out through spill pipe. Remember that plunger should be in lifting position, not in down going position.
(15) Tight the fine adjustment bolt at this time**.**
(16) Unscrew the spill cut-off pipe and fit the delivery valve and its parts after cleaning in diesel.
(17) Fit all injection pipes after cleaning.
(18) Tight the pump foundation completely and check the coupling bolt and adjusting bolt.
(19) Fit the inspection cover of pump.

(20) Fill lubricating oil in injection pump and governor as per manufacturer; oil is filled in mechanical governor, not in pneumatic governor.
(21) Keep injector pipe loose at injectors and rotate the engine by self starter. When the diesel starts coming through the pipes, then tight the pipes at injectors.
(22) Self start the engine and after warming up adjust idle speed by stop screw.

(23) Diesel should not leak through pipes, filters or bleeding screw.

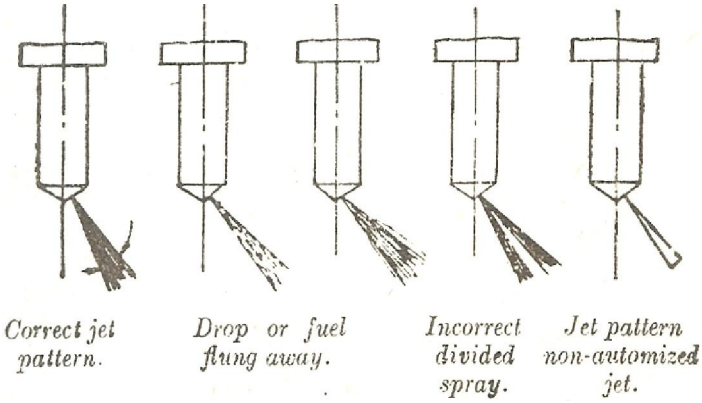
TEST AND ADJUSTMENTS OF INJECTORS

These tests are done on injector testing machine to test an injector:

1. Pressure test.
2. Leak-off test.
3. Spray test.

1. **Pressure test: -** Clamp the injector on the tester and operate the tester pump. Note the reading of the dial indicator at which the injector nozzle starts spraying. It gives pressure reading. It should be the same as recommended by the company. If it is less, then tighten the adjusting screw of the injector. If it is more, then loosen the adjusting screw. Repeat the process until the correct pressure reading is obtained. Finally, tighten the lock nut.

2. Leak off test: - Clamp the injector on the tester and built up the pressure about 150Kg/cm^2 by operating the tester pump. Keep this pressure for about 10 seconds. If the pressure drops, it shows that there is leakage in the injector. Check the nozzle seat and nozzle valve needle and nozzle body. Correct the seat and needle by grinding and lapping, and after that again do the leak off test.



3. Spray test: - Spray test is also done on the same injector testing machine. While operating the tester pump, see carefully the spray. It should not like a current of oil or with drops splitting away, but it should be fully atomized.

INSPECTION OF CRANK SHAFT:

A) Check for cracks:
Make a very careful inspection for cracks.

B) Alignment check:
Position the crank shaft on a pair of "v" blocks or in the lathe. With the help of dial test indicator take reading on two intermediate journals. Run out should not be more than 0.002".

C) Roughness:
There should not be any sign of roughness on journals and crank pins. It is checked with a copper piece by rubbing a copper piece on the journals or pin, it should not leave any sign.

D) Discolourisation:
Bluing (bluish) color indicates over heating.

E) Bend test:
Place the crank shaft on a pair of "V" locks on a surface plate turn the crank shaft and bring a pair of crank pins at T.D.C. Taking reading with a dial test indicator for equal height. Bring the same paid crank pins to B.D.C. And note reading, repeat the same on the other pins. From the reading the bend can be checked up.

F) Twist test:
Place the crank shaft on a pair of "v" blocks. Bring no. 1 crank pin at T.D.C. And scribe a vertical line on the fly wheel with the help of fitter square. Turn the crank shaft and bring no 1 crank pin to B.D.C. And scribe another vertical line. If both the lines scribe are coinciding, then there is no twist similarly check the other pins also.

G) Bow test:
Place the crank shaft as above and check the reading on the intermediate journals by a dial test indicator. If they are gradually increasing or decreasing outwardly, it means there is a bow.

H) Test for static balance:
Place the crank shaft main journals on a knife edge "V" block with a pair of pins a T.D.C. Push the crank shaft with a finger. If it falls to B.D.C. and stays there the crank shaft is out of balance.

I) Ovality and taper wear:

Check main journals and crank pins with a micro meter to determine if they are out of round. Measurement should be taken in several places; to check for taper wear. If the journals and pins are tapered or out of round more than .003”, they should be reground.

TROUBLE SHOOTING OF CUMMINS ENGINE AS PER PLASSER MAKE WORSITE TAMPERS (08-32) OF RDSO

S. No.	Faults	Probable Causes	Remedial Actions
1.	Engine does not start	1. Emergency stop switch is pressed.	Emergency stop switch should be in release position.
		2. No fuel in the tank.	2. Fill fuel in the tank and bleed air from fuel system as given in following steps: i) Loosen the bleed plug on the fuel filter and operate the priming pump until the fuel emerges free of bubbles. Tighten the bleed plug. ii) Then loosen banjo plug on injection pump and operate the priming pump until fuel emerges free of bubbles. Tighten the banjo plug.
		3. Shut down mechanism is stuck	3. Check the electrical supply at coil. if it is ok, then lubricate the piston of shut down coil and mechanism with lube oil and operate it manually. If still not working, then coil may be defective. Replace it.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in item no. 2 above.
		5. Governor is stuck.	5. Replace the complete fuel injection pump.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Valve clearance is not proper.	7. Adjust the valve clearance as given in engine manual.
		8. Weak batteries.	8. Check electrolyte level in the batteries. Terminals should be clean and the charging system should be working. Over-aged batteries should be replaced.
		9. Injectors not properly functioning.	9. Remove defective injectors and get them overhauled/calibrated or replace them with new one.
		10. Valves not seating properly.	10. i) Check the valves spring and replace the broken spring if any. ii) Lap the valves. iii) Lap the valve seat, if required.
2.	Engine running too hot.	1. Coolant level too low.	1. Check coolant level and top up to the mark in the filler neck.
		2. Defective thermostat	2. Check thermostat as given in the following steps: i) Drain cooling water and catch it for reuse. ii) Loosen hose clamps, pull back hoses and then remove thermostat.

			iii) Heat the water in container to approx. 85^{o} C and place thermostat in it. Maintain temperature of water by agitating

2.	Engine running too hot.	2. Defective thermostat	iv) By short-circuiting and radiator opening, check whether the thermostat opens fully. If not, then install new thermostat.
		3. Defective water pump.	3. Check/repair the water pump.
		4. V-belt for water pump needs adjustment.	4. Check the V-belt tension. To adjust, release the guide pulley and regulate tension in the belt. Then tighten the guide pulley. If required, replace the V-belt.
		5. Oil cooler not working properly.	5. Repair / replace the Oil Cooler.
		6. Valve clearance is not proper.	6. Adjust the valve clearance as explained in engine manual.
		7. Air filter is choked.	7. Clean the air filter.
		8. RPM of coolant fan is too low.	8. Adjust the RPM of the motor to 1600. Check hydraulic system and change pump and motor if necessary.
		9. Water radiator choked.	9. Get the radiator cleaned.
		10.Radiator cap missing or worn out	10. Fit new cap.
		11. Water hose too old.	11. Replace the water hose.
3.	Engine misfiring	1. Dirty fuel filter.	1. Check fuel filters and if necessary Change it filter.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow steps as given in s. no.1, item no.2.
		3. Air in fuel system.	3. Bleed air from the fuel system as explained in s. no.1, item no.2.
		4. Defective Injector.	4. Remove the defective injector and get them overhauled/calibrated/ replace with new one.
		5. Valve clearance is not proper.	5 Adjust valve clearances as given in engine manual
		6. Fuel injection timing not proper.	6. Adjust the timings.
4.	Excessive engine smoking.	1. Engine oil level too high.	1. Check oil level. For this, draw dipstick and clean with lint-free cloth. Return dipstick, wait a little until the oil has wetted the dipstick. Then remove the dipstick again and check oil level.
		2. Defective injector	2. Follow the s.no.1, item no.9.
		3. Valve clearance is not proper.	3. Follow the s. no.1, item no.7.
		4. Air in fuel system.	4. Follow the s.no.1, item no.2.
		5. Clogged air cleaner.	5. Clean the element or change if required.
		6. Excessive carbon on cylinder head and piston.	6. De-carbonise the engine.
		7. Engine overloaded.	7. Check and reduce the load.
		1. No fuel.	1. Fill fuel in the tank and follow the steps as given in s. no. 1, item no.2.

		2. Air in the fuel system.	2. Bleed air from fuel system as explained in s. no.1, item no.2.
		3. Valve clearances are not proper.	3. Adjust the valve clearances as explained in s.no.1, item no.7 above.
		4. Governor is stuck.	4. Replace complete fuel injection pump.
		5. Overheating of engine	5. Take remedial action as given in s.no.5 below.
		6. Shut down circuit fails.	6. Check the electrical circuit and repair as required.
6.	Engine knocking	1. Incorrect Injector setting.	1. Remove the faulty injector and get it reset or replace it with new one.
		2. Mechanical damage to piston/cylinder.	2. Get the engine top overhauled.
		3. Valve clearance is not proper.	3. Adjust the valve clearance as given in engine manual.
		4. Fuel injection timing is not proper.	4. Correct the timings.
7.	Output of the engine too low	1. Dirty fuel filters and fuel line.	1. Check the fuel filters and if necessary change it.
		2. Air in fuel system.	2. Bleed the air from system as explained in s. no.1, item no.2.
		3. Defective Injectors.	3. Remove the defective injectors and get them overhauled or replace with new one.
		4. Valve clearances are not proper.	4. Adjust the valve clearances as given in engine manual.
		5. Air filter choked.	5. Clean the air filter element or replace if required.
		6. Improper compression	6. Engine needs to be top overhauled.
		7. Governor is stuck.	7. Replace the complete fuel injection pump.
8.	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter.
		2. Oil control valve not working.	2. Repair the control valve or replace it.
		3. Dirty oil cooler	3. Clean the oil cooler.
9.	Oil film present in crank case ventilation	1. Incorrect compression.	1. Engine needs to be top overhauled
		2. Lube oil brands.	2. Use lube oil of proper brand and grade as recommended by the OEM.
10.	Engine speed is irregular.	1. Air in fuel system	1. Bleed air from the system as explained in s. no.1, item no.2.
		2. Governor is stuck.	2. Replace complete fuel injection pump.
11.	Fuel consumption too high.	1. Use of incorrect lube oil brand.	1. Use proper grade and quality lube oil.
		2. Incorrect setting of Injector.	2. Overhaul/ Replace the defective injectors.
		3. Incorrect engine timing.	3.Get the engine timing reset.
		4. Clogged air filter.	4. Clean the air filter.
		5. Poor compression	5. Engine needs to be top overhauled.
12.	Lube oil consumption too high.	1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Poor compression	2. Engine needs to be top overhauled.
		3. Oil filter dirty.	3. Replace the filter.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 44)
Lesson-X: Maintenance Steps. Session-45: Trouble shooting of Deutz and MWM Engine.

TROUBLE SHOOTING GUIDE OF BALLAST CLEANING MACHINE (RM-80)
ENGINE: DEUTZ - BF-12L 513C 453HP @ 2300 rpm

	Faults	**Probable Causes**	**Remedial Actions**
1.	Engine doesn't start.	1. Emergency stop switch is depressed.	Emergency stop switch should be in release position.
		2. No fuel in the tank.	2. Fill fuel in the tank and bleed air from fuel system as explained below: Loosen the Bleed Plug on the fuel filter and operate the priming pump until the fuel is free from air bubbles. Tighten the bleed plug. Then loosen Banjo Plug on injection pump and operate priming pump until fuel is free from air bubbles. Tighten the Banjo Plug.
		3. Shutdown mechanism stuck.	3. Check shut down mechanism i) Release engine shutdown lever from stop position. ii) Check electrical shutdown circuit for proper functioning.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in s. no. 1, item 2 above.4. Bleed air from fuel system as explained in s. no. 1, item 2 above.
		5. Governor is stuck.	5. Replace complete fuel injector pump.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Faulty valve clearance	Adjust the valve clearance following these steps: i) Unscrew bolts and remove cylinder cover. ii) Crank the engine until the inlet valve is closed, then turn approximately half turn further. iii) The feeler gauge of 0.20mm and 0.30mm should pass between rocker lever and the cross head for the exhaust and intake valve with suction consequently. This will be done by loosen the lock-nut and readjust by means of setting screw. Renew gasket sealing ring of cylinder head cover. iv) Tighten the lock-nut and readjust valve clearances with the prescribed feeler gauge mentioned in SL(iii)
		8. Not de-clutched.	8. De-clutch where possible
		9. Wrong SAE grade of engine oil or poor quality of oil.	9. Replace by correct type of oil.
		10. Cable connection starter circuit loose / oxidized	10. Check the same.

1.	Engine doesn't start.	11. Weak batteries.	11. Check electrolyte level in the batteries. Terminals should be clean and the charging system should be working. Over-aged batteries should be replaced.
		12. Injectors not properly functioning.	12. Remove faulty injectors and get it overhauled/calibrated or alternatively replace it with new one.
		13. Valves not seating properly.	13. i) Check the valve springs and replace the broken spring if any. ii) Lap the valves. iii) Lap the valve seat, if required.
		14. Too much fuel in engine or flooded engine.	14. i) Clean fuel return pipe. ii) If return pipe is already clean, calibration of fuel pump may be defective and should be got calibrated.
		15. Starter defective or starter relay defective or pinion does not engage.	15. Check, rectify or replace.
2.	Engine stops suddenly during run.	1. No fuel.	1. Fill fuel in the tank and follow steps same as 1(2).
		2. Air in the fuel system.	2. Bleed air from fuel system as explained in steps same as 1(2).
		3. Valve clearances are not proper.	3. Adjust valve clearances as explained in 1.7.
		4. Governor is stuck up.	4. Governor needs repairs/ overhauling in workshop.
		5. Overheating of Engine	5. Take remedial action same as 1(5).
		6. Fuel filter / fuel pre-filter contaminated.	6. Check / clean/replace as per need.
		7. Shut down circuit fails.	7. Check and repair the faulty circuit.
		8. Lube oil pressure too low.	8. i) Check lube oil pump. ii) V-Belt for lube oil pump may be broken. Change with new one. iii) Wrong grade of lube oil. Use proper grade of oil.
3.	Engine misfiring.	1. Dirty fuel filter.	Check fuel filters and if necessary replace the same.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow steps same as 1(2).
		3. Air in fuel system.	3. Bleed air from the system, same as 1(2).
		4. Faulty Injector/Injection line leaky.	4. Remove the faulty injector and get it overhauled / calibrated. Alternatively, replace the faulty injector with new one.
		5. Faulty valve clearance.	5. Adjust valve clearances
		6. Fuel injection timing improper.	6. Correct the timings or call the service engineer.
4.	Excessive black smoke at idle.	1. Restricted fuel lines.	1. Check the fuel lines.
4.	Excessive black smoke at	2. Plugging of injector spray holes	2. Injectors needs cleaning
		3. Cracked injector	3. Replace the broken one.

	idle.	body	
		4. Long idle period	4. Do not run the engine at idle speed for long period.
		5. Gasket blow-by or leakage	5. Replace the defective gasket
		Broken or wrong piston rings	6. Use the piston rings of standard part no. from engine manufacturer
		7. Injectors needs calibrations	7. Get the engine calibrated through specified agency
5	Excessive white smoke at idle	1. Excessive white smoke at idle	1. Use proper grade of fuel. It will be better if fuel is tested chemically
		2. Cracked injector body	2. Replace the cracked one
		3. Coolant temperature low	3. During winter season top up the radiator with boiled water to keep the water temperature normal.
		4. Long idle periods	4. Do not run the engine at idle speed for long periods.
		5. In correct valve and injection timing	5. Correct valve and injection timing
6.	Excessive smoke under load	1. Restricted air in take	1. Clean the air filter or replace if required
		2. Dirty turbo charger	2. Get it clean
		3. Poor quality of fuel	3. Same as 5(1).
		4. Restricted fuel lines	4.Check the fuel lines and clean it as per requirement
		5. Fuel pump calibration in correct	5.Get the fuel pump calibrated through specified agency
		6. Injector needs calibration	6. Get the injector calibrated through the specified agency.
		7. Engine due for overhaul	7. Get the engine overhaul through service engineer of engine manufacturer.
7.	Engine running too hot.	1. Coolant level too low.	1. Check coolant level and top up with coolant up to the mark in the filler neck.
		2. Oil cooler/ cooling fins soiled.	2. Clean oil cooler/cooling fins.
		3. Air Blower defective.	3. Check and replace.
		4. Air Blower coupling broken.	4. Replace broken coupling/ bushes.
		5. Faulty valve clearances	5. Adjust the valve clearance, same as 1 (7).
		6. Atmospheric air temperature rise/ hot air circulation.	6. CHECK.
		7. Oil level too low or high.	7. Keep the oil level within limits.
		8. Engine overloaded.	8. Check and reduce loads.
7.	Engine running too hot.	9. Lube oil pressure too low.	9. Engine has to be repaired at workshop.
		10. Faulty fuel pump.	10. Repair the pump or replace as required.
		11. Choking of corrugated fins of cylinder.	11. Clean the cylinder fins with water jet during monthly schedule and clean the engine externally daily before and after the block with compressed air jet.
8.	Engine	1. Incorrect Injector	1. Remove the faulty injector and get it reset or

	knocking	setting or defective injector	alternatively replace it with new one.
		2. Mechanical damage to piston ring/liners.	2. Call in the service engineer.
		3. Connecting rod bearing damaged	3. Replace connecting rod bearing.
		4. Injection line leaky	4. Check the leakage.
		5. Fuel filter / fuel pre-filter contaminated.	5. Check/clean/replace.
		6. Incorrect tappet clearance.	6. Adjust tappet clearance.
		7. Faulty fuel pump.	7. Repair /Replace the pump.
9	Output of the engine too low.	1. Dirty fuel filters and fuel line.	1. Replace fuel filter and clean fuel line. Same as 3(1).
		2. Air in fuel system.	2. Bleed air from system as explained, same as 1(2).
		3. Faulty Injector/Fuel Pump.	3. Remove faulty injector/Fuel pump and get it overhauled or alternatively replace it with new ones
		4. Faulty valve clearances.	4. Adjust valve clearances same as Sl. No. 1(7).
		5. Air filter choked.	5. Clean/replace air filter element.
		6. Leakage of compression	6. Engine needs repairs in work-shop.
		7. Governor sticking.	7. Governor needs repairs in workshop
10	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter element.
		2. Improper oil grade	2. Use proper grade of engine oil.
		3. Oil control valve not working.	3. Call the service engineer for repair of control valve.
		4. Oil level too low	4. Fill the oil up-to the required level
		5. Excessive inclination of engine	5. Check
		6. Dirty oil cooler.	6. Call in the service engineer for cleaning of the oil cooler.
10	Oil pressure low.	7. Excessive wear in connecting rod/ main bearing.	7. Engine needs to be overhauled in workshop.
		8. Mixing of diesel or coolant in Engine oil.	8. Call the service engineer of OEM.
11.	Oil film present in crank case ventilation.	1. Incorrect compression.	1. Engine needs repairs at work-shop or call in the service engineer.
		2. Wrong grade of lube oil.	2. Use lube oil of proper brand and grade as recommended by the OEM.
12.	Engine speed is irregular.	1. Air in fuel system.	1. Bleed air from the system , same as sl.no.1 (2).
		Governor struck-up.	2. Call in the service engineer. Governor needs repairs.
		3. Incorrect firing order	3. Adjust firing order (1,8,5,10,3,7,6,11,2,9,4,12).
		4. Incorrect fuel	4. Get the fuel pump calibrated through specified agency.

		pump calibration.	
13	Fuel consumption too high.	1. Incorrect setting of Injector.	1. Replace or overhaul faulty injector.
		2 Incorrect valve and injection timing	2. Get the engine timing reset.
		3. Clogged air filter.	3. Clean air filter.
		4. Poor compression.	4. Call the service engineer. Engine needs repairs in workshop.
		5. Lube oil level too high	5. Keep the oil level within limits.
14.	Lube oil consumption too high.	1. Incorrect lube oil brand	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Excessive inclination of engine.	2. Check.
		3. Oil level too high.	3. Keep the oil level within limits.
		4.Oil leaking from compressor.	4. Overhaul the compressor
		5.Poor compression.	5. Replace compression rings or valve, valve seat or lap.
		6. Broken or wrong piston rings / piston / liner.	6. Engine is due for overhauling.
15.	Mixing of diesel in oil.	1. Defective injector.	1. Replace the defective injector.
		2. Long idle periods	2. Do not run the engine at idle speed for long periods.
		3. Internal/external fuel leakage.	3. Prevent the leakage

TROUBLE SHOOTING GUIDE OF BALLAST CLEANING MACHINE (RM-80)

POSSIBLE DISTURBANCES IN TURBO-CHARGED DIESEL ENGINES WITHOUT BOOST PRESSURE CONTROL VALVES

16.1	Lack of power boost pressure too low.	1.0 Air filter system dirty. Suction and pressure pipes deformed and /or leaking.	1.0 Examine filter system, service or replace filter if required. Check and repair or replace pipes, tighten un-tight joints.
		1.1 Too high flow resistance in the exhaust gas system and / or leakage un-stream of turbine.	1.1 Check exhaust brake, pipes, gaskets and silencers, carry out repairs required.
		1.2 Injection unit and/or fuel system defective	1.2 Check setting values and function, correct if required.
		1.3 Compression too low	1.3 Check valves, cylinders and pistons, service or replace defective parts if required.
		1.4 Charge air cooler dirty.	1.4 Clean unit and replace if necessary.
		1.5 Turbocharger defective. Wheels rubbing on housing walls.	1.5 Examine turbocharger, repair or replace if necessary.
16.2	Power and / or boost pressure too high.	Injection unit defective	Check setting values and correct if required.
16.3	Black exhaust	Same as points 1.0, 1.3, 1.4, 1.5	See points 1.0, 1.3, 1.4, 1.5

	smoke.		
16.4	Blue exhaust smoke	1. Worn valve guides and piston rings.	1. Measure blow-by volume at crankcase outlet. Overhaul engine if required.
		2. Compressor side and / or turbine-side sealing in the turbocharger defective.	2. Examine turbocharger, repair or replace it as required.
		3 Turbocharger oil drain-pipe clogged and / or deformed.	3. Clean oil drain pipe, repair if necessary.
16.5	Oil leakage at turbocharger.	1. Oil-feed pipe and/or oil drain pipe loose and leaking	1. Clean Turbocharger, check for leakage and rectify.
		2.Leakage at connection between compressor and bearing housings	2. Repair or replace turbocharger.

17.0 IMPORTANT: In case of engine failure during traffic block working

17.1	Machine stopped during working in block section/ engine no. 1 failed	Engine failed/cordon shaft connecting engine no. 1 and gear box failed/ Failure on main gear box no. 1 in block section.	Since engine no. 1 failed, to reduce the time and avoid process of connection and disconnection of pipes, the system is modified for speedy winding up. In this system arrangement has been made to receive hydraulic pressure from external source, so that various assemblies can be lifted and locked in case of failure of both the engines.
			After locking up the various assemblies such as chain trough, lifting unit etc, the machine can be moved with only engine no. 2 working and axle no. 3 & 4 powered. The electrical circuit of axle 1 and 2 automatically gets disconnected. When engine no. 1 shut down and separates isolation of these switches is not necessary.
17.2	Machine stopped during working in traffic block / engine no. 2 of the machine failed.	Engine no. 2 failed / cordon shaft connecting engine and gearbox failed/failure of main gearbox.	The winding of the machine can be done as usual because the hydraulic pump for these operations are run by the engine no. 1. After winding up, the machine can run with axle no. 1 and 2 powered. Electrical isolation of axle no. 3 & 4 takes place when engine no. 2 is shut down.
17.3	Both engine no. 1 and 2 failed in the block section.	It is not possible to start either of the engine during traffic block / working.	Immediately ask for assisting power. Separate backup system is not provided on this machine. Normally these machines are followed by tamping machines. In this case a separate hydraulic pipe can be connected from the tamping machine to the BCM as explained in item 15.1 and winding up of the machine can be carried out. For this purpose hydraulic pipe SAE 100R2 size 5/8" of 30 meter long with end fittings should be kept on the machine. After winding up, the section can be cleared by coupling to the tamping machine or by assisting

			engine. BCM other than Sl. No. 285 to 291 are provided hand operated hydraulic system (back up system) to wind up the machine.

TROUBLE SHOOTING MANUAL OF 09 –32 CONTINUOUS TAMPING MACHINE ENGINE (MWM TBD 232 V 12)

S. No	Faults	Probable Causes	Remedial Actions
1.	Engine does not start.	1. Emergency stop switch is pressed.	Emergency stop switch should be in release position.
		2. No fuel in the tank.	2. Fill fuel in the tank.Bleed air from fuel system in the following steps: i) Loosen the bleed plug on the fuel filter and operate the priming pump until the fuel emerges free of bubbles. Tighten the bleed plug. ii) Then loosen banjo plug on injection pump and operate priming pump until fuel emerges free of bubbles. Tighten the banjo plug.

		3. Shut down mechanism stuck	3. Check the electrical supply at coil if it is ok, then lubricate the piston of shut down coil mechanism with lube oil and operate it manually. If still not working, then coil may be defective. Replace it with new one.
		4. Air in fuel system.	4. Bleed air from fuel system as explained in s.no.1,item 2 above.
		5. Governor is stuck.	5. Call in the service engineer. Governor needs repairs.
		6. Misconnection of starting switch.	6. Check starting switch and if any misconnection is noticed, rectify it.
		7. Valve clearance is not proper.	To check valve clearances, follow these steps: Unscrew bolts and remove cylinder cover. Crank engine until the inlet valve is closed. Then turn approx. ½ turn further. The feeler gauge should pass between the valve cone end and the rocker lever with suction. If the valve clearances need resetting, loosen the lock nut and readjust by means of the set screw. Tighten lock nut and recheck valve clearances. Renew gasket, sealing ring and fit cylinder head cover.
		8. Weak batteries.	8. Check electrolyte level in the batteries. Terminals should be clean and the charging system should be working. Over-aged batteries should be replaced
		9. Injectors not properly functioning.	9. Remove Defective injectors and get it overhauled/calibrated or alternatively replace it with new one.
		10. Valves not seating properly.	10. i) Check the valves spring and replace the broken spring if any. ii) Lap the valves. iii) Lap the valve seat, if required.
		11. Too much fuel in engine.	11. Clean fuel return pipe.
2.	Engine stops	1. No fuel.	1. Fill fuel in the tank and follow steps as in s. no. 1, item no.2.
		2. Air in the fuel system.	2. Bleed air from fuel system as explained in s. no.1, item no.2.
		3. Valve clearances is not proper.	3. Adjust valve clearances. See s.no.1, item no.7 above.
		4. Governor is stuck.	4. Call in, the service engineer. Governor needs repairs.
		5. Overheating of engine	5. Take remedial action as in s.no.5 below.

		6. Shut down circuit fails.	6. Recheck and repair the circuit.
3.	Engine misfiring	1. Dirty fuel filter.	Check fuel filters and if necessary- i) Change fuel filter. ii) Change fuel filter elements. iii) Clean the inlet filter.
		2. No / less fuel in tank.	2. Fill fuel in the tank and follow step in s. no.1, item no.2.
		3. Air in fuel system.	3. Bleed air from the system. Same as s. no.1, item no.2.
		4. Defective Injector.	4. Remove the defective injector and get it overhauled / calibrated/ replace with new one.
		5. Valve clearance is not proper.	5 Adjust valve clearances as in s. no.1, item no.7.
		6. Fuel injection timing not proper.	6. Correct the timings or call the service engineer.
4.	Excessive engine smoking.	1. Engine oil level too high.	1. Check oil level. For this purpose, draw dipstick and clean with lint-free cloth. Return dipstick, wait a little until the oil has wetted the dipstick. Then remove dipstick again and check oil level.
		2. Defective injector	2. Same as s.no.1, item no.9.
		3. Valve clearance is not proper.	3. Same as s. no.1, item no.7.
		4. Air in fuel system.	4. Same as s. no.1, item no.2.
		5. Clogged air cleaner.	5. Clean element and change oil.
		6. Excessive carbon on cylinder head and piston.	6. De-carbonise the engine.
		7. Engine overloaded.	7. Check and reduce the load.
5.	Engine running too hot.	1. Coolant level too low.	1. Check coolant level and top up with coolant up to the mark in the filler neck.
		2. Defective thermostat	2. Check thermostat as in the following steps: i) Drain cooling water and catch it for reuse. ii) Loosen hose clamps, pull back hoses and then remove thermostat. iii) Heat water in container to approx. 85^{o} C and place thermostat in it. Maintain temperature of water by agitating. iv) By short circuiting and radiator opening, check whether the thermostat opens fully. If not, call in the Service Engineer to fit new thermostat. Or Alternatively check temperature of coolant in radiator for functioning of thermostat.
		3. Defective water pump.	3. Call in the service engineer to check/repair water pump.
		4. V-belt for water pump needs	4. Remove V-belt guard and check V-belt tension. To adjust, release take-up pulley mount

		adjustment.	or generator and regulate tension in the belt. Then tighten the take-up pulley. If required, replace the V-belt.
		5. Oil cooler properly not working.	5. Call service engineer for repair/ replacement of Oil Cooler.
		6. Valve clearance is not proper.	6. Adjust valve clearance as explained in s. no.1, item no.7.
		7. Air filter is choked.	7. Clean air filter.
		8. RPM of coolant fan is too low.	8. Adjust RPM of the motor to 1650. Check hydraulic system and change pump and motor if necessary.
		9. Water radiator choked.	9. Get the radiator cleaned in work-shop.
		10.Radiator cap missing or worn out	10. Fit new cap.
		11. Water Hose too old.	11. Replace water hose.
6.	Engine knocking	1. Incorrect Injector setting.	1. Remove the faulty injector and get it reset or replace it with new one.
		2. Mechanical damage to piston/ cylinder.	2. Call in the service engineer.
		3. Valve clearance is not proper.	3. Adjust valve clearances, as explained in s. no.1, item no.7.
		4. Fuel injection timing not proper.	4. Same as s. no. 3, item 6.
7.	Output of the engine too low	1. Dirty fuel filter and fuel line.	1. Clean fuel filter see s. no.3, item no.1.
		2. Air in fuel system.	2. Bleed air from system as explained in s. no.1, item no.2.
		3. Defective Injector.	3. Remove defective injector and get it overhauled or replace it with new one.
		4. Valve clearances are not proper.	4. Adjust valve clearances as explained in s. no.1, item no.7.
		5. Air filter choked.	5. Clean air filter element and change oil.
		6. Improper compression	6. Engine needs repairs in workshop.
		7. Governor is stuck.	7. Call in the service engineer. Governor needs repairs.
8.	Oil pressure low.	1. Dirty lube oil filter.	1. Replace the lube oil filter.
		2. Oil control valve not working.	2. Call the service engineer for repair of control valve.
		3. Dirty oil cooler	3. Call in the service engineer for cleaning of the oil cooler.
9.	Oil film present in crank case ventilation	1. Incorrect compression.	1. Engine needs repairs in workshop.
		2. Lube oil brands.	2. Use lube oil of proper brand and grade as recommended by the OEM.
10.	Engine	1. Air in fuel	1. Bleed air from the system as explained in s.

	speed is irregular.	system	no.1, item no.2.
		2. Governor is stuck.	2. Call in the service engineer. Governor needs repairs.
11.	Fuel consumption too high.	1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil.
		2. Incorrect setting of Injector.	2. Replace or overhaul Defective injector.
		3 Incorrect engine timing.	3. Get the engine timing reset.
		4. Clogged air filter.	4. Clean air filter.
		5. Poor compression	5. Engine needs repairs in workshop.
12.	Lube oil consumption too high.	1. Incorrect lube oil brand.	1. Use proper grade and quality lube oil as recommended by OEM.
		2. Poor compression	2. Engine needs repair in workshop.
		3. Oil filter dirty.	3. Replace the filter as explained in s.no.8 item no.1.

SUB-DISCIPLINE:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps. Session-46: Setting of Torque wrenches, tightening torque of different engine assemblies, Clearance of moving parts.

Setting of Torque wrenches:-

Torque wrench is a device used for tightening a bolt / nut with a pre-determined torque. It is an essential tool required for engine repair. Normally a torque wrench provides a facility of setting pre-determined torque in three units –

1. Feet-pound (ft-lb)
2. Kilogram-meter (kg.-m)
3. Newton-meter (N-m)

At the rear end of the torque wrench a small handle is provided which is opened and rotated for setting the pre-determined torque. The sleeve on the torque wrench handle moves and its mark coincides with the graduated mark in any of the three torque units. After setting the torque wrench at the pre-determined torque in this way, it is used for rotating the box type wrench. As soon as the bolt / nut attains the pre set torque the torque wrench sounds and further rotation of box type wrench stops.

Tightening torque of different engine assemblies:-

A) Cummins KTA 1150 L Engine.

a) Cylinder head cap screw torque value

Step No.	Cadmium Plated Cap-screws (Silver Cad Color)

b) Fly-wheel and fly wheel housing

Fly wheel	New min.	New max.

c) Vibration damper and adapter

Vibration damper alignment mark (rubber) ± 1/16”

Torque value	New min. ft-lb [N-m]	New max. ft-lb [N-m]
Vibration damper (rubber) to crankshaft	160 [217]	180 [244]
Vibration damper adapter to crankshaft	320 [434]	340 [461]
Vibration damper to adapter	65 [88]	75[102]

NOTE: other torque values may be obtained from KTA 1150 Diesel Engine Shop Manual.

B) Duetz BF12L 513 C Engine

Location	Torque (Nm)
Rocker cover	8.5
Rocker arm setscrew	21
Mount flywheel side	187
Mount turbocharger side	8.5
Air intake manifold	21
Exhaust manifolds	50
Oil drain plug	16
Injector mounting	30
Injection line mounting oil pan (cast iron)	29
Oil pan (sheet metal)	21
Ref.-operating manual.	

C) MWM TBD 232 V12 Engine.

Description	Torque in kg-m
Cylinder head bolt	21.0
Flywheel bolt	26.0
Crankshaft pulley bolt	21.0
Water pump pulley nut	16.0
Flywheel housing bolt	8.0
Vibration damper	8.0
Fuel pump coupling Allen screw	4.5
Main bearing bolt	28.0
Connecting rod bolt (12.9)	25.0
Connecting rod bolt (10.9)	21.0
Engine foot bolt	8.0

Clearance of moving parts:-

A)Cummins Engine

Crankshaft end clearance- Inch (mm)

Engine series	New minimum	New maximum	Worn Limit

B) MWM TBD 232 V12 Engine

End float	**mm**
Crankshaft	0.1-0.26
Camshaft	0.1-0.29
Balance shaft	0.1-0.29
Run out maximum	**mm**

Sub-discipline:- INTERNAL COMBUSTON ENGINE (Lessons: X Sessions: 49)
Lesson-X: Maintenance Steps Session-47-49: 1 day visit to TM Workshop, PD/ MGS

(A) To see & note down the various components of a dismantled I. C. Engine available at **TM Workshop, PD/ MGS; such as**

1. Deutz Engine
2. MWM Engine
3. Cummins Engine
4. Kirloskar Engine etc.

(B) To see & note down the various components of Workshop Machines available at **TM Workshop, PD/ MGS**; Such as

1. Lathe Machines
2. Radial drill Machine
3. Shaper
4. Planner etc.

(C) To see & note down the various components of Track Maintenance Machines available at **TM Workshop, PD/ MGS**; Such as

1. SBCM
2. BCM
3. BRM
4. Plain Track Tampers
5. Points & Crossing Tampers
6. Track Laying Machines etc.

SUB: INTERNAL COMBUSTION ENGINE & WORKSHOP TECHNOLOGY
Duration: 80 Sessions = 160 Periods
Sub-discipline:- Metallurgical & Chemical training (Lessons: I Sessions: 6)
Lesson-I: M & C Trainings. Session-4: Heat Treatment: Hardening, Tempering, Annealing, Normalizing, Case Hardening, Nitring.

HEAT TREATMENT PROCESS

1) **ANNEALING:**

Refine the grains and provide homogenous structure
Relive internal stress
Soften the metal – improves the machinability

A) ***Full annealing:*** Increase in ductility and softness.

-Complete phase recrystallisation takes place, hence all imperfections wiped out.
-Heat it from 30°c to 50 °c above upper critical temperature for hypo-eutectoid steel and by the same amount above lower critical temperature for hypereutectoid steels.
-Hold at that temperature for sufficient time.
-Cool slowly (in furnace 10 to 30°c per hour upto 30°c below LCT. then air cool it to room temperature(embed in sand, lime, mica, ash etc.)
-Structure (Heating) à Austenite (Cooling) à coarse pearlite + ferrite or coarse pearlite + cementite.

B) ***Process annealing:*** Ductility and softness will increase. Cheaper and quicker than full annealing

-Heat it to the temperature slightly below the L.C.T (550°c to 650°c).
-Hold for sufficient time at that temperature.
-Cool at slower rate in air.

C) ***Spherodise annealing:*** To produce well dispersed spheroids of cementite in ferrite matrix.

<u>For high carbon steels</u>:-

-Heat it slightly above the LCT.(730-770 degree c).
-Hold at this temperature for sufficient time.
-Cool in furnace upto 600 to 500°c followed by slow cooling in still air.

<u>For tool steels and high alloy steels:-</u>

-Heat to the range of 750 to 800°c or even higher.
-Hold at this temperature for several hours

-Cool it slowly.

D) ***Diffusion annealing:*** Used for steel casting before applying full annealing. It removes the heterogeneity in chemical composition of steel ingots and heavy castings. Full annealing will provide fine grained structure.

-Heat it to the range of 1100 to 1200°c where diffusion occurs and austenite grains are homogenized.
-Hold at diffusion temperature for a short period of time to allow complete diffusion.
-Keep it inside the furnace for 6-8 hours à cool down to 800 to 850°c.
-Then cool in air to room temperature.

E) Iso-thermal annealing: Total annealing time is considerably reduced.

-Heating to austenite state (above UCT)
-Cool it to the range of 630 to 680°c at relative faster rate.
-Hold at this temperature isothermally for some time.
-Cool to room temperature at rapid rate.

During isothermal holding full decomposition of pearlite structure takes place & it is advantage for alloy steel which otherwise will consume lot of time in slow cooling for attaining a pearlitic structure.

2**) NORMALISING:** Removal of internal stress, grains become fine, improves impact strength.

-Heat it to the range of 40 to 50°c over the higher critical point.
-Hold at that temperature for relatively short time (15 minutes).
-Cool it in still air at room temperature.
Austenite à Ferrite + pearlite for hypoeutectoid steels
à Total pearlite for eutectoid steels.
à Pearlite + cementite for hyper eutectoid steels
à Sorbite + ferrite in case of alloy steels.
In compare to annealing, normalized steels is less ductile but stronger and harder.
To improve mechanical property normalizing preferred.
To attain better machinablity, softening and greater removal of internal stress annealing is preferred.

3) **HARDENING:** This is applied to all cutting tools, dies, heavy duty machine parts.

-Heating to hardening range *i.e.* 30 to 50°c above UCT for hypoeutectoid steel and by same range above LCT for hypereutecoid steels.
-Hold at that temperature for sufficient time to attain austenitic structure.
-Quenching (water, oil or salt bath)
- (Heating) à Austenite (quenching) à martensite -very hard substance – renders hardness and brittleness.
More carbon percentage à more hardness
Lower % of carbon à higher required cooling rate
Hardening is followed by tempering to remove extra brittleness etc.

4) **MARTEMPERING:** Misnomer – not tempering but hardening process.

-Heating to hardening range.
-Quenching in a salt bath maintained at temperature slightly above at which martensite formation starts (150-300°c).Soaked in bath till its temperature comes down to bath temperature - not for a longer period lest austenite starts decomposing.
-Remove. Cool to the room temperature in air or oil.
During the second cooling process austenite transforms to the martensite.
2 steps of cooling results in martensite with retained austenite
Chances of warping are very less. Residual stress will be minimized.

5) **AUSTEMPERING**: It combines the good effect of hardening and tempering. It is employed for high carbon steel having thin sections for good resistance to impact.

-Heat metal to usual hardening range.
-Hold the temperature for sufficient time to change to austenite
-Quench in salt bath maintained at temperature range of 300 to 350°c. Isothermal transformation of austenite to accicular troosite or bainite.
-Remove. Cool down to room temperature in natural course.
Faster than hardening and tempering
Strength and ductility increases and chances of distortion minimized.

6) **AUSFORMING**: Very high ductility and strength, creep strength, toughness, longer fatigue life will be obtained.

-Heat it to austenite temperature.
-Metal is cooled by quenching, to a temperature which lies between the temperature ranges of pearlite formation and bainite formation.
-Metal so cooled is capable of retaining its austenitic structure for sometime. In this state itself the metal is subjected to plastic deformation.
-Metal cooled down to room temperature either in air or by quenching.
-If cooled in air it forms bainite structure and in quenching process metal turns into martensite structure (can be then tempered).

7) **TEMPERING**: It is a subsequent treatment after hardening to improve toughness at the cost of some strength and hardness.

-Especially true in case of tools.
-Some martensite (tempering) à ferrite and cementite
-Reheat to a temperature below LCT.
-Hold the temperature for sufficient time.
-Cool down slowly to room temperature.
-For good impact heat the metal to the range of 300 to 350°c.

8) **CASE HARDENING**: To produce hard wear resistant and shock resistant surface having tough core. Also known as carburizing

-Heat the steel to red hot.
-Force carbon content into surface.
-Carbon is infused from CO gas at elevated temperature (870 – 950°c)
It is employed for low carbon content metals like wrought iron, mild steel.
It is performed in two stages carburizing & hardening.
Three methods of carburizing

a) Pack carburizing
b) Liquid carburizing
c) Gas carburizing

9) **NITRIDING**: Surface hardening process. Increase the fatigue resistance.

-Metal will absorb nitrogen (no quenching).
-Alloys carrying Cr, N, Al, Mo & V responds best (nitride forming elements).

A) ***GAS NITRIDING***

-Heating in the atmosphere of ammonia between 480 – 630 °c.
-Hold for a fairly long period.
-Ammonia decomposes – nitride is formed.
Degree of hardness is highest.
A case depth of 0.5mm may take 2 to 3 days.

B) ***SALT BATH NITRIDING***: It is suitable for nitriding of cutting tools.

-Liquid salt bath is heated to 480 – 590°c and maintained.
-Parts suspended for soaking for a long period

-Part removed (No quenching).

10) **CYNIDING**: Surface finish not deteriorated, chances of cracks and distortion are minimized. It is a type of case hardening process. Used for producing hard cases on low and medium carbon steel.

-Metal absorbs carbon and nitrogen to acquire a hardened surface layer.
-Heat metal in molten salt bath about 800 to 950°c.
-A salt bath typical combination- sodium cyanide, sodium chloride and sodium carbonate in equal proportions.
-After soaking for required period at proper temperature the steel piece is removed.
-Quenched in water, brine or oil.

SUB: INTERNAL COMBUSTION ENGINE & WORKSHOP TECHNOLOGY
Duration: 80 Sessions = 160 Periods
Sub-discipline:- Workshop Technology (Lessons: VIII Sessions: 25)
Lesson-I: Smithing and Forging. **Session-1**: Forging Materials, Heating Devices, Forging Temperatures, Smith Forging Operations

---

FORGING MATERIALS

In all plastic deformation processes such as in forgings, the work piece calls for materials that should possess a property describe as ductility – that is, the ability to sustain substantial plastic deformation without fracture even in the presence of tensile stresses. If failure occurs it occurs by the mechanism of ductile fracture and is induced by tensile stresses. A material of a given ductility may fare very differently in various processes, depending on the conditions imposed on it. Therefore, it is proper to think of a more complex property called work-ability in plastic deformation processes, and forge-ability in forging processes. All one can say is that wrought alloys must possess a minimum ductility that the desired shape should possess.

Forgeable Metals

This requirement of wrought metals is amply satisfied by all pure metals with sufficient number of slip planes, and also by most solid solution alloys of the same metals. Two-phase and multi-phase materials are deformable if they meet certain minimum requirements.
Almost all commonly used metals and alloys satisfy these minimum requirements, and can be used for forging. The low and medium carbon steels are readily forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. The metals and alloys which are forged include carbon steels; alloy steels including stainless steels, Wrought iron; copper-base alloys, nickel and nickel copper alloys; aluminum alloys and magnesium alloys. Low carbon and low alloy steels and aluminum alloys account for over half the total tonnage. Stainless steels, nickel-based super alloys, and titanium are forged, especially for aerospace uses.
The metal of alloy to be forged is usually purchased as hot rolled bars or billets with round or rectangular cross sections.

Forge ability

The basic lattice structure of metals and their alloys seems to be a good index to their relative forge ability or workability. Forge ability increases with temperature up to a point at which a second phase, e.g., from ferrite to austenite in steel, appears or if grain growth becomes excessive. Certain mechanical properties also influence forge ability. Metals which have low ductility have reduced forge ability at higher strain rates, whereas highly ductile metals are not so strongly affected by increasing strain rates.

Good	Some what difficult	Difficult	Very difficult

Aluminum alloys	Martensitic stainless	Titanium alloys	Nickel-base alloy
Magnesium	Maraging steel	Iron-base super alloys	Tungsten alloy
Copper alloys	Austenitic stainless	Cobalt base supper alloys	Beryllium
Carbon and alloy steels	Nickel alloys Semi-austenitic stainless	Columbium alloys Tantalum alloys	Molybdenum alloys

HEATING DEVICES

The stocks are heated to the correct forging temperature in a smith's hearth or in a furnace located near the forging operations. Gas, oil or electric-resistance furnaces or induction heating classified as open or closed hearths can be used. Gas and oil are economical, easily controlled, and mostly used as fuels.

FORGING TEMPERATURES

For forging, a metal must be heated to a temperature at which it will possess high plastic properties both at the beginning and at the end of the forging process. For instance, the temperature to begin the forging for soft, low carbon steel is 1250^0C to 1300^0C, the temperature to finish forging is 800^0C to 850^0C. The respective temperature for hard, high carbon and alloy steels are 1100^0C to 1150^0C and 825^0C to 875^0C. Wrought iron is best forged at a temperature little below 1300^0C. Nonferrous alloys like brass and bronze are heated to about 600 to 950^0, and aluminum and magnesium alloys to about 350^0C to 500^0C.

SMITH FORGING OPERATIONS

A number of operations are used to change the shape of the raw material to the finished form. The typical forging operations are:

1. Upsetting.
2. Drawing down.
3. Setting down
4. Punching.
5. Bending.
6. Welding.
7. Cutting.
8. Fullering.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-I: Smithing and Forging. Session-2: Forging processes: Hand forging, Power Forging etc.

Hand forging: - The forging is done by hammering the piece of metal, when it is heated to the proper temperature, on an *anvil*. While hammering, the heated metal is generally held with suitable tongs. *Formers* are held on the forging by the smith while the other end is struck with a sledge by a helper. The surfaces of *former* have different shapes, and they are used to impart these shapes to the forgings. One type of former, called a *fuller*, having a well-rounded chisel-shaped edge is used to draw out the work. Fullers are also made as anvil fitting so that the metal can be drawn out, using both top and bottom fullers. Anvil of various shapes can be placed in the square hole of the anvil. For cutting the metal, hot *chisel* are used. *Punches* and *block* having proper-sized opening are used for punching out holes. *Welding* can be done by shaping the surface to be welded, removing any scale or impurities from between the surfaces with a flux, and hammering the surfaces together.

Hand forging is employed only to shape a small number of light forgings chiefly in repair shops. Hand forging has, of recent years, been superseded by power forging.

Power forging: Large machine part cannot be forged by hand, since the comparatively light blow of a hand-or sledge-hammer is unable to produce a great degree of deformation in the metal being forged. Moreover, hand forging is a lengthy process and requires repeated heating of the metal. This has led to the use of power hammers and presses in forging. Machines which work on forgings by blow are called *hammers,* while those working by pressure are called *presses.*

POWER HAMMERS:-

All power hammers employ the same general principle of operation, a falling weight striking the blow, with the entire energy being absorbed by the work. Where further blows are necessary, the striking weight is raised for the succeeding blow. Some hammers employ only a gravity fall, the energy delivered on the work being the product of the weight of the hammer head and the distance of the fall. Other hammers increase the striking velocity of the hammer head by mechanical means.

The part of the hammer which serves as a rigid support during forging is called the *anvil block.* The anvil block of a forging hammer is built on a foundation separate form the frame so that the shock of the hammer blows will be cushioned by the foundation and will not be transmitted to the frames. The heavy falling part of the hammer is called the *ram.* The anvil block and the ram each has one die called upper-die and lower-die respectively for squeezing the metal to be forged. In smith forging, the working surfaces of both the upper and lower dies are flat and horizontal.

Hammers are classified as mechanical and air- and steam- hammers. In turn, the former is further classified into helve and trip hammer, lever spring hammer, and pneumatic hammer. Air- and steam-hammers are sub-classified into single and double acting hammers. The *capacity* of a hammer is determined by the weight of the falling parts. The weight of the anvil and the reciprocating parts usually has a ration of 15 to 1 (anvil block).

HELVE HAMMERS: Helve hammers are well adapted for general engineering work where the size of the stock is changed frequently. They consist of a *horizontal* wooden helve, pivoted at one end with a hammer at the other end. An adjustable eccentric between the pivot and the hammer end operates the helve. The eccentric raises the hammer which when falls strikes a blow. They are made in sizes from 5 to 200 kg.

Trip HAMMERS: Trip hammers have a vertically reciprocating ram that is actuated by toggle connection driven by a rotating shaft at the top of the hammer. Trip hammers are also built in sizes from 5 to 200 kg. The stroke range of both helve and trip hammers range from about 400 a minute for small sizes to about 175 for large sizes.

Lever –Spring HAMMERS: They are mechanical driven hammers with a practically constant lift ad an insignificantly variable striking power. It only increases with increasing operating speed and thus has increased number of strokes per minute. The ram is driven from rocking lever acting on an elastic rod. The rocking lever consists of a leaf spring so that an elastic drive is brought about.

They are suitable for drawing out and flattening small forgings produced in large numbers their disadvantage is the frequent breaking of springs due to vibrations when in operation.

Spring hammers are built with rams weighing from 30 to 250 kg. The number of strokes varies from 200 to 40 minutes.

Pneumatic hammers: The hammer has two cylinders: compressor cylinder and ram cylinder. Piston of the compressor cylinder compress air, and delivers it to the ram cylinder where it actuates the piston which is integral with ram delivering the blows to the work. The reciprocation of the compression piston is obtained from a crank drive which is powered form a motor through a reducing gear. The air distribution device between the two cylinders consists of rotary valves with ports through which `air passes into the ram cylinder, blow and above the piston, alternately. This drives the ram up and down respectively.

The size of pneumatic hammer may vary in a range form 50 to 1000kg. Hammers operated at 70 to 190 blows per minute.

Steam OR AIR AIR-HAMMERS: Steam or air hammers can be operated by steam or compressed air. They have no built-in compressor and, therefore, require additional facilities for supplying high pressure steam or compressed air to raise the striking stroke.

Both single-acting and double acting steam or air hammer may be constructed for forging. Single acting is made for comparatively light work, while double-acting is made for heave work. Steam pressure at the hammer is usually 6 to 9 kgf per sq. cm. (590 to 790 kN/m^2) and air pressure is bit smaller than that required for steam.

Rated size of steam forging hammers range from about 400 to 8,000 kg.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-II: Welding and Related Processes. Session-3: Types of Welding and Metallurgy of weld

---

Introduction:

Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of filler material.

Weldability:

The term "weldability" has been defined as the capacity of being welded into inseparable joints having specified properties such as definite weld strength, proper structure etc.

TYPES OF WELDING:

Modern methods of welding may be classified under two broad heading: (1) plastic welding and (2) fusion welding. They are also called pressure welding, and non-pressure welding, respectively.

` In the plastic welding or pressure welding, the pieces of metal to be joined are heated to a plastic state and then forced together by external pressure. This procedure is used in forge welding, resistance welding, "thermit" welding, and gas welding, in which pressure is required.

In the fusion welding or non-pressure welding, the material at the joint is heated to a molten state and allowed to solidify. This includes gas welding, are welding, "thermit welding, etc.

It is seen, therefore, that except in cold-welding heat is used to bring about a plastic or molten state at the surface of the metal to be joined. In cold-welding, the joints are produced without the application of heat, but by applying pressure which results in inter surface molecular fusion of the parts to be joined. This process is mainly used for welding nonferrous sheet metal, particularly aluminium and its alloys.

MATALLURGY OF WELD

Knowledge of what happens in metal when it is welded is necessary for an understanding of the welding operation, and is explained hereunder:

Fusion Welding:

In the weld metal, whether melted from the edges to be joined (autogenous welding), or supplied separately, solidifies from the liquid state and usually below the recrystallization temperature without any applied deformation. Fusion welds are, therefore, essentially castings. Since the surrounding parts are good conductors of heat the fusion weld may be called a chilled casting, and its structure will, therefore, usually be columnar (dendritic). The actual crystalline structure presents, however, depends primarily on the number of "runs" made to deposit the weld metal.

In a single-run weld, long columnar crystals will grow outwards from the sides of the weld. If the temperature is high enough these columnar crystals will meet at the centre of the weld deposit forming a plane of weakness. This will eventually cause intercrystalline cracking within the weld. If, on the other hand, the welding temperature is correct, ***equiaxed*** grains will form at the centre resulting in an appreciably stronger joint.

A multi-run welding exhibits a quite different structure. The first run, as before, shows the structure for a single-run weld. In ordinary steels, the second run normalizes the first layer, causing a considerably degree of grain refinement. Each successive run thus normalizes the preceding one so that the final deposits exhibit the coarse cast structure typical of a single-run weld. However, in a multi-run weld the possibility of defects such as slag and gas inclusions will increase.

Slag inclusions are frequently trapped in fusion welds due to bead contour and the difficulty of melting the slag in subsequent runs. In metallic arc welds, in mild steel, microscopic inclusions are also present. Controlled amounts of nitrogen and manganese together with a dispersion of fine nonmetallic inclusions and especially a fine grain size with high dislocation density provide strengths of 43 to 57 kgf/mm^2 (430 to 570 N/mm^2) with adequate ductility to mild steel arc welds.The contour of welds by forming ‘notches’ can affect both fatigue and low temperature properties of a structure.

Gas solubility in liquid and solid weld metals, and gas reaction, are important in controlling the porosity of a weld. Metallic arc welds made with a bare wire are liable to contamination by gases from the atmosphere. The nitrogen of the atmosphere frequently appears as needles on certain planes in the crystals in the long run. This causes low impact strength especially after water quench.

The stresses set up in the weld by shrinkage are often of considerable importance as they are found to be responsible for weld metal cracking. These stresses may be relieved by annealing the entire object after welding is finished.

In brief, the action of the atmosphere on the melted metal, its fluidity and surface tension, the solidification process including segregation and shrinkage, all play their anticipated important roles as in castings.

Pressure Welding:

In pressure welding process, the metal in the joint is heated to the plastic condition, or above, and compressed while hot.

GAS WELDING

Gas welding is done by burning a combustible gas with air or oxygen in a concentrated flame of high temperature. As with other welding methods, the purpose of the flame is to heat and melt the parent metal and filler rod of a joint.

OXY-ACETYLENE WELDING

Oxy-acetylene gas welding is accomplished by melting the edges or surface to be joined by gas flame and allowing the molten metal to flow together, thus forming a solid continuous joint upon cooling. This process is particularly suitable for joining metal sheets and plates having thickness of 2 to 50mm. With materials thicker than 15mm, additional metal called filler metal is added to the weld in the form of welding rod. The composition of the filler rod is usually the same or nearly the same as that of the part being welded. To remove the impurities and oxides present on the surfaces of metal to be joined and to obtain a satisfactory bond a flux is always employed during the welding except mild steel. The temperature of the oxy-acetylene flame in its hottest region is about $3,200^0$C.

Gas Flame:

When oxygen and acetylene are supplied to the torch in nearly equal volumes, a neutral flame is produced having a maximum temperature of $3,200^0$C. This neutral flame is desired for most welding operations, but in certain cases a slightly oxidizing flame, in which there is an excess of oxygen or slightly carburizing flame, in which there is an excess of acetylene is needed. The condition of the flame is readily determined by its appearance. A carburizing flame is one in which there is an excess of acetylene. When welding steel, this will tend to give the steel in the weld a higher carbon content than the parent metal, resulting in a hard and brittle weld. This flame is necessary for welding brass.

Gas Cylinders:

Oxygen gas in cylinders is usually charged with about 40 liters of oxygen at a pressure of about 154 kgf per sq. cm (15400kN/m^2) at 21^0C. A full cylinder has the weight of about 80kg. Acetylene gas can be manufactured either by the water-to-carbide method or the carbide-to-water method.

High pressure acetylene cylinders are charged to a pressure of about 1 kgf per sq cm (100kN/m^2) It is not allowed to bring acetylene to a pressure over 2kgf per sq. cm (200kN/m2) otherwise it decomposes and explodes. The cylinder is therefore packed with 80 per cent porous material such as asbestos, balsawood, charcoal, industrial earth, silk fiber or kapok.

The are column is generated between an anode, which is the positive pole of de (direct current) power supply, and the cathode, the negative pole. When these two conductors of an

electric circuit are brought together and separated for a small distance (2 to 4mm) such that the current continues to flow through a path of ionized particles (gaseous medium), called plasma, an electric are is formed. This ionized gas column acts as a high resistance conductor that enables more ions to flow from the anode to the cathode. Heat is generated as the ions strike the cathode. Approximately 1 KWH of electricity will create 250 calories (1000J), the temperature of an electric are, of course, depends upon the type of electrodes between which it is struck.

The heat of the air raises the temperature of the parent metal which is melted forming a pool of molten metal. The electrode metal or welding rod is also melted and is transferred into the metal in the form of globules of molten metal. The deposited metal serves to fill and bond the joint, or to fuse and build up the parent metal surface. Two thirds of the heat is developed near the negative pole. As a result, an electrode that is connected to the positive pole will burn away approximately 50 per cent faster than that is connected to the negative pole. This is helpful in obtaining the desired penetration of the base metal.

AIR-ACETYLENE WELDING

This process uses a torch similar to a Bunsen burner and operates on the Bunsen burner principle. The air is drawn into the torch as required and mixed with the fuel gas. The gas is then ejected and ignited, producing an air-fuel flame. The common fuels used in the air-fuel welding are acetylene, natural gas, propane and butane. This type of welding has limited use in since the temperature is lower than that attained by other gas processes. The air-fuel welding processes are used successfully in lead welding and many low-melting-temperature metals and alloys such in brazing and soldering processes.

OXY-HYDROGEN WELDING

The oxygen-hydrogen process was once used extensively to weld low-temperature metals such as aluminium, lead and magnesium; but it is not as popular today because more versatile and faster welding process such as TIG (tungsten inert gas) and MIG (metal inert gas) have replaced the oxygen-acetylene system, with the only difference being a *special regulator* used in metering the hydrogen gas.

ARC WELDING EQUIPMENTS

Arc Welding Machine:

Both direct current and alternating current are used for electric arc welding, each having its particular applications; in some cases either is suitable. D.C. welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines. For ac welding supply, transformers are predominantly used for almost all arc welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normal open circuit welding voltage (50-90 volts). A 100 to 200A machine is small but portable and satisfactory for manual welding of average work.

With direct current the greater heat is generated at the positive pole of the arc, and in metal-arc welding, it has been the general practice to connect the work to the positive pole of the D.C. generator and the filler rod to the negative pole, in order to melt the greater mass of metal in the base material. On the other hand, certain types of modern electrodes due to their coating and material properties, are connected advantageously to the positive pole of the generator. The electric energy consumption per kg of deposited metal in a.c. welding is from 3 to 4 kWh while for D.C. welding it is as high as 6 to 10 kWh. One disadvantage of A.C. welding is the comparatively low power factor at the welding station, usually not exceeding 0.3 or 0.4. The motor in a D.C. welding has a power factor of 0.6 to 0.7.

Arc Welding Current and Voltage:

Open circuit voltage (no load voltage), i.e., the voltage needed to strike the arc, is higher than the arc voltage in order to facilitate easy starting of the arc. With direct current, the open-circuit voltage must be at least 30 to 35V.

In a Table gives a survey of permissible intensities of current.

Diameter of Electrode mm	Cross-sectional area of electrode mm^2	Mean Total A	Intensity Per mm^2 A/mm^2
2	3.14	45	14.3
2.5	4.90	70	14.3
3.25	8.29	105	12.7
4	12/56	140	11.1
5	19.63	180	9.4
6	28.27	235	8.3
8	50.26	310	5.9

RESISTANCE WELDING

In resistance welding the metal parts to be joined are heated to a plastic state over a limited are by there resistance to the flow of an electric current and mechanical pressure is used to complete the weld. Recently, with air and hydraulic systems for applying pressure at the correct time and in right amount through electronic controls, resistance welding has been advanced. In this process, preferably two copper electrodes are incorporated in a circuit of low resistance and the metals to be welded are pressed between the electrodes. The circuit is thus completed and the

electrical resistance at the joint of the metals to be welded is so high, in comparison with the rest of the circuit, that if the current is heavy enough the highest temperature will be produced directly at the joint. The heat generated in the weld may be expressed by

$$H = I^2 RT$$

Where H is the heat, I the current, R the resistance of the assembly and T the time or duration of current flow. That is the heat developed by the current is in proportion to the electrical resistance of the joint.

Resistance Welding Methods

The field of resistance welding can be subdivided into several processes, the most important being:

a) Butt.
b) Spot
c) Seam
d) Projection
e) Percussion welding

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-II: Welding and Related Processes. **Session-6:** Welding Related Processes: Soldering, Brazing etc.

WELDING RELATED PROCESSES

SOLDERING

Soldering is the method of uniting two or more pieces of metal by means of a fusible alloy or metal, called *solder*, applied in the molten state. Soldering is divided into two classifications: soft and hard.

Soft soldering is used extensively in sheet-metal work for joining parts that are not exposed to the action of high temperatures and are not subjected to excessive loads and forces. Soft soldering is also employed for joining wires and small parts. The solder, which is mostly composed of lead and tin, has a melting range of 150 to 350 ^{0}C. A suitable flux is always used in soft soldering. Its function is to prevent oxidation of the surfaces to be soldered or to dissolve oxides that settle on the metal surfaces during the heating process.

The different compositions of solder for different purpose are as follows :

1. Soft solder – lead 37 percent, tin 63 percent.
2. Medium solder – lead 50 percent, tin 50 percent.
3. Plumber's solder – lead 70 percent, tin 30 percent.
4. Electrician's solder – lead 58 percent, tin 42 percent.

Hard soldering employs solders which melt at higher temperatures and are stronger than those used in soft soldering. *Silver soldering* is a hard soldering method, and silver alloyed with tin is used as solder.

BRAZING

Brazing is essentially similar to soldering, but it gives a much stronger joint than soldering. The principal difference is the use of a harder filter material commercially known as *spelter*, which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined. Filler metals used in this process may be divided into two classes: copper-base alloys, and silver-base alloys.

Silver alloys (silver and copper or silver, copper and zinc) having a melting range of 600 to 850^{0}C are suitable for brazing any metals capable of being brazed. They give a clean finish and a strong ductile joint.

The parts to be joined by brazing are carefully cleaned, the flux applied and the parts clamped in position for joining. Borax is widely used flux, but many proprietary brands are available. They are then heated to a temperature above the melting point of the spelter to be used, and molten spelter is allowed to flow by capillary action into the space between the parts and to cool slowly. The actual heating may be done in a number of ways. *Torch brazing* in which heating is done by a blow torch is very common. *Furnace brazing*, particularly in controlled atmospheres, is a favourite for production. Induction heating is useful to confine the heat to the joint, if general heating must be avoided. *Resistance brazing* is done on some small parts in production. *Immersion brazing* is used in large scale production. The parts are cleaned and fluxed, clamped together, and then immersed into a tank of molten spelter.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-II: Welding and Related Processes Session-7: Procedure for welding of tamping tool and defects in tamping tool welding.

PROCEDURE FOR WELDING OF TAMPING TOOL

After continuous working with Tamping tools, these tools need reconditioning as the tools gets worn out. Maximum 20% wear in X-section area is allowed. For the purpose of reconditioning of Tamping tools hard facing electrodes are used. Normally Cithorial-3 L & T electrodes are used for the welding of tamping tools. With the help of hard facing electrodes a layer of sufficient thickness matching with the parent surface is made. Front size of 140 X 70 mm and side thickness 20 mm at top & 5 mm at bottom is maintained. The reconditioning work is done by electric Arc welding.

Following precautions should be observed while welding the Tamping Tool

1. Before recondition of tool, surface should be cleaned properly. It should not contain grease or oil.
2. While reconditioning of Tamping tool, positive supply is given to Electrode and negative supply is given to the tool.
3. A small gap of 2 to 4 mm between Anode and Cathode (Electrode and Work piece is maintained.
4. Hard facing electrode should be used for reconditioning of Tools. Mild Steel electrodes should not be used.
5. Continuous welding should not be done to avoid excess heat generation.
6. One welding layer should be cooled up to hand bearing temperature, and then another layer should be welded.

DEFECTS IN TAMPING TOOL WELDING

1. Incomplete penetration: – It occurs due to improper cleaning of surface.
2. Lack of fusion: – Due to improper Electrode.
3. Under cutting: – It happens due to high current and more Arc gap.
4. Shape deformation:- Due to excess heat generation.
5. Size defects.
6. Slag inclusion.
7. Porosity.
8. Burnt metal.
9. Cracks.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-II: Welding and Related Processes. Session-8: Welding of BCM turret gears, Main links, Intermediate links and cutter bar and grinding operation.

Welding of BCM (Turret gear) Dredger Drum:

For the purpose of welding of dredger drum of BCM, 2B Electrode L&T is used to recondition and hardness is maintained to 350 BHN. The process of welding is done at slow rate and also at the same time, excess heat should not develop other wise it will be subjected to deformation. It is then done in different layers. Afterwards the grinding is done to give proper shape to the component. Templates are also used to guide the Welder or the Grinder.

Main (Links) Shovel and Intermediate (Links) Shovel Welding:

The welding of shovel is done by high manganese electrodes as 12 to 14% Mn is available in the parent material. Mostly L&T and more Mn-electrodes electrodes are used. For the purpose of welding templates are also used.

Method of Welding:

The job is immersed in a container up to ½ portions. Then the welding is done at the portion which is out of water and then the job is reversed to weld the other half portion. This method is adopted to avoid cracking of material. The welding is done at slow-rate as heat generation is very high. Excess temperature should not be allowed

Welding of Cutter Bar:

For the purpose of welding of cutter bar, worn out portion is removed through gas cutting and either a new plate or flange of rail is welded by M.S. Rod. Uniform welding is to be done otherwise it is subjected to deformation.

Grinding Operation:

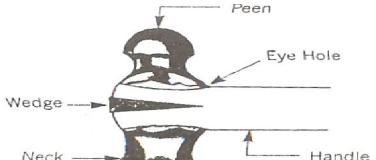
Grinding is done by hand grinder.

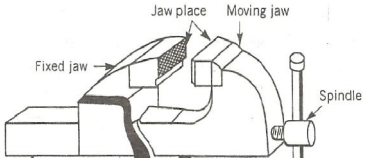
SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-II: Bench Work and Fitting. **Session-9:** Various tools, their uses and Bench work.

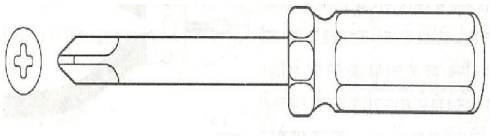
COMMON HAND TOOLS

1. Hammers: - Hammers are of following types :- (i) Ball peen hammer(ii) Cross peen hammer(iii) Claw hammer(iv) Double face hammer(v) Mallet hammer or Soft hammer.

2. Vice: - It consists of one fix jaw and another movable jaw; jaw plates are fixed to the jaws by set screws and replaced when worn out. Jaw plates have cross-cut for gripping the job. The size of the vice is known by the width of its jaws. The width suitable for common work varies from 80 to 140mm, the maximum opening being 95 to 180mm.





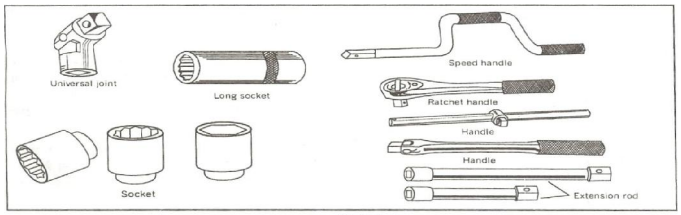


3. Screw Driver: - It consists three main parts: - (i) Handle (ii) Shank (iii) Blade or tip
According to length of shank, screw drivers are of various sizes. According to shape the screw drivers used on machine are - (a) Standard screw driver. (b)Philips screw driver.
Safety precautions:-1. Small jobs should not be kept in hand while using screw driver.
2. Don't use screw driver with oily hand.

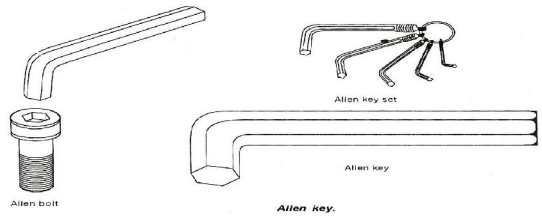
4. Pliers: - Following pliers comes in our use-(i) Combination pliers (ii) Long nose pliers (iii) Side cutting pliers (iv) Adjustable pliers(v) Circlip pliers (External and internal)

5. Spanner and Wrenches: - These are of following types: - (i) Open ended spanner (ii) Box Type spanner (iii) Adjustable spanner (iv) C-Spanner
(i) Open ended spanner: - These are of two types (a) Single ended spanner (b) Double ended spanner.
(ii) Box type spanner: - These are of following types: - (a) Ring spanner (b) Socket spanner (c) Tubular spanner.
(**iii) Adjustable spanner:** These are of following types: - (a) Screw wrench (b) Pipe wrench
(**iv) C-Spanner:** - This is used for opening and tightening of round nuts. There are single or double slots in the round nuts, by which the nuts can be opened or tightened.

6. Allen key: - There are six sides on these spanners and are used for opening and tightening the Allen screw or Allen bolts. These are available in inch and mm sizes.



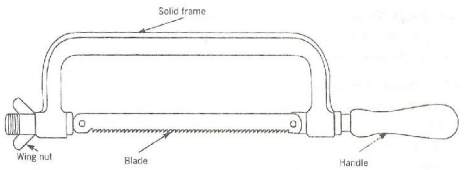
Socket set.



Allen key.

7. Stud extractor: - This is used for removing broken bolts or studs.
8. Chisels: -(i) Hot chisel (ii) Cold chisel: - This is used in workshop for cutting cold irons. This is made of high carbon steel. As per requirement of job it is also made of tool steel or cast steel.

9. Hacksaw: - It consists two main parts- (i) Frame
(ii) Blade: - Blades are generally made of high carbon steel, high speed steel or low alloy steel and tempered.



Fixed Hacksaw Frame.

Precautions: - (i) A cut should be marked by a triangular file.
(ii) Hacksaw should be driven slowly at the start.
(iii) Force should be more in forward stroke and less in return stroke.
(iv) During end of cut, job should be held by hand at one end and hacksaw should be driven slowly.
(v) Drive 40-50 strokes in one minute.
(vi) Blade should be driven in full length.
(vii) Blade should be driven straight.
(viii) Force should be applied according to material.

10. Files: - According to shape or section files are of following types:-1. Hand files 2.Flat files 3. Half round files 4.Triangular files 5. Square files 6. Round files 7. Knife edge files 8. Needle file set.

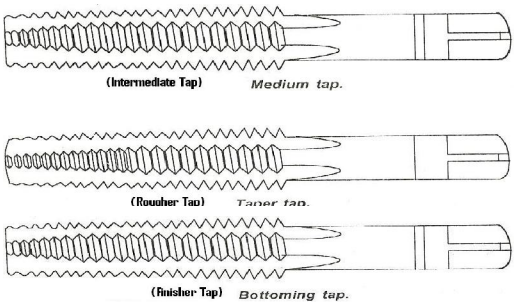
Precautions: - (i) Make sure that the handle is firmly fixed to the file.
(ii) Job surface and file surface should be free from any oil or grease.

(iii) Files are brittle hence should be placed carefully.
(iv) Files should be operated in full length on the job.
(v) Any rust on the job surface should be cleaned by file nose.
(vi) Files should not be operated too fast on the job.

11. Drill: - It is made of High carbon steel: - For soft metals. High speed steel: - For hard metals. Twisted fluted drill is used for metal works. Lip angle for general work is 118°.

Precautions: - (i) Cutting edge of drill should be sharp. Blunt cutting edge should be ground on grinder to make sharp. The length of the both cutting edges should be kept equal.
(ii) Before drilling make a mark on the job by centre punch.
(iii) Drill should be tightened properly by key in the chuck.
(iv) Small diameter drill should be given more speed and less pressure.
(v) Coolant should be used during drilling.

12. Taps: - There are generally three taps in a set
(i) Rougher Tap (Taper Tap): -6-8 threads are ground in taper.
(ii) Intermediate Tap (Medium Tap): - 3-5 threads are ground in taper.
(iii) Finisher Tap (Bottoming Tap): - 1-2 threads are ground in taper.



Tap Wrench: - It is a tool for holding the tap. It is also called a tap handle.

Tap-Drill size: - Drill size should be proper in accordance with tap size for exact cutting of threads.

Formula: - T.D.S = T.S-2d Where, T.D.S = Tap drill size
D = 0.61p T.S = Tap size
Thumb rule: - T.D.S= T.S*0.8 P = Pitch= 1/Thread per inch

Precautions: - (i) Hole size should be proper in accordance with tap size.
(ii) Taps should be operated in correct sequence of rougher, intermediate and finisher.
(iii) Tap should be moved quarter round back for half round forward.
(iv) Tap handle should be kept balance.

13. Scrapers: - Three types of scrapers are mostly used: -
(i) Flat scrapers. (ii) Half round scrapers. (iii) Triangular scrapers.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-II: Measurement and inspection. Session-10: Standards of Measurement, Classification of Measuring Instruments and Linear Measurement.

MEASUREMENT AND INSPECTION:

A measuring instrument is any device that may be used to obtain a dimensional or surface measurement. While a gauge is intended for quickly checking parts in production that is to determine whether or not a dimension is within its specified limits. A gauge usually does not reveal the actual size of dimension.

Standards of Measurement: International standard meter has been defined in terms of a wavelength of light, being the length equal to 1650 763.73 vacuum wave lengths of orange radiation of Krypton-85.

Line and End Standards:

The length standard can be classified as the line standard and end standard. In the length standard, the unit of length is defined as the distance between the centers of engraved lines as in a steel rule, whereas in the end standards it is the distance between the end faces of the standard as in a micrometer.

Classification of Measuring Instruments:

1. **Precision Instruments:**
   Precision instruments are those which have the ability to measures parts within an accuracy of 0.01mm or more.
2. **Non-precision:**
   Non-precision instruments are limited to the measurement of parts to a visible line graduation on the instrument used, such as a graduated rule or scale.

External Micrometer:

The essential parts of the instrument are as follows:

1. **Frame:** The frame is made of steel, cast steel, malleable cast iron or light alloy.
2. **Hardened anvil:** The anvil shall protrude from the frame for a distance of at least 3mm in order to permit of the attachment of a measuring wire support.
3. **Screwed spindle**. This spindle does the actual measuring and possesses threads of 0.5mm pitch.
4. **Graduated sleeve or barrel**. It has datum or fiducial line and fixed graduations.
5. **Thimble**. This is a tubular cover fastened with the spindle and moves with the spindle. The beveled edge of the thimble is divided into 50 equal parts, every fifth being numbered.
6. **Ratchet or friction stop**. This is a small extension to the thimble. The ratchet slips when the pressure on the screw exceeds a certain amount. This produces uniform reading and prevents any damage of distortion of the instrument.
7. **Spindle clamp or clamp ring.** This is used to lock the instrument at any desired setting.

Reading: The graduation on the barrel is in two parts, namely one above the reference line and the other below. The graduation above the reference line is graduated in 1mm intervals. The first and every fifth are long and numbered 0, 5, 10, 15, 20, and 25. The lower graduations are graduated in 1 mm intervals but each graduation shall be placed at the middle of the two successive upper graduations to be read 0.5mm.

The micrometer screw has a pitch of 0.5mm, while the thimble has a scale of 50 divisions round its circumference. Thus, on going through one complete turn, the thimble moves forward or backward by one thread pitch of 0.5 mm and one division of thimble is 0.01 mm.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (LESSONS: VIII SESSIONS: 25)
Lesson-II: Measurement and inspection. **Session-11:** Comparators, Measuring machines, Angular and Taper Measurements.

Comparators:
Comparators are instruments which derive their name from the fact that they are used for simple and accurate comparison of parts as well as working gauges and instruments with standard precision gauge blocks, comparators of every type incorporate some kind of magnifying device to magnify how much a dimension deviates, plus or minus, from an ideal. The common types are:

1. Mechanical Comparators
2. Electrical Comparators
3. Optical Comparators
4. Pneumatic Comparators.

Mechanical Comparators:
A mechanical comparator employs mechanical means for magnifying the small movement of the measuring stylus brought about due to the difference between the standard and the actual dimension being checked. Mechanical comparators are available having magnifications from 300 to 5000 to 1. Dial indicators as mechanical comparators.

Dial Indicators – The essential parts of the instrument is like a small clock with a plunger projecting at the bottom. Very slight upward pressure on the plunger moves it upward and the

movement is indicated by the dial pointer. The dial is graduated into 100 divisions. A full revolution of the pointer about this scale corresponds to 1mm travel of the plunger. Thus a turn of the hand by one scale division represents a spindle travel of 0.01mm.The indicator is adjusted to zero by either turning the rim of the dial or turning the head of the plunger while holding the dial stationary.

Electrical Comparators:
Electrical Comparators are used as a means of detecting and amplifying small movements of a work contacting elements.
An electrical comparator consists essentially of a pick-up head or transducer for converting a displacement into a corresponding change in current and a meter or recorder connected in the circuit to indicate the electrical change, calibrated to show in terms of displacement. Generally, an amplifier is needed to provide the requisite sensitivity and to match the characteristics of different parts of the circuit. Electrical comparators can be classified according to the electrical principle used in the pick-up head. Most of the comparators use either a differential transformer, an inductance bridge, a strain gauge or a capacitor as a means of detecting movement of the gauging element.

Optical Comparators:
Optical Comparators have a high degree of precision and the magnification is obtained with the help of light beams which have the advantage of being straight and weightless. Optical comparators, therefore, suffer less wear during usage than the mechanical type.

Pneumatic Comparators:
In recent years, pneumatic comparators have been extensively used specially in automatic size control. They are cheap, independent of the contact pressure, and simple to operate. Besides, this form of comparator is free from mechanical wear. However, pneumatic comparators are sensitive to temperature and humidity changes and their accuracy may be influenced by the surface roughness of the parts being checked. The magnification of this type of comparator is as high as 10,000.

Angular Measurement:
The accuracy of these tools and instruments varies considerably according to particular application from that of the angle gauge or protractor to high precision optical and spirit level instruments. In angular measurement two types of angle measuring devices are used. They are angle gauges corresponding to slip gauges, and divided scales corresponding to line standards.
Protractors:
The instrument consists of two arms which can be set along the faces and a circular scale which indicates the angle between them. The body of the instrument is extended to form one of the arms, and this is known as the stock. The other arm is in the form of a blade which rotates in a turret mounted on the body.

Bevel Gauge:
This tool, consists of two adjustable blades which may be moved into almost any position to give any desired angle. But no direct reading is obtained, and the angle must be set or checked from some other angular measuring device.

Engineers Square:
With either plain or bevel square, it is possible to finish a surface and measure angles to extreme accuracy. The square should be held firmly against the true side and then lowered on to the face which is to be checked, the observation then being made against a good light and viewed along the plane of the surface and not at an angle to it.

Combination Set:

It combines in one instrument a square head, a centre head, and a bevel protractor. The three heads are used separately being held in at any desired position by nuts which engage in a slot machined on the whole length of the beam at its back.

Bevel Protractor:
The universal bevel protractor is an instrument used for measuring and testing angles. It is well adapted for all classes of work where angles are to be laid out or measured to within the limits of five minutes.

Dividing Head:
Although the index or dividing head was originally developed for use on milling machine, it is used in inspection work for checking angles about a common centre. The head consists of a worm and worm gear set having a ratio of 40 to 1. So, one turn of the crank will turn the spindle one-fortieth of a revolution or 9 degrees. By using index plates with the head, a desired angle can be obtained with close accuracy.

Sine Bar:
Measurement of angles using bevel protractor is direct, whereas sine bars make indirect measurements. Sine bars are frequently used in conjunction with slip gauges for setting of angles and of tapers from a horizontal surface, preferably a clean surface plate. The accuracy attainable with this instrument is quite high and the errors in angular measurement are less than 2 seconds for angles unto 45 degree.
The most common type of sine bar consists of an accurately lapped steel bar which is stepped at the ends, with a roller secured in to each step by a screw which holds it in contract with both faces of the step. A sine bar is specified by the distance between the centers of two rollers, i.e. 100 mm or 250mm; a 100mm bar is very common. For accurate measurements, the following points in its construction are important:

1. The rollers must be of the same diameter.
2. The distance between their centers, i.e. 100mm or 250mm must be absolutely correct.
3. The centre line of roller centre must be absolutely parallel with bottom and top edges of the bar.

Angle Gauges:
Angle gauges are used for measuring and setting out angles in the workshops where precision work in the measurement of angles are required. These are wedge shaped steel blocks and their working faces are finished in the same manner as slip gauges, enabling them to be wrung together in combinations. A full set comprises twelve pieces divided into three series: degrees, minutes and fractions of a minute as follows: 1.3, 9.27 and 41 degrees, minutes ; 1, 3, 9 and 27 minutes; 0.1.0.3 and 0.5 minute. With twelve separate gauges used in conjunction with a precision square, it is possible to set up any angle between 0 and $36^0 0$ to be built up in steps of 6 seconds by wringing blocks together in additive or subtractive manner. Thus taking the 1^0, 3^0, 9^0 blocks.

$$3^0 + 1^0 = {}^{40}, 9^0 = (3+1)^0 = 5^0, 9^0 - 1^0 = 8^0 \text{ and so on.}$$

There are two sets of gauges available, designated as A and B. The standard B contains all the 12 gauges, while standard A contains one additional gauge of 0.05' (3") which enables combinations to be built up to 3".
The block formed by a combination of a number of these gauges is rather bulky, and can not always be conveniently used directly to the work, but it is usually possible to use the gauges as a reference in conjunction with angle measuring device such as a bevel or autocollimator.

Taper Measurement:
The taper angle is measured by the following measuring instruments:

1. Bevel protractor

2. Tool room microscope
3. Autocollimator
4. Sine bar and dial gauge
5. Rollers, slip gauges and micrometers

Taper Micrometer:
This measuring instrument makes it possible to check both internal and external tapers ten times faster than with older conventional methods and does not require sine bars or more elaborate equipment. The instrument has within itself the sine bar principle, and it gives the actual value of the taper of small angles. Larger tapers can be directly obtained from micrometer reading.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-V: Measurement and inspection. Session-1 2: Demonstration in model room.

---

1. To demonstrate various tools such as Open end spanner, Ring spanner, Allen key, Hacksaw, Taps etc.

2. To demonstrate the components of Micrometer and taking dimension of a job.

3. To demonstrate the components of Vernier and taking dimension of a job.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-V: Limits, Fits and Surface Quality. Session-13: Interchangeability, Limits, Fits, Allowances, Tolerances and Surface Finish.

INTERCHANGEABILITY:

The object of all modern methods of manufacturing is to produce parts of absolute accuracy. But it is not always possible, particularly in mass production, to keep the exact measurement. Given sufficient time, any operator could work to and maintain the sizes to within a close degree of accuracy, but there would still be small variation. It is known that if the deviations are within certain limits, all parts of equivalent size will equally fit for operating in machines and mechanisms. Certain deviations are, therefore, recognized and allowed to ensure interchangeability of mating parts, coupled with the desired degree of tightness or looseness on assembly. When a system of this kind has been worked out, so that one component will assemble correctly with any mating component, both being chosen at random, the system is called an interchangeable system, sometimes called a limit system or a system of limits and fits.

If interchangeability is not achieved, selective assembly will be required; that is each part must be selected to fit its mating part. Selective assembly is costly and should be avoided wherever possible.

1. The basic size is the size in relation to which all limits of variation are determined. This is fixed up by the designer from its functional considerations.
2. The nominal size is the size specified in the drawings as a matter of convenience. The nominal size is used primarily for the purpose of identification of a component, and is never used in the precision measurement of parts.
3. The actual size of a dimension or part is its measured size. An actual size of a ready part will, therefore, always deviate from one specified in the drawing, i.e., from the nominal or basic size. But the difference between the basic size and actual size must not exceed a certain limit.

Deviation and Zero Line:

The algebraic difference between size (actual, maximum, etc.) and the corresponding basic size is called the deviation.

The upper deviation is the algebraic difference between the maximum limit of size and the corresponding basic size.

The lower deviation is the algebraic difference between the minimum limit of size and the corresponding basic size.

Tolerances of Parts:

Tolerance on a dimension is the difference between the maximum limit of size and minimum limit of size. The tolerance, however, is equal to the algebraic difference between the upper and lower deviations and has an absolute value without sign.

There are two basic ways of specify tolerance: (1) bilateral and (2) unilateral, tolerances. Bilateral tolerances are used where the parts may vary in either direction from the desired or nominal size. The dimension $25^{+0.05}_{-0.05}$ is n example of bilateral tolerance. It is not necessary that the variation should be equal.

Unilateral tolerances are used where it is important for the dimension to vary in only one direction.

In an example. $40^{+0.08}_{-0.02}$ the basic size is 40mm, the upper deviation is 0.03mm, the lower 0.02mm. Hence, the maximum limit size is (40+0.03) = 40.03mm, the minimum limit size being (40-0.02) = 39.98mm. Therefore, the tolerance in this case is (40.03-39.98) = 005mm.

FITS, ALLOWANCES, CLEARANCES AND INTERFERENCES:

One which enters into the other is known as the enveloped surface or male part, and the other in which one enters is the enveloping surface or female part. The enveloped surface of a cylindrical part is considered as a shaft whiles the enveloping surface as a hole. The dimensions corresponding to them are called a shaft diameter and a hole diameter. In the case of a key and its keyway, the key represents a shaft, while the keyway represents a hole.

Fits: The relation between the two parts where one is inserted into the other with a certain degree of tightness or looseness is known as a fit.

Allowance: An intentional difference between the hole dimensions and shaft dimension for any type of fit is called the allowance.

An allowance may be either a positive (+) or a negative (-) amount according to the type of fit required. If the conditions are such that the shaft is smaller than the hole we say that there is positive allowance, but if the shaft is larger than the hole we say that there is negative allowance.

Types of fit:

Clearance Fits: In a clearance fit there is a positive allowance between the largest possible shaft and the smallest possible hole. With such fits the minimum clearance is greater than zero. Such fits give loose joints, i.e. there must be same degree of freedom between a shaft and a hole. Clearance fits may be subdivided as: (1) Slide fit, (2) Easy slide fit, (3) Running fit, (4) Slack running fit and (5) Loose running fit.

Interference Fits: In an interference fit there is a negative allowance or interference between the largest hole and the smallest shaft, the shaft being larger than hole. Interference fits may be classified as: (1) Shrink fit (2) Heavy drive fit and (3) Light drive fit.

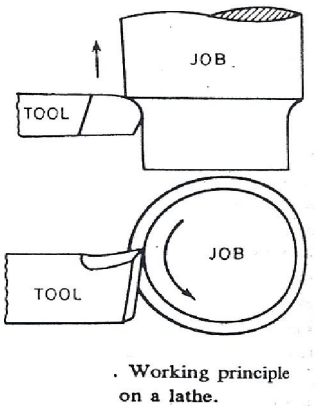
Transition: Fits: The use of transition fits does not guarantee either an interference or a clearance, i.e., any pair of parts mating with a transition fit may fit with interference, while another pair with the same fit may have a clearance fit.
Transition fits may be classified as: (1) force fit, (2) tight fit, (3) wringing fit, and (4) push fit.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-VI: Workshop Machines. Session-14: Lathe Machines, Different Lathe Machines Operations

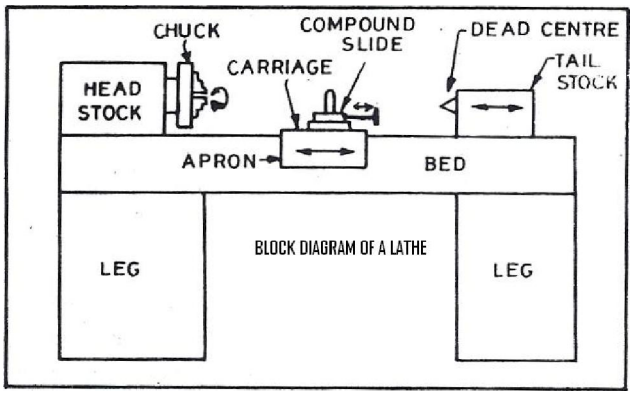
---

LATHE

The first useful form of lathe was made by H. Moudslay (British) in 1800. Lathe was the first useful machine which came into existence as a useful machine for metal cutting. Lathe is a machine tool which holds the work between two rigid and strong supports the work piece revolves and tool is fed against the work. The work revolves about its own axis to cut the desired material.



. Working principle on a lathe.



MAIN PARTS OF A LATHE:-1.Bed 2.Head stock 3.Tail stock 4.Carriage 5.Feed Mechanism 6.Legs.

Bed: - The bed of the lathe is the base on which different fixed and operating parts of the lathe are mounted. It provides inverted guide ways for well guided and controlled movement of the operating parts (Carriage) . It withstands various forces exerted on the cutting tool during operation .Bed is made of cast iron alloyed with nickel and aluminum.

Head Stock: - Head stock is housing for the driving pulleys and back gears. The head stock is secured at the left end of the lathe bed. It provides mechanism for work rotation at multiple speeds. It contains a hollow spindles and mechanism for driving and altering the spindle speed.

Tail Stock:-The tail stock is located on the ways at the right end of the bed. It has two main uses: - (1) It supports the other end of the work (2) It holds tool for performing operations such as drilling, reaming, tapping etc.

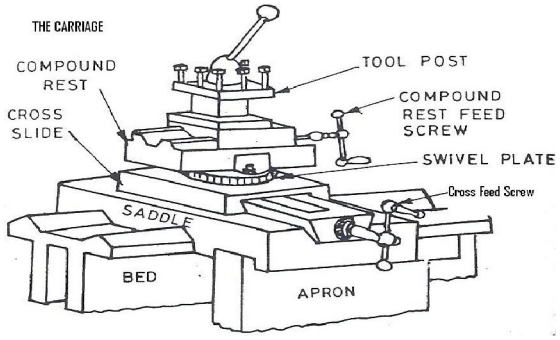
To accommodate different lengths of work the tail stock is slided to a desired position and is clamped. The tail stock spindle can be moved forward and reverse by a hand wheel.

Carriage: The carriage of a lathe serves the purpose of supporting, guiding and feeding the tool against the job during the operation. It consists of several parts:-

(a) Saddle (b) Cross slide (C) Compound rest (d) Tool post (e) Apron

Saddle: It is the part of carriage which slides along the bed ways and supports the cross slide, compound rest and tool post.

Cross Slide: It is mounted on the saddle and moves in a direction normal to the axis of main spindle. It may be operated by hand; cross feed may be given by power feed through apron mechanism.



Compound Rest: It is mounted on the cross slide and carries a graduated circle base. The circle is graduated on the cross slide in degrees and compound rest may swivel to any angle on horizontal plane on the circular base. The upper part of the compound rest called compound slide can be moved by a feed screw.

Tool Post: It is the top most part of the carriage and it is used for holding the tool.

Apron: It is the hanging part in front of the carriage. It serves as housing for a no. of gear trains through which power feed can be given to the carriage and cross slide.

Legs: They are the supports which carry the entire load of the machine over them.

Centering: The centering is the process of making the longitudinal axis of job coinciding with the axis of chuck.

LATHE OPERATIONS:

Facing: In this operation feeding of the tool is perpendicular to the axis of rotation of the job. By this operation ends of a job is machined to produce a flat surface perpendicular to the axis.

Turning: Turning is the operation of removing excess material from the work piece to produce a cone shaped or cylindrical surface. Various turnings are as follows:

Straight Turning: In this operation the job is rotated about the lathe axis and the tool is fed parallel to the lathe axis. The straight turning produces a cylindrical by removing excess metal from the work piece.

Taper Turning: Taper turning means to produce a conical surface on the job. In this operation job rotates about the lathe axis and the tool is fed at an angle to the lathe axis.

Chamfering: It is the operation of beveling the extreme end of work piece. This is done to remove the burrs to have a better look, to pass the nut freely on the threaded work piece.

Thread Cutting: It is the most important operation performed on a lathe. The principle of thread cutting is to produce a helical groove on job surface by feeding the tool longitudinally when the job is rotated by a chuck.

The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the work piece.

Knurling: It is the process of embossing a diamond shaped pattern on the surface of a work piece. The operation is performed by a special knurling tool. The tool is held rigidly on the tool

post and the rollers are pressed against the revolving work piece to squeeze the metal against the multiple cutting edges, producing depressions on the surface of work piece.

Some other operations are: 1. Drilling 2.Reaming 3.Tapping 4.Boring 5. Parting off etc. Following operations are performed by using special attachments:

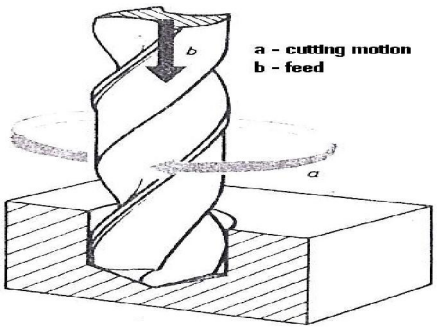
1. Grinding 2.Milling

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Workshop Machines. Session-15: Drilling and Boring machines

---

DRILLING

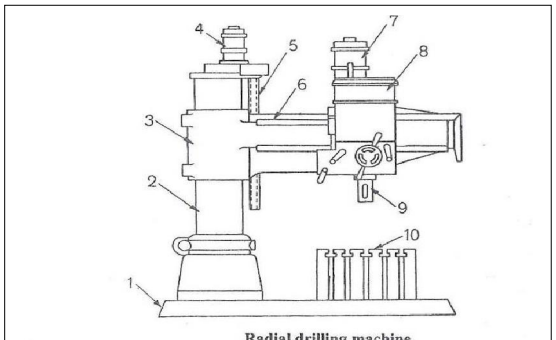


Drilling machine is used for generating holes in a work piece. The hole is generated by the rotating edge of a cutting tool, known as drill. The drill exerts pressure on the job clamped on the table and rotates generating holes.

Types of drilling machine

1. Portable drilling machine
2. Sensitive drilling machine
3. Upright drilling machine
   (a) Round column section
   (b) Box column section
4. Radial drilling machine
   (a) Plain (b) Semi universal
   (c) Universal
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep hole drilling machine

The principle parts of a drilling machine are explained below.



Radial drilling machine

1. Base, 2. column, 3. Radial arm, 4. Motor for elevating the arm, 5. Elevating screw, 6. Guide ways, 7. Motor for driving the drill spindle, 8. Drill head, 9. Drill spindle, 10. Table

Base: The base is the part of the machine on which vertical column is mounted.

Column: The column is a vertical member of the machine which supports the table and head containing all driving mechanisms. At the face of the column, rack teeth may be cut for vertical movement of the table.

Table: The table is mounted on the column and is provided with T-slots for clamping the job directly on its face. The table may have 3 types of adjustment i.e. vertical adjustment, circular adjustment about its own axis and radial adjustment.

Head: The head is mounted on the top of the column and houses the driving and feeding mechanism for the spindle .The head may have vertical adjustment for accommodating different height of job.

Spindle and drill head assembly: The spindle is a vertical shaft which holds the drill. It receives its motion from the top shaft. The spindle has vertical adjustment for setting the drill on the job.

Spindle drive and feed mechanism: The spindle drive mechanism incorporates an arrangement for obtaining multiple speed of the spindle. The feed is effected the vertical movement of the vertical movement of the drill into work.

Drill Material: 1.High speed steel. 2. Carbon steel.

Drill Size: In metric system drills are nominated by their mm size. These are manufactured commonly from 0.2 mm to 10 mm. In British system drills are nominated by their inch size.

Tap- Drill Size: Dia. of hole, $D = T - 2d$

Where T = Dia of tap d = depth of thread = 0.61p p = pitch of thread

REAMER:-Reamer is a tool used for enlarging/finishing the hole previously drilled to give an accuracy of dimension. It is a multi tooth cutter which gives the removal of metal in relatively small amount.

BORING MACHINE

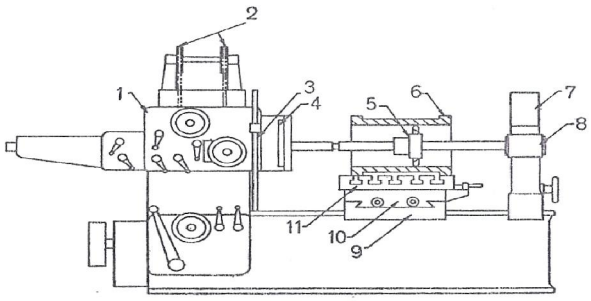
Boring machine is used to bore holes in large and heavy parts, which are practically impossible to hold and rotate in an engine lathe or a drilling machine. These parts are – engine frames, steam engine cylinders, machine housing etc.

Types Of Boring Machines:-

1. Horizontal boring machine.
   - (a) Table type.
   - (b) Floor type.
   - (c) Planer type.
   - (d) Multiple head type.

2. Vertical boring machine.
   - (a) Vertical turret lathe.
   - (b) Standard Vertical boring machine.
3. Precision boring machine.
4. Jig boring machine
   - (a) Vertical milling machine type.
   - (b) Planer type.

1. Horizontal Boring machine: - In this machine work is supported on a table which is stationary and the tool revolves in a horizontal axis.



Horizontal boring machine

1. Headstock, 2. Pulley for counter balancing weight of headstock, 3. Headstock elevating screw, 4. Boring head, 5. Boring cutter on boring bar, 6. Work, 7. End supporting column, 8. Bearing block, 9. Saddle, 10 Cross-slide, 11. Table.

Parts of a horizontal Boring Machine:-

Bed: - The bed is that part of the machine which is fitted on the floor of the shop and has a box like casting. It supports the columns, tables and other parts of the machine.

Head stock supporting column: - The column provides support to the head stock and guides it up and down accordingly by the guide ways provided on the face of the

End supporting columns: - The end supporting column houses the bearing block for supporting a long boring bar. The column may be adjusted on the slide ways of the bed towards or away from the spindle for supporting different lengths of boring bars or it may be moved at right angles to the spindle as in the case of a floor type machine.

Head stock: - The head stock mounted on the column supports drives and feeds the tool. The head stock may be moved up and down on the column for setting the tool for different height of the work. The head stock and the end supporting bearing block are raised or lowered in unison by the help of screws.

Saddle and Table: - The table supports the work and is therefore provided with T-slots for clamping the work or for holding various devises. The saddle permits the work to be moved longitudinally on the bed .The table may be moved crosswise on the saddle. These movements may be slow or rapid.

Boring Bar: - The boring bar supports the cutter for boring operations on jobs having large bore diameters. For short holes the bar may be supported on the head stock spindle end only, where as for long work the bar is also supported on the column bearing block.

Size of a Horizontal Boring Machine: -The size is specified by diameter of its spindle in mm. The diameter of spindle varies from 75 to 355mm.Other important dimensions are:-Motor horse

power, column heights, size of the table or size of the floor plate ,spindle speeds, feeds and length of feeds, floor space, weight of machine etc.

2. Vertical boring machine: - The work rotates on a horizontal table about a vertical axis and the tool is stationary except for the feed.

3. Precision boring machine: -The machine uses single point tools to machine surfaces rapidly and accurately. Cemented carbide and diamond tipped single point tools are operated at very high speed to produce accurately sized holes with a fine surface finish .The machine may be horizontal or vertical type.

4. Jig boring machine: - These machines are used for production of jigs, fixtures, tools and other precision parts which require high degree of accuracy. The machine accuracy is very high within a range of 0.0025mm.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-VI: Workshop Machines. Session-16: Shaper and planer

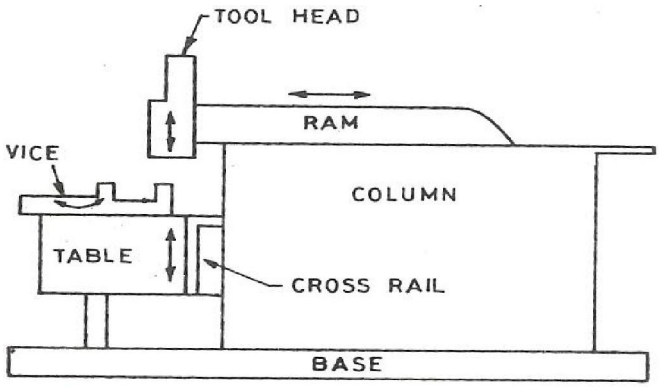
SHAPER

WORKING PRINCIPLE:-The job is rigidly held in a vice or clamp directly on the machine table. The tool is held in the tool post mounted on the ram of the machine. This ram reciprocates to and fro. In doing so the tool cuts materials in the forward stroke. Return stroke is called idle stroke because no material cutting takes place in that stroke. The job is given an indexed feed in a direction normal to the line of action of cutting tool.

The time spent in return stroke is obviously a waste. We cannot make this time equal to zero, but it can be reduced. A mechanism called Whitworth Quick Return Mechanism is fitted in the shaper to reduce the time wastage during return (idle) stroke.

MAIN PARTS OF SHAPER MACHINE:

1. Base 2. Column 3.Cross rail.
4. Table 5. Ram 6. Tool head
7. Vice.



Main parts of a shaper.

CUTTING TOOL MATERIAL:

1. High Speed Steel
2. Carbide Tipped tools for hard materials.

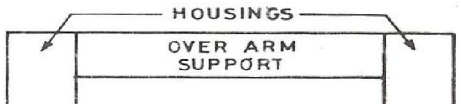
PLANER

WORKING PRINCIPLE: - The work is rigidly held on the work table of the machine. The tool is held vertically in the tool head mounted on cross-rail. The work table together with the job is made to reciprocate past the vertically held tool .The indexed feed, after each cut, is given to the tool during the idle stroke of the table. The machine may comprise side tool posts also. This is used to machine side surfaces of the job.

The fundamental difference between a shaper and a planer is that in planer, the job which is mounted on table reciprocates past the stationary cutting tool and the feed is supplied by the lateral movement of the tool, but in shaper the tool which is mounted upon the ram reciprocates and the feed is given by the crosswise movement of the table.

MAIN PARTS:

1. Bed 2.Table



SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-VI: Workshop Machines. Session-17: Slotting and Grinding machines

---

SLOTTING MACHINE

It operates almost on the same principle as that of a shaper. The major difference between a slotter and a shaper is that in a slotter the ram holding the tool reciprocates in a vertical axis, where as in shaper the ram holding a tool reciprocates in a horizontal axis. A vertical shaper and a slotter are almost similar. The only difference, in the case of a vertical shaper, the ram holding the tool may also reciprocate at an angle to the horizontal table in addition to the vertical stroke. The ram can be swiveled not more than 5° to the vertical. The slotter is used for cutting grooves, key ways and slots of various shapes, for making regular surfaces both internal and external etc.

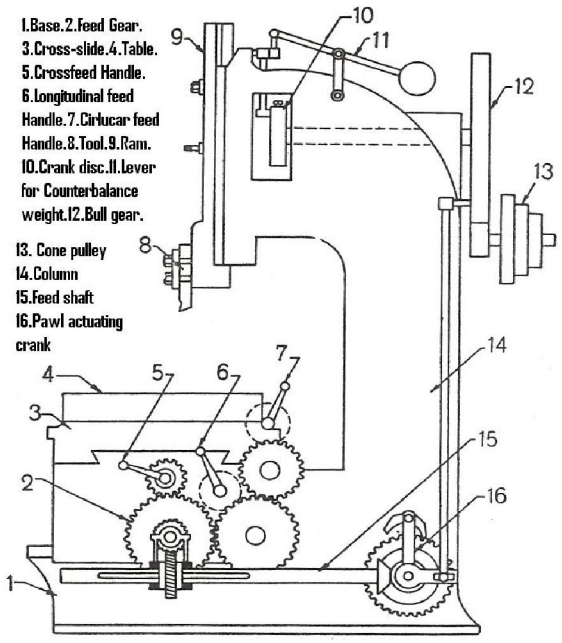
Types of slotting machines: - 1. Punch slotter. 2. Precision slotter.

1. Puncher slotter: - The puncher slotter is a heavy, rigid machine designed for removal of large amount of metal from large forging or castings. The length of a puncher slotter is sufficiently large. It may be as long as 1800 to 2000 mm.

2. Precision slotter: - The precision slotter is a lighter machine and is operated at high speeds. The machine is designed to take light cuts giving accurate finish.

Slotter Size: - The size of a slotter is specified by the maximum length of stroke of the ram, expressed in mm. The size of a general purpose or precision slotter usually ranges from 80 to 900 mm. Other important dimensions are diameter of the table in mm, amount of cross and longitudinal travel of the table expressed in mm, number of speed and feeds available, H.P. of the motor, floor space required, etc.

Slotting Machine Parts: -The different parts of a slotting machine are as follows: -
1. Base. 2. Column. 3. Saddle. 4. Cross-slide. 5. Rotating table.6. Ram and tool head assembly. 7. Ram drives mechanism. 8. Feed mechanism.



Slotter Operations: - The operations performed in a slotter are:
1. Machining flat surface. 2. Machining cylindrical surface.3. Machining irregular surfaces and cams machining. 4. Machining slots, key ways and grooves

Slotter Tools: - In a lathe, shaper or a planer tool the cutting pressure acts perpendicular to the tool length, whereas in a slotter the pressure acts along the length of the tool. Slotter tools are provided with top rake, front clearance and side clearance, but no side rake is given. The nose of

the tool projects slightly beyond the shank to provide clearance. Different slotter tools are used in different operations. Keyway cutting tools are thinner at the cutting edges. Round nose tools are used for machining circular or contoured surfaces. Square nose tool are used for machining flat surfaces.

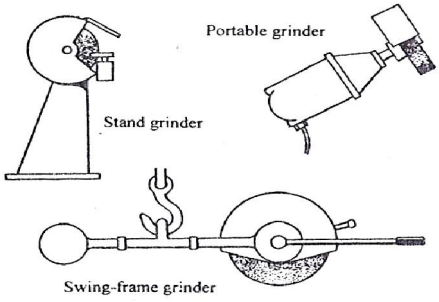
GRINDING

Grinding is a cutting operation performed by means of a rotating abrasive wheel that acts as a tool. The abrasive wheel is called grinding wheel .It is used to remove comparatively little material 0.25mm to 0.5mm.

GRINDING MACHINES: 1.Rough grinders (**Floor stand grinder)** and 2.Presion grinder (**Bench grinder)**

Abrasive: An abrasive is a substance that is used for grinding and polishing operations. The abrasives are mainly:-

1. Natural Abrasives: (a) Sand stone (Solid quality)
   (b) Emery (Natural Al_2O_3)
   (c) Corundum (Natural Al_2O_3)
   (d) Diamond (Natural Al_2O_3)
2. Artificial Abrasive: (a) Silicon carbide (SiC)
   (b) Aluminum oxide (Al_2O_3)



Rough grinding machines
1. Stand grinder, 2. Portable grinder,
3. Swing frame grinder.

Bonds: A bond is an adhesive substance that is employed to hold abrasive grains in the form of grinding wheel. Bonding materials are:

1. Vitrified bond	(V)	Mostly used in Industrial Application
2. Silicate bond	(S)	
3. Shellac bond	(E)	
4. Resinoid bond	(B)	
5. Rubber bond	(R)	
6. Oxy – Chloride bond	(O)	

Grit: Grit means grain size and is denoted by a number indicating the no. of meshes per linear inch of the screen through which the grains pass when they are graded after crushing.

Coarse	10	12	14	16	20	24
Medium	30	36	46	54	60	
Fine	80	100	120	150	180	
Very Fine	220	240	280	320	400	500

Grade: Grade means hardness with which the bond holds the abrasive grains in a grinding wheel.

Soft grade → A TO H
Medium grade → I TO P
Hard grade → Q TO L.

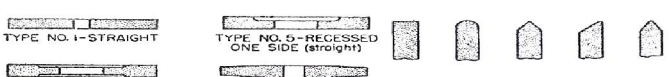
Structure: The relative spacing of an abrasive is known as structure. It is denoted by the no. of cutting edges per unit area of wheel face. It is also denoted by the no. of voids spaces between grains.

Open Structure ------	1	2	3	4	5	6	7	8
Dense Structure -----	9	10	11	12	13	14	15	or higher

Marking of Grinding Wheel: W A 46 K 5 V 17

1. Manufacturer's code — W
1. Abrasive type (Al_2O_3) — A
2. Grain size (Medium) — 46
3. Grade (Medium) — K
4. Structure (Open) — 5
5. B o n d (Vitrified) — V
6. Manufacturer code. — 17

Wheel Shapes and Sizes: Grinding wheels are made in many different shapes and sizes



SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Workshop Machines. Session-18: Milling machine and Gear cutting

MILLING MACHINE

It is a machine tool that removes metal as the work is fed against a rotating multiple tooth cutter. The cutter rotates at a high speed and because of multiple cutting edges; it removes metal at a very fast rate. The machine can also hold more than one cutter at a time.

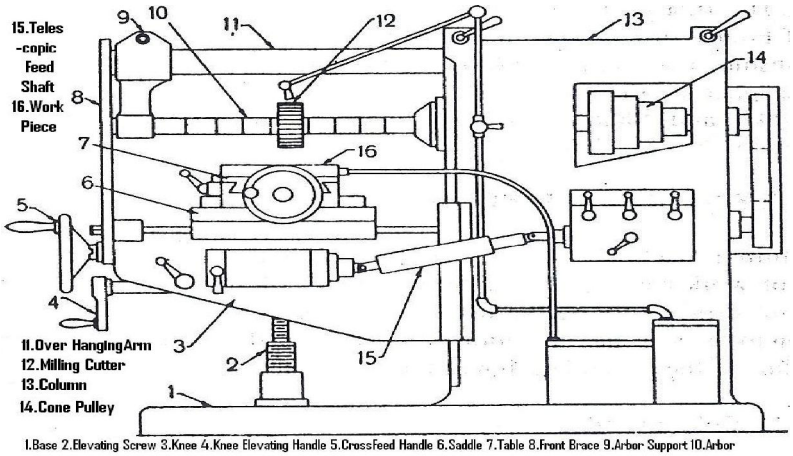
TYPES OF MILLING MACHINES:

1. COLUMN AND KNEE TYPE:
   - (a) Hand milling
   - (b) Plain milling
   - (c) Universal milling
   - (d) Omniversal milling
   - (e) Vertical milling
2. Manufacturing and fixed bed type milling machine
3. Planer type milling machine
4. Special type milling machine

1. COLUMN AND KNEE TYPE:-Table is mounted on the knee casting. Knee casting is mounted on the vertical slide of the main column. The knee is vertically adjustable on the column to accommodate works of various sizes. These machines are classified according to the various methods of supplying power to the table, different movement of the table & different axis of rotation of the main spindle.

Main Parts: Base, Column, Knee, Table, Over Hanging, Arm, Front Brace, Spindle, Arbor

MILLING CUTTER:-The milling cutters are revolving tools having one or several cutting edges equally spaced on the circumference of the cutter. Milling cutters are classified as:

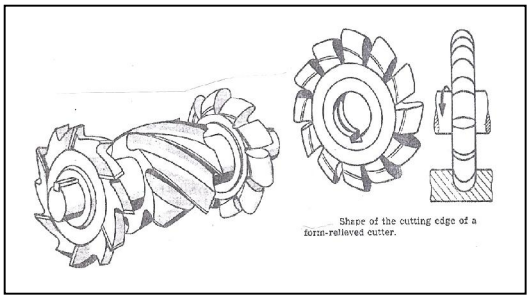


Column and knee type milling machine

1. Solid cutters
2. Tipped solid cutters
3. Inserted teeth cutter.
4. Arbor type cutter
5. Shank type cutter
6. Right hand cutter
7. Left hand cutter
8. Straight teeth cutter
9. Helical teeth cutter
10. Standard milling cutter
11. Special milling cutter

CUTTER MATERIALS:

1. High Speed Steel
2. Super High Speed Steel
3. Non Ferrous cast alloys etc.



GEAR CUTTING

Gears may be manufactured by casting, stamping, machining or by powder metallurgical process, but the most common and accurate method is machining. The different methods of production of gears by machining are as follows:-

1. **Formed cutter method :-**(a) By a formed disc cutter in a milling machine.
   - (b) By a formed end mill in a milling machine.
   - (c) By a formed single point tool in a shaping or planning machine.
   - (d) By a formed cutter in a "shear speed" gear shaper.
   - (e) By a formed cutter in a broaching machine.

2. Template Method in a gear cutting machine.

3. Generating method :- (a) By a rack tooth cutter in a gear cutting machine.

(b) By a pinion cutter in a gear cutting machine.

(c) By a hob cutter in a gear cutting machine. (d) By a bevel gear generator.

1. **Formed cutter method: -** A single point cutting tool or a milling cutter has the same form of cutting edge as the space between the teeth being cut is used. The method uses simple and cheap tools in conventional machines.

Disadvantages: - (1) Accuracy is very poor. (2) The production capacity is very low.

(a)Gear cutting by formed disc cutter:-The method involves the mounting of a gear blank at the end of a dividing head spindle fitted on the table of a horizontal, column and knee type milling machine and then feeding the work past a rotating, formed, peripheral type of cutter mounted on the horizontal arbor of the machine.

(b)Gear cutting by a formed end mill: - The end mills having cutting edges formed to correspond to the tooth space of a gear employed to cut a spur, helical or a herring bone gear in a milling machine. The end mills are used to cut gears of large module from 20 mm and larger where ordinary disc type cutters are unsuitable due to excessive pressure required.

(c)Gear cutting by a formed single point tool: - A single point cutting tool having cutting edges formed to correspond to the tooth space of a gear is employed to cut a spur or a bevel gear in a shaping or a planning machine by using the shaper centre.

(d)Gear cutting by shear speed process: -The shear speed process involves the production of all the teeth on a gear simultaneously by a ring of formed blades arranged on the periphery of the gear blank. Each blade having formed cutting edges cuts one tooth space and the number of blades on the cutter equals the number of tooth spaces on the gear. The shear speed process is the quickest method of producing external and internal spur gears, splines toothed clutches, ratchet wheels etc.

(e) Broaching gear teeth:- A broaching tool having formed cutting edge is employed for producing internal gears of accurate shapes on a broaching machine.

2. Template gear cutting process:- The template gear cutting process involves the production of a gear tooth profile by a single point cutting tool which is reciprocated and made to follow a guided path by a template whose profile corresponds to the shape of the gear tooth being cut. After one tooth is finished, the blank is indexed by the usual manner. The template method is employed for producing very large spur gear teeth and for cutting accurate bevel gears.

3. Generating methods: - The generating methods of gear production enable to cut mathematically correct tooth profile by means of relative motions between the cutters and the gear blanks. The principle of generating process is based on the fact that any two involute gears of the same module will mesh together. If out of two mating gears one is used as a cutter and is made to reciprocate or fed continuously along the entire width of the gear blank, while still rotating as a mating gear, so that the pitch surface of the cutter rolls without slipping on the pitch surface of the gear, an accurate tooth profile can be generated. As the principle of generating gears is based upon involute system, cycloidal gears cannot be produced by this method. The gears may be generated by a rack cutter, pinion cutter or a hob.

(a)Rack cutter generating process: - The rack cutter generating process is also called shaping process. In this method, the generating cutter has the form of a basic rack for the gear to be generated. The cutting action is similar to a shaping machine.

(b)Pinion cutter generating process:-The pinion cutter generating process is fundamentally the same as the rack cuter process, and instead of using a rack cutter it uses a pinion to generate the tooth profile.

(c)Gear hobbing: - Hobbing is a process of generating a gear by means of a cutter, called a hob, that revolves and cuts like a milling cutter. In gear hobbing, the gear blank is first moved in towards the rotating hob until the proper depth is reached. The action is the same as if the gears were meshing with a rack. As soon as the proper depth is reached, the hob cutter is fed across the face of the gear until the teeth are complete, both gear and cutter rotating during the entire process.

(d)Bevel gear generating process: - The fundamental of bevel gear generating process involves the rolling of a bevel gear blank on a crown wheel.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Workshop Machines. Session-19: Press, Jigs And Fixtures

---

Press: - The press is a metal forming machine tool designed to shape or cut metal by applying mechanical force or pressure. The metal is formed to the desired shape without removal of chips.

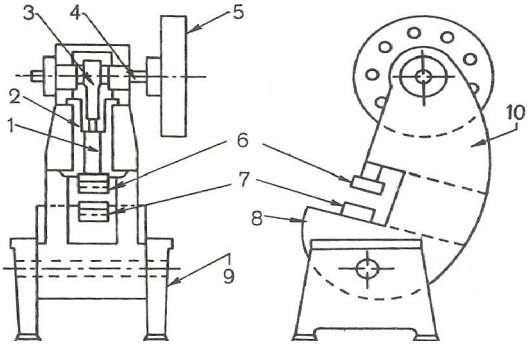
Types of presses: - The classification of different types of presses are given below:-

1. Classification based on source of power :
   (a) Hand press or ball press or fly press (b) Power press.
2. Classification based on design of frame:
   (a) Gap (b) Inclinable (c) Adjustable (d) Horn (e) Straight side (f) Pillar

Power press parts: 1. Base 2. Frame 3. Bolster plate 4. Ram 5. Pitman 6. Crank, eccentric or other driving mechanism 7. Fly wheel 8. Clutch 9. Brakes:

Press Tools: A punch is the parts of the press tool which enters into the cavity formed in the die section. The punch is usually the upper member of the press tool which is mounted on the lower end of the ram and slides with it.

A die is that part of the press tool which has an operating or cavity to receive the punch. The die is usually the lower member of the press tool which is clamped on the bolster plate fitted on the table and remains stationary.



POWER PRESS

1. Ram 2.Ram guide 3.Pitman 4. Crankshaft 5. Flywheel 6.Punch 7.Die 8.Bolster plate 9.Base 10.Frame

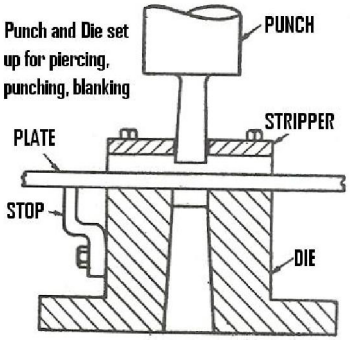
The punches and dies are generally made of high speed steel.

Types of dies and operations

1. Classification based on operations performed:

(A) Shearing operation: As the punch descends upon the work piece, the pressure exerted by the punch causes the metal to be deformed plastically in the die. As the clearance between the punch and the die is very small, the plastic deformation takes place in a localized area and the metal adjacent to the cutting edges of the punch and the die becomes highly stressed. When the stress reaches beyond the ultimate strength of the material, the fracture starts from both the sides of the plate along the cutting edges of both die and the punch, and as the punch continues to descend,

the fracture meet at the centre of the plate. The metal is now completely severed from the sheet metal and drops out through the die opening.



(a) Piercing: The piercing is the operation of production of hole in a sheet metal by the punch and die. The materials punched out to form the hole constitute the waste.

(b) Punching: The punching operation is similar to the piercing operation. While punching the formation of the hole is the desired result. The difference between the punching and the piercing is that in the case of punching a cylindrical hole is produced, whereas in the case of piercing the hole produced may be of any other shape.

(B) Bending operation: While bending the metal is stressed in both tension and compression at the two sides of the neutral axis beyond the elastic limit but below the ultimate strength of the material. As the material is loaded beyond the elastic limit, some amount of plastic deformation takes place and when load is removed, the metal retains the bent shape given by the die. There is,

of course, some amount of elastic recovery of the metal when the load is removed, resulting in a slight decrease in the bent angle. The effect is known as spring back. To correct the effect of spring back, the metal is bent through a greater angle so that when the load is removed, the component will spring back to the desired angle.

(a) Angle bending,(b) Curling, (c) Forming, (d) Plunging

(C) Drawing operation: The drawing is the operation of production of cup shaped parts from flat sheet metal blanks by bending and plastic flow of the metal.

(a) Squeezing operation, (b) Coining, (c) Embossing, (d) Flattening or planishing

2. Classification based on construction:

(a) Simple die: In a simple die, only one operation is performed at each stroke of the ram.

(b)Follow or progressive die: In a progressive die, two or more operations are performed simultaneously at a single stroke of the press by mounting separate sets of dies and punches at two or more different stations. The metal is progressed from one station to the other till the complete part is obtained.

(c)Compound die: In a compound die two or more cutting operation are accomplished at one station of the press in every stroke of the ram.

(d)Combination die: In a combination die, both cutting and noncutting operation are accomplished at one station of the press in every stroke of the ram.

(e) Rubber die: In a rubber die, the rubber is used as a medium of applying pressure on the sheet metal blanks.

Jig and fixtures: The jig and fixture are the economical means to produce repetitive type of work by incorporating special work holding and tool guiding devices.

Jig: A jig may be defined as a device which holds and locates a work piece and guides and controls one or more cutting tools. The holding of the work and guiding of the tools are such that they are located in true position relative to each other.

Fixture: A fixture may be defined as device which holds and locates a work piece during an inspection or for a manufacturing operation. The fixture does not guide the tool. Difference between a fixture and a jig is as follows:

1. A fixture holds and positions the work but does not guide the tool, whereas a jig holds, locate and as well as guides the tool.
2. The fixtures are generally heavier in construction and are bolted rigidly on the machine table, whereas the jigs are made lighter for quicker handling, and clamping with the table is often unnecessary.
3. The fixture are employed for holding work in milling grinding, planning, or turning operations, whereas the jigs are used for holding the work and guiding the tool particularly in drilling, reaming or taping operations.

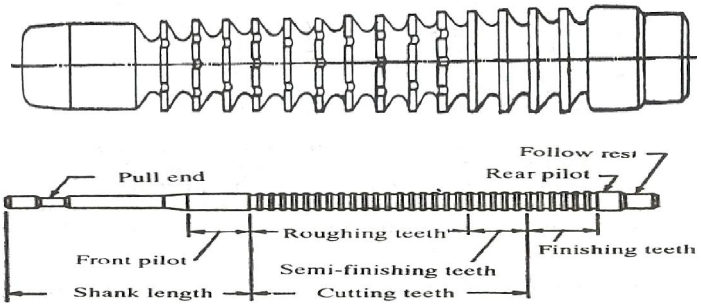
Advantages of jigs and fixtures: -

(i) It eliminates the marking out, measuring and other setting methods before machining.
(ii) It increases the machining accuracy.
(iii) It enables productions of identical parts which are interchangeable.
(iv) It increases the production capacity.
(v) It reduces the operators labour as handling operations are minimizes.
(vi) It facilitates the use of semiskilled operator.
(vii) It reduces the expenditure of quality control.
(viii) It reduces the over all production cost by fully or partly automatising the manufacturing process.

BROACHING MACHINE

Broaching is a method of removing metal by pushing or pulling a cutting tool called a broach which cuts in fixed path. Surfaces finished by broaching may be flat or contoured and may be either internal or external. Broaching is generally limited to the removal of about 6 mm of stock or less.

BROACHES: - A broaches is a multiple-edge cutting tool that has successively higher cutting edges along the length of the tool.



Types of Broaches*:* - Broaches may be classified in various ways, according to:-

1. Type of operation: - internal or external.
2. Method of operation: - push or pull.
3. Types of construction: solid, built-up, inserted tooth, progressive cut, rotor cut double jump, or overlapping tooth.
4. Function: - surface, keyway, round hole, splint, spiral, burnishing, etc.

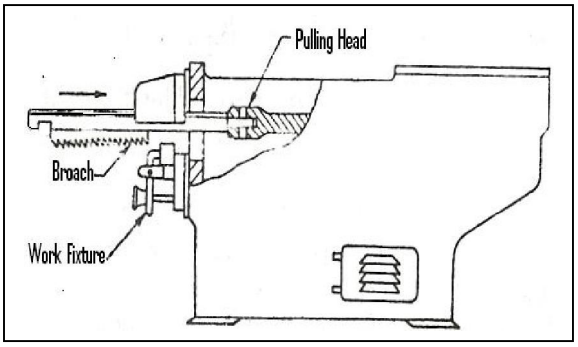
Broach material:-Most broaches are made from 18-4-1 tungsten chromium vanadium steel ground after hardening. Carbide broaches are used extensively in the broaching of cast iron in the automotive field.

BROACHING METHODS: - Broaching, according to the method of operation, may be classified as follows:-

1. Pull Broaching. 2. Push broaching 3. Surface broaching 4. Continuous broaching

BROACHING MACHINES

Horizontal Broaching Machines:-Nearly all horizontal machines are of the pull type. They may be used for either internal or external broaching, although internal work is the most common. A horizontal broaching machine consists of a bed or a base a little more than twice the length of the broaching stroke, a broach pilot and the drive mechanism for pulling the broach.



Vertical broaching machines: - The vertical type may be obtained in either push or pull type. The push type is the most popular. A vertical broaching machine is employed in multiple operations, since they are convenient to pass work from one machine to another, and they are more likely to be found doing surface operations. Of the three models available, pull up, pull down, and push down, the pull up type is most popular.

Surface broaching machine: - Surface broaching machines have their broaching tools attached to a ram or rams forced in a straight path along guide ways past the work piece.

Continuous broaching machines: - For mass production of small parts, the highly productive continuous broaching method is used on rotary or horizontal continuous broaching machines.

Broaching machine sizes: - The size of a broaching machine is specified mainly by the length of stroke in mm and the force in tones that can be applied to the broach. Thus a 1000-10 machine has a 1000 mm stroke with a 10 tones nominal broach driving force. Other important parameters for specifying a broaching machine are broaching speed, return speed and machine horse power.

Broaching operation: - Broaching is applied for machining various internal and external surfaces, for round or irregular shaped holes from 6 to 100 mm in diameter, for external flat and contoured surfaces. Certain types of surfaces, for example, spline holes, are machined at the present time only by broaching due to the exceptional difficulties in machining such surfaces by

other methods. Most broaching operations are completed in one pass, but some are arranged for repeated cuts to simplify the design of the broach.

SAWING

In sawing, the individual teeth of the saw, "track" through the work, deepening the cut made by the preceding tooth in the direction of feed. Either the saw or the work may be fed and, by controlling the direction of feed, either straight or curved cut can be produced. The width of the cut is approximately equal to the width of the saw itself.

Sawing machines: - Sawing machines may be classified by the motion used for the cutting action.

1. Reciprocating saw.
   (a) Horizontal sawing machine. (b) Vertical sawing machine.
2. Circular saw.
   (a) Cold saw. (b) Friction disk. (c) Abrasive disk.
3. Band saw.
   (a) Contour band saw. (b) Friction blade.

Reciprocating saw: - Reciprocating saws are represented by power hacksaws. A power hacksaw consists of a saw frame, a means for reciprocating the saw and frame, a work table and vice, a supporting base, and a source of power. In operation, machine drives a blade back and forth through a work piece, pressing down on the cutting stroke and releasing the pressure on the return. The stock to be cut is held between the clamping jaws. Several pieces of bar stock can be clamped together and cut at the same time. Both square and angular cuts can be made.

Circular saws: - Circular saws are cut by means of a revolving disc. The disc may have large teeth or almost no teeth. Machines of this type are divided into three classifications as given before.

The **cold saw** has a circular blade with inserted teeth for cutting small or large bars to length.

Friction disc are circular blades having almost no teeth. They operate at high speeds and generate heat. The heat of friction softens the metal of the work piece in contact with the disc, and the soft metal is rubbed away.

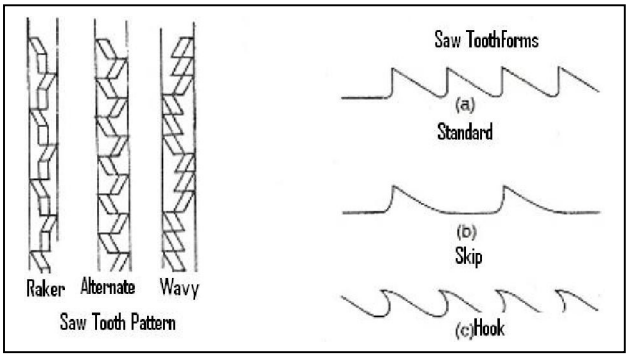
Abrasive discs, as the name implies, are thin flexible grinding wheels. Thin resionoid or rubber bonded wheels rotating at high speeds are generally used.

Band saws: - In a band saw, a continuous saw blade runs over the rims of two wheels, one of which drives the saw at the desired cutting speed. The work is mounted on the table between the two wheels. They are mainly divided into two classifications as given before.

The **contour band saw** is the most versatile of all types of sawing machines in application. The work may be fed in any direction on the table, and the direction of feed is readily controlled and changed while cutting is in process to produce any desired out line. These machines are widely used for making dies or other parts with a contour internal shape.

A **friction band saw** operates on the same principle as the friction circular saw. The dull blade produces great friction and the kerf of the teeth removes small, softened particles of the work.

Selecting a blade for sawing machine: - Blade materials include standard carbon steel, high speed steel and bimetallic high speed steel. There are three tooth sets that can be used; raker, alternate and wavy. There are tooth forms also, standard, skip and hook.



1. To note down the various components of the Track Maintenance Machines being assembled at M/s Plasser India Pvt. Ltd. and to understand the manufacturing process.

2. To see & note down the various components of Workshop Machines available at M/s Plasser India Pvt. Ltd. Such as

    i) Lathe Machines
    ii) Radial drill Machine
    iii) Shaper
    iv) Planner etc.
    v) Cropping machine

3. To visualize inert gas welding.

4. To visualize the hydraulic pipe end fittings crimping process.

5. To visualize and note down any other production activities.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Threads. Session-24: Different Types Of Thread

THREAD:

The helical groove cut on an internal or external cylindrical surface is called thread. The thread on internal cylindrical surface is called internal thread and that on external cylindrical surface is

called external thread. According to movement, threads are of two types: - 1. Right hand threads 2. Left hand threads.

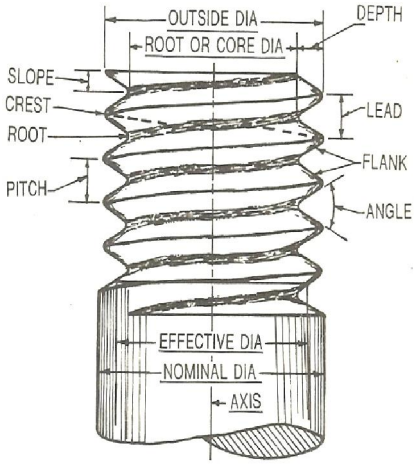
Terms of Screw Threads:-

Major diameter, Minor diameter, Pitch diameter

Pitch Dia. = Major Dia.— single Depth of thread

Pitch: - It is the distance measured parallel to the axis, between a point on one thread form and a corresponding point on the adjacent thread form, i.e. form crest to crest or root to root

Lead: - It is the distance measured parallel to the axis from a point on a thread to a corresponding point on the same thread after one revolution. It is also described as the distance moved by a Nut in the axial direction in one complete revolution. The lead is equal to the pitch in case of single start threads, twice in double start thread; thrice in triple start thread etc.



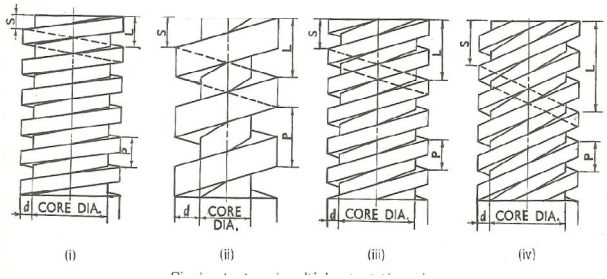
Screw thread

Crest, **Root**, **Flank or side**

Angle of thread: - It is the angle between the flanks measured on an axial plane.

Helix angle: - The angle of inclination of thread is called helix

Depth of thread, Number of thread, Crest, **Root**, **Flank or side**



Angle of thread: - It is the angle between the flanks measured on an axial plane.

Helix angle: - The angle of inclination of thread is called helix

Depth of thread, Number of thread

Types of threads:-1. 'V'- Thread 2. Square Thread 3. Acme Thread 4. Worm Thread 5. Knuckle Thread 6. Buttress Thread.

1. 'V'-Thread: - These threads are in 'V' shape. According to thread angle these are of following types:-

(a)British standard Whitworth thread or B.S.W:-Included angle of this thread is 55° and routes and crests are rounded. The theoretical depth D=0.96P, where P= pitch of the thread; 1/6 of the theoretical depth is rounded off at the top and the bottom. This thread was invented by Sir Joseph Whitworth in 1841.

(b)British standard fine thread:-These have the same with worth profile (included angle 55°) but their pitches are finer and hence the depths smaller. Thus they have larger effective and core diameters than the B.S.W threads. B.S.W threads are generally used automobile and aircraft work.

(c)British Association thread: - This is a very fine thread. This thread is used for nominal diameter less than 1/4" or 6mm such as instruments, watches, radio etc. The included angle is 47 ½ °. 0.236 of the theoretical depth is rounded off at the top and at the bottom, leaving the actual depth equal to 0.6P.

Theoretical depth, D = 1.136P Actual depth, d = 0.6P.

(d) British Standard Pipe thread:- These threads are used for gas, steam or water pipes. They are specified by the bore of the pipe and not by the out side diameter. Thus, the out side diameter of a thread pipe having a bore of 1"normal diameter is 1.309". The pipes of 1"to 6"diameters have the same number of threads per inch, viz. 11. These threads are cut taper ¾" per foot. The included angle is 55°.

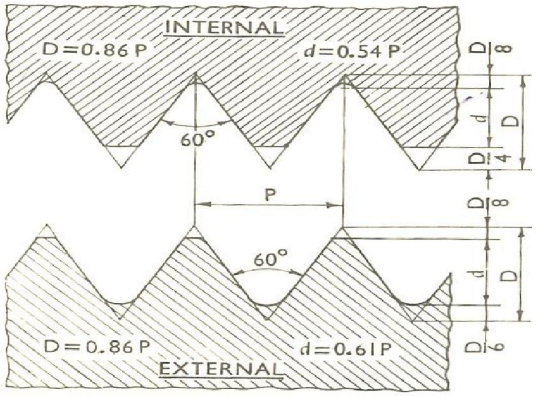
(e)American national thread (Seller's thread):- It has an included angle of 60°. One-eighth of the theoretical depth is cut-off parallel to the axis of the screw at the top and at the bottom. Therefore, the crests and the roots of this thread are parallel.

Theoretical depth, D = 0.866P Actual depth, d = 3/4 D = 0.649P

(f)International Standard thread (Unified thread):-

This is the I.S.O basic profile recognized in two series based on inch and metric systems of measurements. In this form, the external thread (on a bolt) varies slightly from the internal thread (inside a nut). The angle of the thread is 60°. Roots of both-internal and external threads are rounded, while the crests are cut parallel to the axis of screw. The root of the internal thread is rounded within the depth of D/8.

The maximum depth of engagement between the internal and external threads is 5/8D



Unified thread

(g)Metric Thread: - The Bureau of Indian standards has recommended the adopting of Unified screw thread profile based on metric system and has designated it as Metric thread. In this system pitch of the thread is fixed (not thread per unit length.).These threads are designated by the letter M followed by nominal diameter and pitch in mm. Ex: - M10X1.5

2. Square thread: - This thread has its flanks or sides normal to the axis. The depth and the thickness of the thread are each equal half of the pitch. The thread is much stronger than the 'V' threads. It is generally used for power transmission in jacks, vice etc.

3. Acme thread: - This thread is a modification of the square thread - thicker at the root and less thick at the crest, hence stronger at the root. The thread angle is 29°.

Depth, d = 0.5P + 0.25 mm Thickness at the crest = 0.3707P.

It is particularly used where the nut, which is made in two parts, is required to engage or disengage from a screw at frequent intervals such as in lead screw of the lathe.

4. Worm thread: - This is like an acme thread with the difference that depth of thread is some what more.

5, Knuckle thread: - It is formed by rounding off the corners of the square thread to such an extent that it has a completely rounded profile. Its section comprises of semicircles of radius R = 0.25P Depth d = 0.5P

This thread can withstand heavy wear and rough usage. They are used in coupler of railway carriage and electrical bulbs.

6. Buttress thread: - This thread is a combination of the triangular and the square threads. One flank of the thread is perpendicular to the axis of the screw. The angle between its two flanks is 45°. The theoretical depth is equal to the pitch. One-eighth of which is cut off parallel to the axis at the crest and at the root. This thread is suitable only when the force acts entirely in one direction. It is used commonly in screw of bench vice.

Theoretical depth D = P Actual depth d = ¾ D = 0.75P

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Quality Controls. Session-25: Statistical Quality control, control charts and their application

---

INTRODUCTION

The basic purpose of manufacturing is to produce engineering materials and parts to specified shape, size and finish. The specifications for the shape, sizes and finishes are furnished to the

shop by part drawings or manufacturing drawings. These specifications are often called quality characteristics.

The measured quality of manufactured product is always subject to a certain amount of variation as a result of chance. Some stable "system of chance causes" is inherent in any particular scheme of production and inspection. The reason for variation outside this stable system should be discovered and corrected to avoid wastage and finally to improve quality.

INSPECTION AND QUALITY CONTROL

Inspection:-Inspection is the method of measuring and/or checking the quality of product in terms of specified standard. There are three basic areas of inspection: - (1) Receiving inspection, (2) In process inspection and (3) Final inspection.

Quality Control: - The word "quality" as used in manufacturing implies "the best for the money in vested" and does not necessarily mean the "best". A component is said to be of good quality if it works well in a particular situation for which it is meant while in other situation it may not work well and it is said to be bad quality. The word "control" implies regulation and regulation implies observation and manipulation. It suggests when to inspect and how much to inspect.

Inspection is considered to be tool of quality control. It checks the products while quality control attempts to bring the variable factors under control.

SATISTICAL QUALITY CONTROL

Certain statistical techniques have been devised to evaluate machines, materials and processes by observing capabilities and trends in variations so that continual analysis predictions may be made to control the desired quality level. These statistical techniques are called statistical quality control methods. These methods or tools are:-

1. The Shewhart Control Charts for measurable quality characteristics. These are described as charts for, variables, or as charts for $\bar{X}$ and R (average and range) and charts for $\bar{X}$ and (average and standard deviation).
2. The Shewhart control chart for fraction defective. This is described as the *p* chart.
3. The Shewhart Control Chart for number of defects per unit. This is described as *c* chart.
4. Sampling plans dealing with the quality protection

CONTROL CHARTS FOR VARIABLES($\bar{X}$ AND R Chart)

$\bar{X}$-Chart: Sample of consecutive parts are taken from the machine at frequent time intervals and recorded on the chart in their sequence of manufacture. A sample consists of subgroups, the size of which should be carefully measured. Generally, the sub group size is five to ten. It is always better to take frequent small subgroup than infrequent large subgroups. The parts are measured and the average of these measurements is plotted on the $\bar{X}$ chart. Average values are plotted instead of individual readings because sample averages tend to approach the normal distribution curve more closely than to individual values. The central line, $\bar{\bar{X}}$ shown on the $\bar{X}$ chart is average of the averages or grand average of the subgroup (5 to 10) average. This is expressed as

$$\bar{\bar{X}} = \sum \bar{X}/K$$

Where $\bar{X}$ is the average value of each subgroup and K is the number of subgroups. The control limits are set at three standard deviations (3) of the sample average from the mean $\bar{\bar{X}}$, and are called upper control limit. (UCLx = X + 3 x) and the lower control limit (LCLx = X – 3 x), where

R-chart: The chart for ranges, the R chart is obtained from the same sample groups that were used in determining the values of $\bar{X}$. the central line or the mean, of the R chart represents the average of the subgroup ranges. Control limits on range chart can be calculated as:

$UCLr = D_4 R$ $LCLr = D_3 R$

Where D_3 and D_4 are constant factors, the values of which are found in the table.

CONTROL CHART FOR ATTRIBUTES (p charts)

The control charts for fraction defective p is used to quality characteristics that can be observed only as attributes - for example, dimensions checked by go and non-go gauges even though they might have been measured as variables.

Fraction defective, p, may be defined as the ratio of the number of defective articles found in any inspection or series of inspections to the number of articles actually inspected. Fraction defective is nearly always expressed as a decimal fraction. This may be expressed as:

p = number of defectives in subgroup / number inspected in subgroup (n)

and $\bar{p}$ = total number of defectives during period / total number inspected during period ($\sum n$).

$UCLp = p + 3\ p$ $\quad$ $LCLp = p - 3\ p$ $\quad$ where $\quad p = \sqrt{\{p\ (1 - p)/n\}}$

CONTROL CHART FOR DEFECTIVES (c CHART)

The c chart applies to the number of defects in subgroups of constant size. A defective is an article whereas articles lacking conformity to specification is a defect.

The c chart is plotted in the same manner as p chart except that the control limits are based on Poisson distribution which describes more appropriately the distribution of defects.

The value of c is first computed. The 3-sigma limits are:

$UCLc = c + 3\sqrt{c}$ $\quad$ $LCLc = c - 3\sqrt{c}$

For example, if there are 200 defects in 25 machines, the average c is 200/25=8.0. Control limits computed from the averages are follows:

$UCLc = c+ 3\sqrt{\ } c = 8 + 3\sqrt{8} = 16.5$ $\quad$ $LCLc = c - 3\sqrt{c} = 8 - 3\sqrt{8} = 0$

Whenever calculations give a negative value of the lower control limit of a chart, that limit is recorded as zero.

THE ISO 9000

ISO 9000 is a family of international standards for quality management and assurance. ISO 9001, ISO 9002, and ISO 9003 detail the requirements, which must be met. ISO 9000 and ISO 9004 are guidelines. Listed below are the models that make up the ISO 9000 family of standards.

ISO9001 Quality System is a model for quality assurance in design/development, production, installation, and servicing. ISO 9001 is made up of 20 sets of quality system requirements.

ISO 9002 Quality System is a model for quality assurance in production and installation.

ISO 9003 Quality System is the model for quality assurance in final inspection and test.

ISO 9004-1 and the other parts of ISO 9004 are the standards of guidelines on the elements of quality management and a quality system.

In its most basic form it requires that you:

Say what you do: Have documented procedures for performing the work that affects product or service quality.

Do what you say: Work according to the written procedures.

Record what you do: Retain records of the activities to provide objective evidence of compliance.

Improvement: Compare what you actually achieve with what is planned and use the information to correct any shortcomings.

SUB :-TRACK MACHINE & WORKING PRINCIPLE

Duration- 74 Sessions = 148 Periods

Sub discipline-Track Machine (Lessons-2 Sessions-2)

Lesson-I: History of Track Machines **Session-1:** History of Mechanization on Indian Railways introduction of Track Machines in chronological order.

Historical Development of Track Maintenance:

1950-80: From manual methods to full mechanization - From the very beginning the railways were aware of the importance of track maintenance. Nevertheless, it was not until 1950s that machines were

developed to do the work. Initially, between 1950 and 1980, efforts were concentrated on mechanizing heavy manual, and on reducing construction costs.

1950-1960: Mechanization of the heavy duty works - Tamping and Cleaning of ballast.

1960: Development of multi-functional machines - Several work processes combined in one machine, starting with the first leveling and tamping machine and followed by the combined leveling, tamping and lining machine for plain track, switches and crossings.

1965: Increased working speeds - Introduction of the first double sleeper tamping machine and the hydraulic high performance ballast cleaning machine

1967 Introduction of complete machine systems - The mechanized maintenance train MDZ and the high speed track relaying train SUZ, the first track renewal using the assembly line method (not working on Indian Railways).

Since **1971:** Further improvements in performance and quality - By designing on-track machines as standard railway vehicles followed by further improvements in the quality of work resulting from the use of electronics, laser technology, computers and automatic work sequences.

Brief History of introduction of Track Machines Worldwide:

World over first mechanical off-track tamper was tried out around 1920, which was doing packing only. First On-Track Tamper was produced by Matissa of Switzerland which was founded in the year 1945. It produced and marketed only one type of tamper, model B-60. Plasser and Theurer established their works at Linz Austria in the year 1953 and produced their first hydraulic tamping machine HGL for use on Austrian Federal Railways. They came into regular production line for the first tamping machine VKR 01 in Cantilever design from 1955 onwards. Further, evolution of track machines is given below:

- 1960: First leveling & tamping machine VKR 04
- 1962: First switch tamping machine with tilting tamping tools WE 75
- 1963: First automatic lining machine with two chord measuring technique
- 1964: First hydraulic ballast cleaning machine RM 62
- 1965: First two sleeper tamping machine Duomatic
- 1970: First leveling & tamping machine in 07 series
- 1972: First leveling, lining & tamping machine for switches 07-275
- 1973: First welding machine K355APT
- 1975: Dynamic Track Stabilizer - a new technology for stabilization of tracks
- 1983: First continuous action tamping machine 09 CSM
- 1996: First continuous action 3 - sleeper tamping machine came into existence

SUB DESCIPLINE- TRACK MACHINE (LESSIONS-02 SESSIONS-02)

Lesson–II: Types of Track Machines **Session-2:**Different types of track machines on Indian Railways, their functions and output.

INTRODUCTION TO ON-TRACK MACHINES ON INDIAN RAILWAYS:

TYPE OF M/C	MODEL NO.	YEAR OF INTRODUCTION ON IR	MANUFACTURER	NO. OF WHEELS	MAX. DRIVING SPEED KMPH	RATE OF PROGRESS / EFFECTIVE HOUR	SALIENT FEATURES
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Tie Tamping Machines – Plain Track Tamping Machine							
Super Lining Control Tamper	06-16-SLC	1968	Plasser & Theurer, Austria	4	40	400 to 500 sleepers	Double chord lining. Obsolete.
Universal Tamper	06-16-USLC	1972	-do-	4	40	500 to 600 sleepers	-do-
Tamper single sleeper	08-16-Unomatic	1985	-do-	8	60	800 to 1000 Sleepers	Single chord lining. One end driving due to Mechanical Gear Box.
Tamper Double Sleepers	08-32-Duomatic	1986	-do-	8	60	1400 to 1600 Sleepers	-do-
Continuous Tamping Machine	09-32-CSM	1989	-do-	8+2	60	2200 to 2400 Sleepers	ZF Gear Box. Satellite unit. Both end driving.
Tamping Express Three Sleepers	09-3X-CSM	2000	-do-	8 + 4	60	2800 to 3500 Sleepers	Two Engines. ALC & Laser.
Tamper Double Sleepers	08-32-New Duomatic	2003	-do-	8	60	1800 Sleepers	ZF gear Box, ALC. Both end driving.
Tamper Double Sleepers	08-32C Fully Imported	2008	-do-	-do-	-do-	-do-	No ALC, PCB 819, Fast Locking and unlocking.
Russian Tamper Double Sleepers	VPR-02M-18	2004	Metex, Russia	8	60	2000 Sleepers	Computer in Front Cabin.
Tie Tamping Machines – Points & Crossing Tamping Machine							
Points & Crossing Tamper	07-275-Unimat	1984	-do-	4	40	1 Turnout in 90 min.	Tool tilting 85^0 outside &5^0 inside. Obsolete

Points & Crossing Tamper	08-275-2S Unimat	1990	-do-	8	60	1 Turnout	Third (Working) cabin in the middle.
Points & Crossing Tamper	08-275-3S Unimat	1993	-do-	8	60	1 Turnout	Cantilever for 3rd rail lifting. T/Unit can be turned up to $8\frac{1}{2}^0$.
Points & Crossing Tamper	08-475-4S Unimat	2009	-do-	10	60	1 Turnout	4 Tamping unit with 2 split head tools & 2 telescopic arms that can be slewed out to L.H or R.H side up to 3300 mm from track centre. Synchronous 3-rail lifting and 4-rail tamping.

TYPE OF M/C	MODEL NO.	YEAR OF INTRODUCTION ON IR	MANUFACTURER	NO. OF WHEELS	MAX. DRIVING SPEED KMPH	RATE OF PROGRESS / EFFECTIVE HOUR	SALIENT FEATURES
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Tie Tamping Machines – Multi Purpose Tamper							
Multi Purpose tamper	Unimat Compact - M	1998	-do-	8	60	1 Turnout or 600 sleepers on Straight	Provision of Jib Crane. For Spot Attention. No Lifting Rollers.
Dynamic Track Stabilizer							
Dynamic Track Stabilizer	DGS-62N/62-PLS	1990	-do-	8	60	1 to 2 Km.	To consolidate track by Controlled Settlement 1Pass = 0.1 Million T.
Ballast Handling Machines							
Ballast Cleaning Machine	BCM	1970	Matissa, Switzerland	8	40	-	Obsolete.

Ballast Cleaning Machine	RM-80 KBC-600	1989	Plasser & Theurer, Austria Kershaw, USA	8	40	650 Cum.	Deep screening of plain track. New M/cs also for Points & Crossings. 2 Engines. Hydrostatic drive.
Ballast Cleaning Machine for Points & Crossing	RM-76	1992	Plasser & Theurer, Austria	8	40	550 Cum.	Deep screening of T/Out as well as plain track. Hydrostatic drive
Shoulder Ballast Cleaning Machine	FRM-80 KSC-600	1992 1986	Plasser & Theurer, Austria Kershaw, USA	12 (8 Dr. + 4 Run.)	40	550 Cum.	Hydrostatic drive.
Shoulder Ballast Cleaning Machine	FRM-85	2004	Plasser & Theurer, Austria	12	40	550 Cum.	Waste Conveyor provided at front side. Engine shifted to rear side. Centre Plough provided.

TYPE OF M/C	MODEL NO.	YEAR OF INTRODUCTION ON IR	MANUFACTURER	NO. OF WHEELS	MAX. DRIVING SPEED KMPH	RATE OF PROGRESS / EFFECTIVE HOUR	SALIENT FEATURES
1	2	3	4	5	6	7	8
Ballast Regulating Machine	BRM 66-4 BRM C56-3	1989	Kershaw, USA	4	50 60	1 Km.	Profiling & Dressing of Track. Hydrostatic drive.

	PBR-40-R	2008	Plasser & Theurer, Austria	4	60	2 km	Front/Shoulder Plough and sweeper unit
Track Relaying Machines							
Track Relaying Machine	PQRS 2000-I (5T) & 201(9T)	1972	Plasser & Theurer, Austria	4	5	1st hr = 20P 2nd hrs.= 17P 3rd hrs = 14P	5T load - 9m panel. 9T load - 13m panel.
Track Relaying Train	TRT P-811S	1989-90	Tamper Corporation, USA	Train	5	1 Km. in 2 Hr. 40 Mts.	For CTR/TSR.
Machine for Turn out Renewal	T-28	1992	Ameca. Italy	4	10	Depends on site conditions.	For complete renewal of turnout.
Special Purpose Machine							
Mobile Flash Butt Welding Plant	K-355 APT	1987	Plasser & Theurer, Austria	8	60	-	Welded with gap 3mm, rail are shorted by 32-35mm.
Rail Grinding Machine	SX-11	1990	Loram, USA	8	60	-	8 Grinding stones on each rail.Micro-processor controlled hydraulic system. Removes corrugation
Air & Vacuum Excavation Machine	RAIL VAC 10000/ 4800	-	Plasser & Theurer Austria	-	-	$25m^3$/Hr	Installation or repair of cable drainage pipes & other underground equipment, excavation for same

SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lesson-I: 08-Unomatic / Duomatic **Session-3:** Main features, Technical Data, Main assemblies and components.

---

08 UNO –DUOMATIC:

MAIN FEATURES:

- Ø 2 Bogies Of 2 - 2 Axles
- Ø Main Gear Box – Mechanical (6 Speed Gear Box)
- Ø Fully Electronics Control M/C
- Ø Tamping Unit Up/Down Proportional Control
- Ø Single Chord Lining System.
- Ø Maximum Permissible Speed 60kmph
- Ø Output Uno -800 – 100 Slipper/ Hour Duo 1400 – 1600 Slipper/ Hour

TECHNICAL DATA:

- Ø Gauge - 1676 mm
- Ø Over All Length - 18710 mm
- Ø Height Above Rail Level 3285 mm
- Ø Width - 3050 mm
- Ø Wheel Dia - 710 mm
- Ø Weight 40 Ton

VARIOUS ASSEMBLIES:

CHASIS: It is welded construction out of steel girders, channel and sheets etc.

UNDER CARRIAGE: M/C is equipped with two-2 axles bogies with axles.

ENGINE: Kirloskar Cummins Dieses Engine, Six Cylinder Vertical Water Cooled, Turbo Charger Modern N .T. 743 C. Output: 243 HP At 2000 RPM.

TAMPING UNITS: Unomatic Model Have 16 Tools And Duomatic –Model Has 32 Tools.

HYDRAULIC SYSTEM: DUOMATIC :

PUMP: - : - **3 DOUBLE PUMPS**

(1) **38 × 17 GPM** COMBINED DELIVER TO SYSTEM PRESSURE OF 120 TO 140 BAR.

(2**)** **38 × 17 GPM**
38 GPM = VIBRATION (ONE SIDE) PRESSURE 150 BAR
17 GPM = COUNTER PRESSURE 35 BAR

(3**)** **38 × 22 GPM**
38GPM = VIBRATION ANOTHER SIDE PRESSURE 150 BAR
22 GPM = HYDRAULIC COOLER MOTOR PRESSURE –50BAR

UNOMATIC: - **3 DOUBLE PUMPS**

(**1**). **38 × 17 GPM** =DELIVER TO SYSTEM PRESSURE ADJUSTED 120 -140 BARS

(**2**) **20 × 17 GPM**
20 GPM = VIBRATION (ONE SIDE) PRESSURE 150 BAR
17 GPM = HYDRAULIC OIL COOLER PRESSURE 50 BAR

(**3**). **20 × 22 GPM or 20 × 17 GPM**
20 GPM = VIBRATION ANOTHER SIDE PRESSURE 150 BAR
17 GPM = HYDRAULIC OIL COOLER PRESSURE 50 BAR.

HYD MOTOR = 5 NOS

Vibration Motor	= 2 Nos
Driving Motor	= 1 Nos
Hydraulic Oil Cooler Motor	= 2 Nos

ACCUMULATOR: - 32 liters capacities, N2 pressure 85 bars for system pressure are produce on both Uno and Duo. Two 1.6 liter capacity N2 pressure 20 bar for counter pressure are provided on Duo only.

PROPORTIONAL VALVE: - 2NOS FOR TAMPING UNIT UP/DOWN CONTROL
SOLONOID VALVE: - UNO - 16 NOS DUO - 18 NOS
HAND OPERATED VALVE: - 01 NO
CYLINDERS : UNO -30 NOS DUO = 38 NOS
HYDRAULIC OIL COOLERS: - 02 NOS
SUCTION FILTERS: - 03 NOS
RETURN FILTERS: - 02 NOS
PRESSURE FILTERS: - 01 NO
PRESSURE CONTROL VALVE: - 09 NOS
PRESSURE REDUCING FILTER: - 03 NOS
FLOW CONTROL VALVES:- 08 NOS

PNEUMATIC SYSTEM:

COMPRESSOR	=	01 NO 500 LITER/MINUTE
UNLOADER VALVE	=	01 NO PRESSURE ADJUSTED 7 BAR
AIR TANK	=	02 NOS CAPACITY 100 LITER EACH
BRAKE CYLINDER	=	02 NOS DIA 12 INCH EACH
CYLINDER	=	43 NOS OFF SIZES.

DRIVING SYSTEM:

1. **Run Drive** - 6 Speed Gear Box Is Provided For Driving Station To Station.

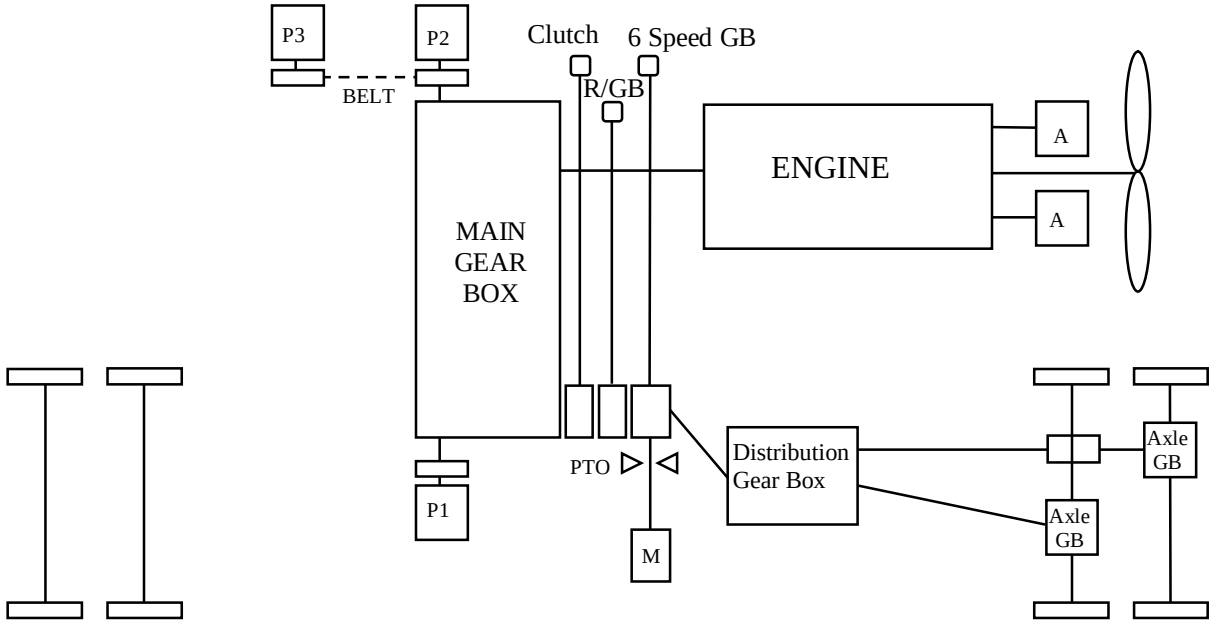
2. Work Drive - Hydraulic motor is provided for work drive at constant speed.

2. Tamping Unit:This is first tamping machine on which proportional valves are provided for smooth and jerk less up and down.

3. Lining : This is first tamping machine on which single chord lining (4 point and 3 point lining) systems are provided.4 point lining is called smoothening mode and 3 point is called precision mode. design lining is possible in every mode for which offset value is feeded.

4. Levelling : Double chord follow up systems are provided on this series machine.In this method one rail is kept base line and other line is cant line.Cant side chord follow up base line to maintain the level of the chord with the help of front pendulum. This machine is design for cross-level correction. the leveling may be done by proportional mode or design mode.

POWER TRANSMISSION :



SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lesson-I:08-Unomatic / Duomatic **Session-5:**Name of PCBs, their functions and Electrical system.

PCB NAME :

SR.NO.	PART NO.	FUNCTION	QUANTITY
1	EK813SV00	DC-DC CONVETER	4 NOS.
2	EK255LV00	FRONT AUTO LEVELLING	1 NOS.
3	EK708/715A00	M MOTOR DRIVE	2 NOS.
4	EK217LV00	FRONT PENDULUM CONTROL	1 NO
5	EK275LV00	DESIGN LINING	1 NO
6	EK 16V00	TEMP UNIT UP-DOWN CONTROL.	2 NOS.
7	ELT1116	SEMI AUTO WORK	1 NO
8	EK335LV00	LINING	1 NO
9	EK290LV00	OVER SLEW	1 NO
10	EK80V00	3 STAGE LINING	1 NO
11	EK229LV00	TRACK LIFTING	2 NOS.
12	EK277LV00	MIDDLE PENDULUM CONTROL	1 NO
13	EK79V00	3 STAGE LIFTING	1 NO
14	ELT631.00	INTERCOM	1 NO

ELECTRICAL SYSTEM

1 BATTERY 12 V/180 AH = 2 NOS. Combined In Series

2 ALTERNATOR 53 A/27 V = 2 NOS.TVS Lucas Make

3 SELF STATER =2 NOS.

4 MARRELLY MOTOR(WIPER MOTOR) = 2 NOS.

5 PENDULUM(MECHANICAL+ ELECT) = 2 NOS.

6 HEIGHT TRANSDUCER = 2 NOS.

7 LINING TRANSDUCER =2 NOS

SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lesson-II:09-32-CSM **Session-6:** Main features, Technical Data, Main assemblies and components.

09 -32 CSM

MAIN FEATURES:

- Ø MACHINE HAVE TWO PARTS I.E. MAIN FRAME & FRAME SATELLITE
- Ø MAIN GEAR BOX—ZF -- (4 SPEED GEAR BOX).
- Ø PROGRAMMABLE LOGIC CONTROL (PLC) MACHINE.
- Ø AUTOMATIC DATA DEEDING BY COMPUTEC (GVA) ONLY FIVE MACHINE.
- Ø LASER LINING (ONLY ON 5 MACHINE)
- Ø LINING & LIFTING SERVO CONTROL.
- Ø FULLY AUTO WORKING.
- Ø DATA RECORDER, (AFTER WORK) 3- CHANNELS.
- Ø TWIST CORRECTION.
- Ø MAXIMUM PERMISSIBLE SPEED 60 KMPH (BY RDSO)
- Ø OUTPUT ---- 2200 TO 2400 SLEEPER / HR.
- Ø MULTICHECK SYSTEM.

GENERAL DATA:

Ø OVERALL LENGTH	--	27640 MM
Ø HEIGHT ABOVE RAIL LEVEL	--	3600 MM
Ø WIDTH	--	3040 MM
Ø WHEEL DIA	--	730 MM
Ø TOTAL WEIGHT	--	64 TON
Ø MINIMUM RADIUS WORKING	--	100 M

MAIN UNITS:

1. SATELLITE --	WEIGHT 14 TON
2. MAIN FRAME	WEIGHT 50 TON
3. ENGINE	MWM 232 TBD 12 V @ 473 BHP
4. TAMPING UNITS (DUO TYPE)	32 TOOLS
5. LIFTING & LINING UNITS	
6. Z. F GEAR BOX.	4 SPEED GEAR BOX.

HYDRAULIC SYSTEM:

PUMP 5 PUMP (4 DOUBLE PUMPS + 1 VARIABLE PUMP)

1**. DOUBLE PUMP** =**38×22 GPM** COMBINED FOR SYSTEM PRESSURE ADJUST**120-140** BAR

2. **DOUBLE PUMP = 38 × 17 GPM**
38 GPM = VIBRATION (ONE SIDE) PRESSURE**150** BAR.
17 GPM = HIGH PRESSURE **150** BAR

3. **DOUBLE PUMP = 38× 17 GPM**
38 GPM = VIBRATION (ANOTHER SIDE) PRESSURE **150** BAR;
17 GPM = COUNTER PRESSURE **35** BAR.

4. **DOUBLE PUMP** = 20 × 17 GPM OR 20 × 114 GPM
20 GPM = 2 HYDRAULIC COOLERS MOTOR PRESSURE **50**BAR
17 GPM = RADIATOR + Z. F.OIL COOLER PRESSURE **50** BAR.

5. VARIABLE PUMP. **= 90 LPM** DRIVING PRESSURE **210** BAR
CHARGING PRESSURE **30** BAR.

MOTORS: - 8 NOS

VIBRATION MOTOR	= 2 NOS
DRIVING MOTOR	= 2 NOS
HYDRAULIC OIL COOLER MOTOR	= 2 NOS
Z. F. + RADIATOR MOTOR	= 2 NOS

ACCUMULATOR: - 4 NOS

1. 32 LITRE CAPACITY N2 PRESSURE 85 LITER FOR SYSTEM PRESSURE -1NO
2. 20 LTS CAPACITY N2 PRESSURE 100 LITER FOR HIGH PRESSURE -1NO
3. 1.5 LTS CAPACITY N2 PRESSURE 20 LITER FOR COUNTER PRESSURE- 2NOS

PROPORTIONAL VALVES: - 3 NOS

TAMPING UNITS UP/DOWN CONTROL	= 2 NOS
SATELLITE MOVEMENT	= 1 NO

SERVO - VALVE - 3 NOS

LIFTING	=	2 NOS
LINING	=	1 NO

SOLENOIDS: - 22 NOS SOLENOID VALVE
CYLENDRS: - 50 NOS
SUCTION FILTER = 3 NOS
RETURN FILTER = 2 NOS
PRESSURE FILTER = 3 NOS

PNEUMATIC SYSTEM:

TWIN CYLINDER COMPRESSOR CAPACITY 600 CM/MINUTE

UNLOADER VALVE	= 1 NO PRESSURE ADJUST 7 BAR
AIR TANK	= 2 NOS CAPACITY 100 LITER EACH
BRAKE CYLINDER FOR MAIN MACHINE	= 2 NOS DIA 12 INCH.
BRAKE CYLINDER FOR SATELLITE	= 2 NOS DIA 8 INCH.
PRESSURE CYLINDER	= 56 NOS OFF SIZES.

WORKING PRINCPLE

DRIVING SYSTEM: -

WORK DRIVE: - During work machine is driven by variable pump with variable speed 0 to 2 kmph. but satellite drive is proportional drive. the speed of satellite varies with the main frame speed.

RUN DRIVE: - Hydro dynamics gear box (zf) is provided on the machine.

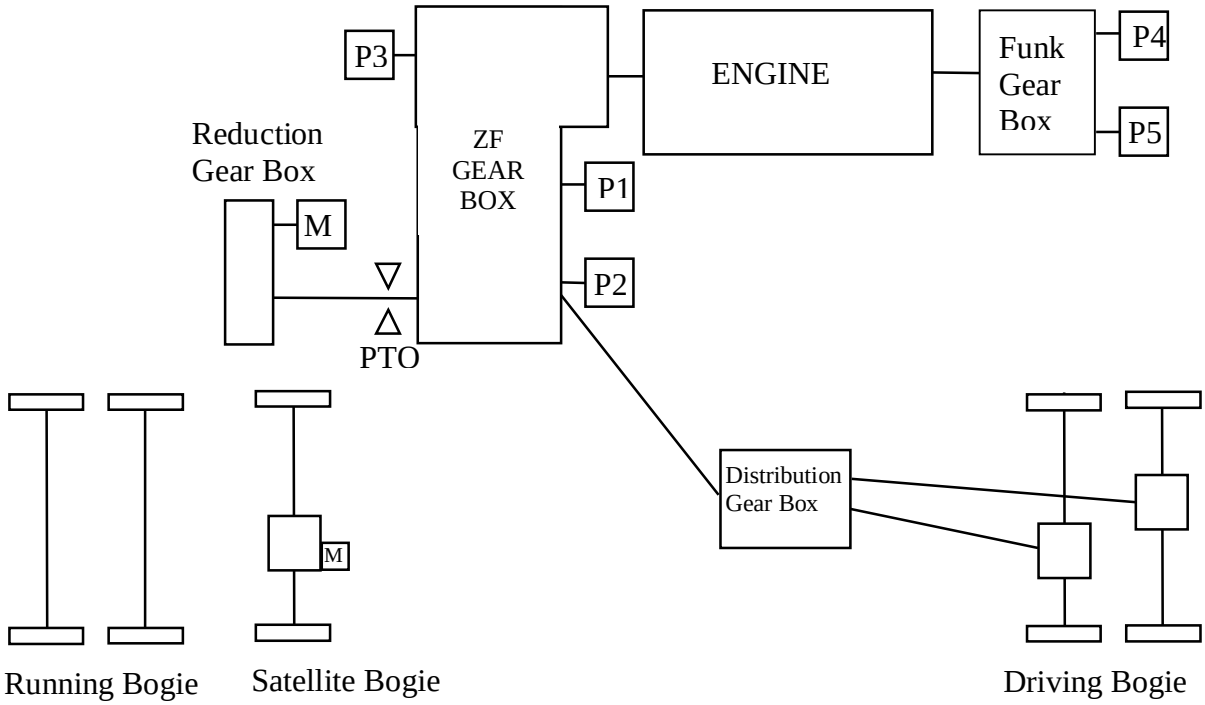
LINING: - Single chord lining system is provided on CSM .on few machine (only 5 machines) laser lining systems are provided.

LEVELING: - On this machine fixed chord double chord leveling system is provided. This machine is designed for the twist correction for that rear pendulum is given.

RECORDER: - 3 channel recorders are provided on each machine to record the parameters i.e. versine, cross level and lift value after work.

GVA: - Geometrical value assessment computer is provided on only first five CSM. computer feeds the required data to the machine automatically with respect to distance. Linear feeding is only possible in this method.

POWER TRANSMISSION:



ELECTRICAL & ELECTRONICS

- Ø BATTERY 12 V/ 180 AH = 2 NOS COMBINED IN SERIES
- Ø ALTERNATOR 28V/55A = 2 NOS BOSH MAKE
- Ø SELF STARTOR = 1 NO
- Ø PENDULUM = 3 NO.
- Ø HIEGHT TRANSDUGER = 2NOS
- Ø LINING TRANSDUCER = 2NOS
- Ø TAMPING DEPTH TRANSDUCER = 2 NOS
- Ø DISTANCE ENCODER = 2 NOS

NAME OF PCB:

Sr. NO.	PART NO.	FUNCTION	QUANTITY
1	EK813SV00	DC to DC Converter	5 Nos
2	EK812SV00	DC to DC Converter	1 No
3	EK851SV00	DC to DC Converter	1 No
4	EK345LV00	Front Input	1 No
5	EK24V00	Satellite Drive	1 No
6	EK28V00	Multiplexer	1 No
7	EK16V00	Tamping Unit UP/DOWN Control	2 Nos
8	EK347LV00	Track Lifting	2 Nos
9	EK346LV00	Pendulum Control	1 No
10	EK348LV00	Satellite Compensation	1 No
11	EK349LV00	Lining Control	1No
12	EK290LV00	Overslew	1 No
13	EK319LV00	Work Drive Control	1 No
14	EK99V00	Distance Simulator	1 No
15	EK110LV00	Pendulum Compensation	1 No
16	EK501P00	Programmer	1 No
17	EK552P00	Delayed Output	1 No
18	EK553P00	Input/Output	9 Nos
19	ELT631	Intercom	1 No

SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lession –III: 08-275 UNIMAT **Session -9:**Main Features Technical Data Main Assembly & Components

---

08 – 275 UNIMAT

MAIN FEATURES: -

- Ø THIS MACHINE HAS GOT 16 TAMPING TOOLS .WHICH CAN BE TILTED.
- Ø MAIN GEAR BOX -- ZF
- Ø THREE CABINS I. E FRONT , REAR & WORKING
- Ø PLC CONTROL
- Ø MULTICHECK SYSTEM
- Ø TWO OPERATORS REQUIRED IN WORKING CABIN.
- Ø DOUBLE CHORD FIXED LEVELING SYSTEM.
- Ø HOOK BLOCK FOR LIFTING
- Ø MAXIMUM PERMISSIBLE SPEED 60 KMPH
- Ø MAXIMUM OUTPUT 90 MINUTE/ T.O.

GENERAL DATA

Ø OVERALL LENGTH	--	19170 MM
Ø HEIGHT ABOVE RAIL LEVEL	--	3500 MM
Ø WIDTH	--	3020 MM
Ø WHEEL DIAMETER	--	730 MM
Ø TOTAL LOAD	--	44000 KG
Ø LINING BASE	--	20600 MM
Ø LEVELING BASE	--	12210 MM

MAIN ASSEMBLY:-

ENGINE -- CUMMINS NT 855 L 320 HP @ 2000 RPM

- Ø CHASSIS --
- Ø MAIN GEAR BOX -- Z F GEAR BOX
- Ø TAMPING UNITS - WITH TILTING ARRANGEMENT
- Ø LINING AND LIFTING - MONOBLOCK WITH SEPARATE LIFT- ARRANGEMENT.
- Ø DISTRIBUTION GEAR BOX
- Ø REDUCTION GEAR BOX.

HYDRAULIC SYSTEM

PUMPS - 3 DOUBLE PUMPS ARE PROVIDED

1. **D/PUMP 38×22 GPM** COMBINED FOR THE SYSTEM PRESSURE.120- 140 BAR.

2. **DOUBLE PUMP - 20 × 17 GPM**
   20 GPM = VIBRATION (ONE SIDE) PRESSURE 150 BAR
   17 GPM = 3 HYDRAULIC COOLERS MOTOR PRESSURE 150 BAR

3 **DOUBLE PUMP 20×22 GPM**
20 GPM = VIBRATION (ANOTHER SIDE) PRESSURE 150 BAR.
22 GPM = HIGH PRESSURE. 150 BAR.

MOTOR: - 7 MOTORS ARE USED ON THIS MACHINE.

VIBRATION MOTOR	-	2 NOS
DRIVING MOTOR	-	2 NOS
HYDRAULIC OIL COOLER	-	2 NOS
Z F COOLER MOTOR	-	1 NO

ACCUMULATOR:-

TWO ACCUMULATORS BLADDER TYPE.

1. 32 LITERS CAPACITY NITROGEN PRESSURE 85 BAR FOR SYSTEM PRESSURE.

2. 20 LITERS CAPACITY NITROGEN PRESSURE 100 BAR FOR HIGH PRESSURE.

PROPORTIONAL VALVE:-

TWO NOS FOR TAMPING UNIT UP/DOWN CONTROL.

SOLENOIDS: - 43 SOLENOIDS.

CYLENDERS: - 57 CYLINDERS OFF SIZES.

PNEUMATIC SYSTEM.

1. COMPRESSOR	=	1 NO CAPACITY 500 CUM/MINUTE
2. PRESSURE TANK	=	2 NOS CAPACITY 100 LITER/ INCH
3. BRAKE CYLINDER	=	2 NOS. DIA. = 12 INCH.
4. CYLINDER	=	48 NOS OF SIZES
5. SOLENOID	=	12 NOS

WORKING PRINCPLE
DRIVING:
RUN DRIVE: - BY HYDRODYNAMICS (ZF) IV SPEED GEAR BOX.

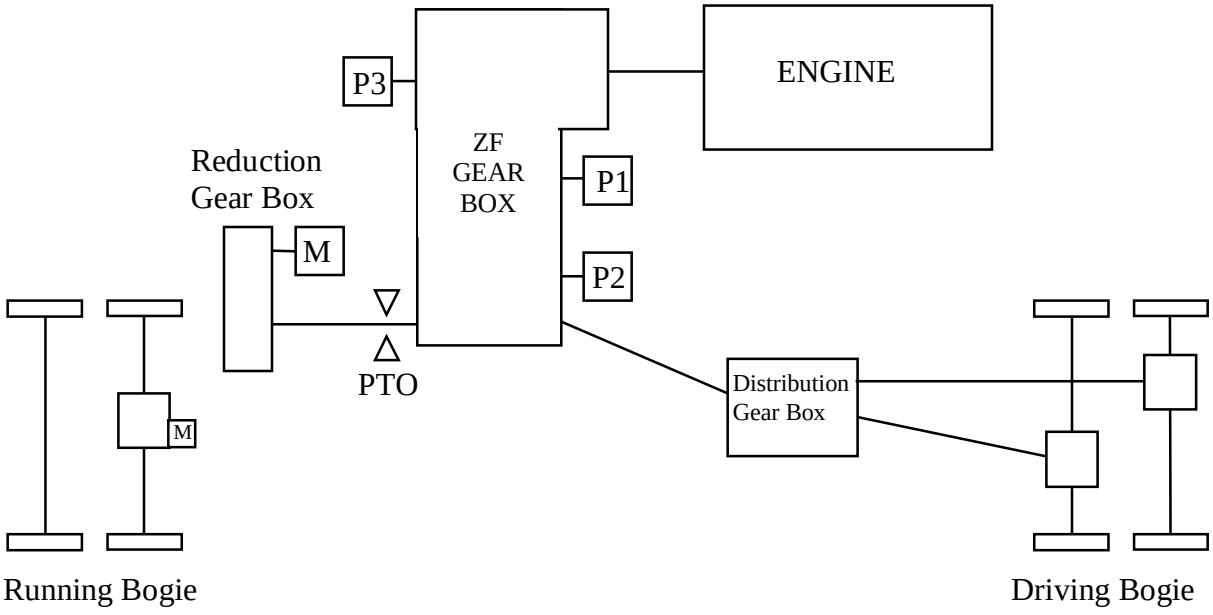
WORK DRIVE: - BY HYDRAULICS MOTOR WITH CONSTANT SPEED.

LINING: SINGLE CHORD LINING SYSTEM.

LEVELLING:- DOUBLE CHORD FIXED TYPE SYSTEM AND CROSS-LEVEL RECORDING REAR PENDULUM IS PROVIDED.

RECORDER 2- CHANNEL RECORDER IS USED TO RECORD CROSS LEVEL AND VERSINE AFTER THE WORK.

POWER TRANSMISSION:



SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lession -III : 08-275-UNIMAT **Session -11:**Name Of PCBs & Their Functions And Electrical System

---

ELECTRIC SYSTEM.

1. BATTERY 12 V/ 180 AH = 2 NOS COMBINED IN SERIES.
2. ALTERNATOR 28 V/55A = 2 NOS BOSCH MAKE.
3. SELF STARTER = ONE
4. PENDULUM = 3 NOS
5. HEIGHT TRANSDUCER = 2 NOS
6. VERSINE TRANSDUCER = 2 NOS
7. TAMPING DEPTH TRANSDUCER = 2 NOS
8 LINING CHORD FOLLOW UP COMPENSATION = 1 NO TRANSDUCER

PCB 15 DIFFERENT TYPE PCB (MAIN)

Sr. NO.	PART NO.	FUNCTION	QUANTITY
1	EK813SV00	DC to DC Converter	4 Nos
2	EK2072LV00	Front Input	1 No
3	EK28V00	MULTIPLEXER	1 No
4	EK132V00	Tamping Unit UP/DOWN Control	2 Nos
5	EK144V00	Hook + Three Stage Regulator	1 No
6	EK2041LV00	Track Lifting	2 Nos
7	EK2042LV00	Pendulum Control	1 No
8	EK2038LV00	Lining Control	1 No
9	EK290LV00	Overslew	1 No
10	EK719A00	Lining Chord Follow up	1 No
11	EK502P00	Programmer	1 No
12	EK552P00	Delayed Output	1 No
13	EK553P00	Input/Output	11 Nos
14	EK554P00	QL Plate	5 Nos
15	ELT631.00	Intercom	1 No

08 – 275 – 3S UNIMAT - 3S

MAIN FEATURES

- Ø ALL FOUR BOGIES ARE POWERED.
- Ø TAMPING UNIT CAN BE RUNNING 8 EACH SIDE.
- Ø 3^{RD} RAIL LIFTING ARRANGED ALSO.
- Ø LINING AND LIFTING: - SERVO VALVE
- Ø SQUEEZING: - PROPORTIONAL VALVE
- Ø MAX. PERMISSIBLE SPEED: - 60 KMPH.
- Ø OUTPUT: - 60 MINUTE/T.O.

GENERAL DATA

- Ø OVER ALL LENGTH = 22305 MM
- Ø WIDTH = 3550 MM
- Ø WHEEL DIA = 730 MM
- Ø L. CHORD LENGTH = 22.60 M
- Ø LEVELING CHORD = 15.58 M
- Ø WEIGHT = 64 TONNES

MPT-2000
MAIN FEATURE

i. It can tamp plain track as well as point and crossing.
ii. It has a small 1 tonne capacity crane for loading and unloading 4 No. Rail pieces of about 6.5 metres long.
iii. It can carry 20 workers to site of work.

GENERAL DATA

LENGTH	:	20.270 M
WIDTH	:	3.100 M
HEIGHT	:	3.700 M
DISTANCE BETWEEN BOGIE PIVOTS	:	12.000 M
WHEEL DIA	:	0.730 M
WEIGHT	:	46 TONNES
ENGINE CUMMINS	:	KT 855
SPEED POTENTIAL	:	80 KMPH

WORKING PRINCPLE
DRIVING:

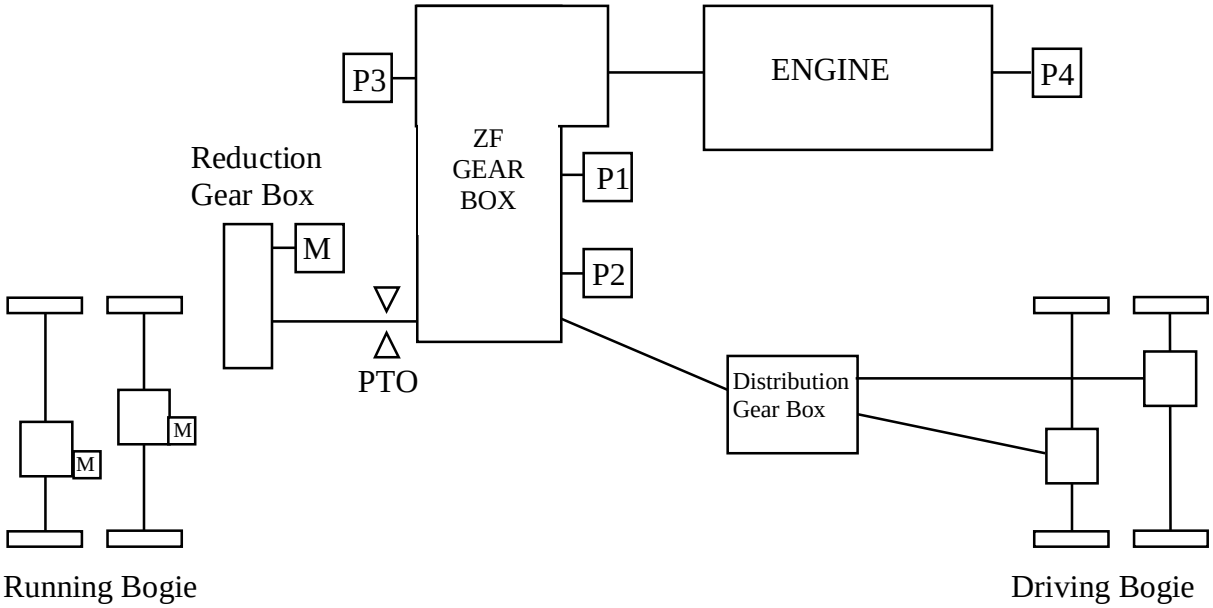
RUN DRIVE: - BY HYDRODYNAMICS (ZF) IV SPEED GEAR BOX.

WORK DRIVE: - BY HYDRAULICS MOTOR WITH CONSTANT SPEED. NORMALLY TWO MOTORS ARE WORKING BUT ON GRADIENT THIRD MOTOR IS APPLIED

LINING: SINGLE CHORD LINING SYSTEM WITH PNEUMATIC FOLLOW UP SYSTEM LEFT OVER ERROR IS VERY LESS (FR = FD/7.6)

LEVELLING:- DOUBLE CHORD FIXED TYPE SYSTEM THIRD RAIL LIFTING ARRANGEMENT IS GIVEN WHICH CAN LIFT ADJACENT RAIL AND PACKED MANUALLY

POWER TRANSMISSION:



NAME OF PCBs & THEIR FUNCTIONS:

08-275-3S:

S. No.	PCB Part No.	Function	Qty.
1.	EK 813 SV 00	DC to DC Convertor 24V→ ± 15 V and ± 10V	4 Nos.
2.	EK 812 SV00	DC to DC Convertor 24V→ +24V and + 12V	1 No.
3.	EK2072 LV00	Front input	1 No.
4.	EK2173 LV00	Lining Inputs control	1 No.
5.	EK2140 LV00	Lining Output& Over Slew control	1 No.
6.	EK2041 LV00	Track lifting	2 Nos.
7.	EK2042 LV00	Pendulum control	1 No.
8.	EK 120 V00	Hook Control	1 No.
9.	EK 140 A00	Proportional squeezing	1 No.
10.	EK 132 V02	Tamping Unit UP/DN control	2 Nos.
11.	EK 28 V02	Multiplexer	1 No.
12.	EK 502 P00	Programmer PCB	1 No.
13.	EK 552 P00	Time Delay	1 No.
14.	EK 553 P00	Programmer Input/output	13 Nos.
15.	EK 554 P00	QL-relay	5 Nos.
16.	EL-T 631.00	Inter com.	1 No.

FOR MPT:

1.	Tamping unit control PCB	→	EK 176V-00
2.	Leveling circuit control PCB	→	EK 2041LV00
3.	Pendulum Control PCB	→	EK 2042LV-00a
4.	Front input	→	EK 3049 LV-002a
5.	Lining control	→	EK 1.1/17LV-00
6.	Over slew lining PCB	→	EK 2140LV-00
7.	Hook control	→	EK120V-00
8.	Drive control	→	EK 3045LV-00
9.	Speed control card	→	EK-197V-00
10.	Processor card	→	EK 650P-00
11.	Power supply card	→	EK-813 SV-002a
13.	Multicheck card	→	EK 28V-00a
14.	Input-output card	→	EK-651P-00
15.	Input-output card	→	EK-553P-00
16.	Time delay card	→	EK-652P-00
17.	Receiver card	→	EK-430 DV.00b
18.	Sender card	→	EK-429 DV.00b
18.	QL relay PCB	→	EK-554P-00a

ELECTRICAL SYSTEMS:

FOR UNIMAT-3S:

1. BATTERY =4 NOS. (12V/180AH-2 NOS, 12V/40AH 2 NOS)
2. ALTERNATOR 28 V/55A = 2 NOS BOSCH MAKE.
3. SELF STARTER = ONE
4. PENDULUM = 2 NOS
5. HEIGHT TRANSDUCER = 2 NOS
6. VERSINE TRANSDUCER = 2 NOS
7. TAMPING DEPTH TRANSDUCER = 2 NOS

FOR MPT:

1. BATTERY = 2 NOS. (12V/180AH)
2. ALTERNATOR 28 V/55A = 2 NOS BOSCH MAKE.
3. SELF STARTER = ONE
4. PENDULUM = 2 NOS
5. HEIGHT TRANSDUCER = 2 NOS
6. VERSINE TRANSDUCER = 2 NOS
7. TAMPING DEPTH TRANSDUCER = 2 NOS
8. LINING CHORD FOLLOW UP COMPENSATION TRANSDUCER = 1 NO

Differences between unimat 2S & 3S	
UNIMAT -08-275-2S	**UNIMATE -08-275-3S**
1. Cummins engine water cooled , model NTA-855 L six cylinder with 320 H.P at 2000 rpm 2. One turbocharger 3. One radiator and one water pump 4. Two batteries of 12 v / 180 AH 5. Inter communication system is not provided in the driving cabin 6. Automatic chord follow up system by electrical power. 7. Two hydraulic motors for work drive 8. Two separate valves are used each for slow & fast movement of lifting & lining operations 9. Three hydraulic pumps of 38/22 GPM, 20/22 GPM and 20/17 GPM Are provided. 10. Pump 38-22 GPM : used for system at 135-150 bar 11. Pump 20-22 GPM : 20 GPM pump vibration at 150 bar and 22 GPM high pressure system of 150 bar 12. Pump 20-17 : 20GPM pump for vibration at 150 bar 17 GPM for cooling circuit 13. Two return & One pressure filter 14. Tamping units moves laterally only 15. Fail safe brake arrangement is not provided 16. No emergency brake-up is provided for locking tamping unit. Lifting unit etc. in case of shut-down or hydraulic pump failure 17. Recorder is provided to record track parameters 18. There are three electrical pendulums one each on front tower. Working cabin and recorder 19. Lining unit frame work is in piece 20. Cannot lift third rail. Jacking has to be done with kutcha packing	1. MWM engine water cooled , model TBD-232 v-12 with 473 H.P at 2000 rpm 2. Two turbochargers 3. Two radiators and two water pumps 4. Two batteries of 12 v / 20AH in additions 2 no.s 12 v 220 AH 5. Inter communication system is provided in all the three cabin 6. Automatic chord follow up system by pneumatic power. 7. Three hydraulic motors for work drive 8. Servo valves are used for lifting and lining operations 9. Three double pumps of 38/17 GPM. 25/25 GPM. And 20/14 GPM are provided and one axial piston pump 10. Pump 38-17 GPM : used for system at 135-150bar 11. Pump 25-25 GPM : for vibration motors LH & RH at 150bar vibration motors are of 22 GPM capacity 12. Pump 20-14 for drive of cooler and engine radiator fans 13. Two return & three pressure filters 14. The t/units can be rotated through 8.5 degrees on both the sides. 15. Fail safe- brakes are provided. 16. Back-up system is provided. 17. Recorder is not provided. 18. Only two pendulums have been provided. 19. Lining unit frame work is in two pieces 20. Can lift third line synchronous with main line but cannot tamp. Manual katcha packing has to be done.

08-475-4S UNIMAT:

Main Features:

- 2 bogies of 2-2 Axles & one idle axle.
- Z.F. Gear box.
- Fully automatic tamping cycle (plain track).
- (Adjustment automatic system) SJA systems.
- ALC system.
- Maximum permissible speed 60 km/hrs..
- Toeing speed 100kg/hrs.
- 3rd Rail Lifting & 4th Rail tamping arrangement.
- Out put one turn out/hrs.
- Intercom in all cabins
- **General Data:**

  Overall length – 28370mm
  Width – 3000mm
  Height – 3743mm
  Axle – 5Nos.
  Wheel diameter – 920mm
  Total Weight – 84100 Kg.

Main Units:

Tamping Unit – In 4 parts & each contains 4 tilt able tools.
Lining & Lifting Unit – 4T tool
ZF Gear Box – 4 speed
Engine – 2 Nos.

(1) Cummins KTA-1150L 350Wat 2100RPM
(2) Additional Engine Kirloskar 6.8KW

Tamping Unit: Tamping Unit in 4 parts & each contains 4 tilt able tamping tools. The two outer tamping unit parts can be slewed laterally 200mm to the inside & 1500mm to the outer side.

- The two tamping unit parts can be slewed on guide columns 200mm to inside & 640mm to the out side of the machine.
- Each tamping unit parts can tilt 8½0.in either side.
- Each tamping tool can tilt 15^0 inside & 85^0 out side.

Proportional valves are provided for smooth and jerk less up and down movement of tamping units .

Lining : In this machine single chord lining (4 point and 3 point lining) systems are provided.4 point lining is called smoothening mode and 3 point is called precision mode.
design lining is possible in every mode for which offset value is feeded.

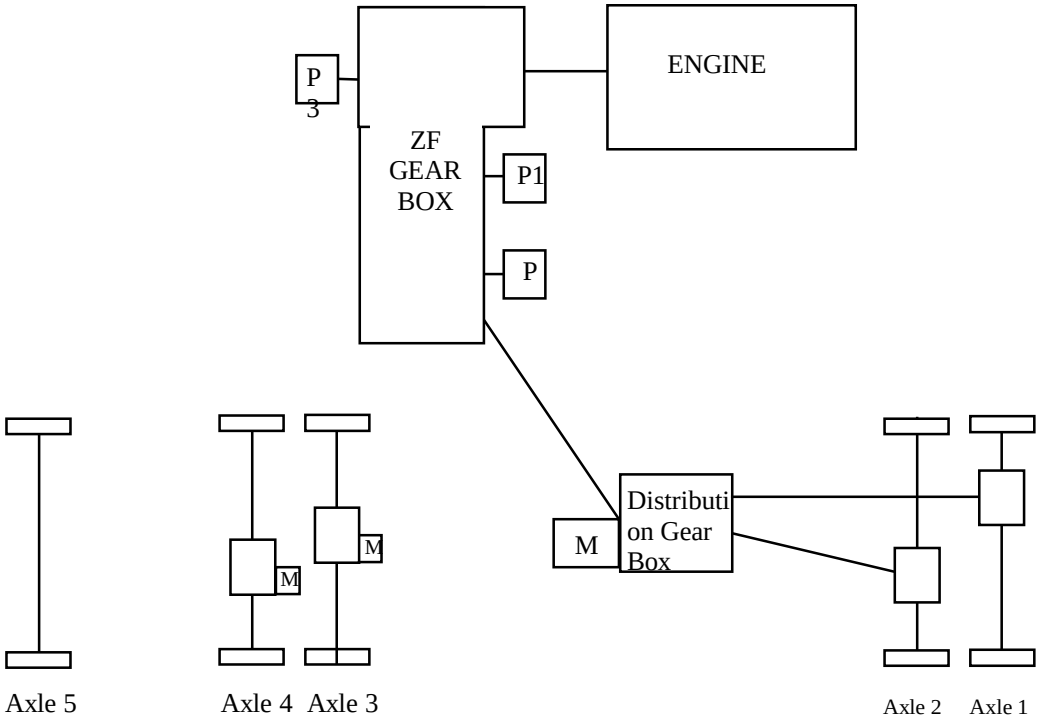
Levelling : Double chord levelling systems are provided on this series machine. In this method one rail is kept base line and other line is cant line. Cross level is maintained with the help of pendulums. This machine is design for cross-level and longitudinal level correction.
the leveling may be done by proportional mode or design mode.

Driving:

Run Drive – By Hydrodynamics (ZF) IV Speed Gear Box.
Work Drive – Three Hydraulic Motors are provided. Machine work in constant speed.

Fuel Tank Capacity – 3000 ltr. + 1 additional tank of 900 ltr. Capacity.

POWER TRANSMISSION :



Engine KT-1150L 350KW 2100RPM
ZG ZF Gear Box Model – 4WG 65II
Distribution Gear Box WN-75 200/1800
MX – Hydraulic Motor – Hy 916N800
P1 = Hydraulic Triple Pump Hy 832 x 24-14-14L
P2 = Hydraulic Triple Pump Hy 832 x 20-14-14L
P3 = Hydraulic Triple Pump Hy 832 x 38-22-14RE

Hydraulic System:

1. Hydraulic Pumps	Hy 832 x 24 x 14 x 144 – 1 No.
2. Hydraulic Pumps	Hy 832 x 38 x 22 x 14RE – 1 No.
3. Hydraulic Pumps	Hy 832 x 38 x 14 x 14Li – 1 No.
4. Gear Pumps	Hy 711 x 08 RE – 1 No.

Hydraulic Motors:
1. For Driving – 3 Nos.

2. For Vibration – 4 Nos.
3. For AC = 2 Nos.
4. Engine Radiator – 1 No.
5. With Small Engine – 1 No.
6. Cooler + ZF Cooler - 3

Hydraulic Filter:

Suction filter	Hys-501-460-150H – 3 Nos.
Return flow filter	Hys-501-330-10A/H – 1 Nos.
Filter Elements	Hyd-501-32-10ES – 2 Nos.
Filter	Hyr-508-05-01 – 3 Nos.
Filter	DL-40-60E – 2 Nos.
Filter	Hyd-501-225-25 – 1 No.
Filter (Diesel)	Hyd-506-10-30 – 1 No.

Accumulator:

1. 85 bar	32 ltr capacity – 2 Nos.
1. 85 bar	20 ltr capacity – 1 No.

Special Valve:
Servo Valve 3 Nos.
Proportional Valve – 4 Nos.

Hydraulic Pressure
Vibration Pressure – 185bar
Squeezing Pressure – 130-140bar
Big Squeezing – 150bar
AC - 10bar

Cardon Shaft – 5 Nos.

Pneumatic System:
Two cylinder compressor
Use (i) For Brake System
(ii) Lifting & Lowering of Trolleys
(iii) For locking of trolleys
(iv) For warming device.

09 - 3X TAMPING EXPRESS

MAIN FEATURES:

- Ø LATEST VERSINE OF CSM
- Ø PROGRAMMABLE LOGIC CONTROL (PLC) MECHANISM.
- Ø COMPUTER
- Ø ALC: - FOR AUTOMATIC DATA FEEDING
- Ø 3.BOGIES OF 2 – 2 AXLES (INCLUDING SATELLITE BOGIE)
- Ø 2 – ENGINES OF CUMMINS NT 855 & KTA 1150
- Ø MAXIMUM PERMISSIBLE SPEED 60 KMPH (BY RDSO)
- Ø OUTPUT 2700 SLIPPER/HOUR

GENERAL DATA:

Ø OVERALL LENGTH	--	22940 MM
Ø WEIGHT	--	4090 MM
Ø WIDTH	--	2900 MM
Ø DISTANCE BETWEEN BOGIE PIVOTS	--	15700 MM
Ø WHEEL DIA	--	730 MM
Ø TOTAL WEIGHT	--	830 TONNES

MAIN UNITS:

- Ø FOUR TAMPING UNITS
- Ø ENGINE: TWO ENGINES ARE PROVIDED KTA 1150L AND NT 855
- Ø SATELLITE HAVING TWO AXLES WITH HYDRAULIC BRAKES
- Ø ZF GEAR BOX WITH FOUR SPEED
- Ø DIFFERENTIAL GEAR BOX

HYDRAULIC SYSTEM:-

PUMP 6 DOUBLE PUMP AND ONE VARIABLE PUMP.

1. Double pump	38×22 GPM Combined for system pressure adjust 130 bar.
2. D/ Pump	35×25 GPM = 01 No.
	35 GPM = Vibration + 2nd tam/ v Pressure 150 bar
	17 GPM = ZF Cooler motor + Radiator of KTA 1150 L
3. D/Pump	35 ×17 GPM = 01 No
	35 GPM = Vibration (another side) pressure 150
	17 GPM = Counter pressure for big cylinder and small Cylinder.
4. D/Pump	35 X 17 GPM
	35 GPM = Vibration of tamping unit
	17 GPM = Hydraulic coolers
5 D/Pump	38 X 25 GPM Combined for the system pressure 130 bar
6 D/Pump	35 X 17 GPM
	35 GPM = Vibration of tamping unit
	17 GPM = Hydraulic cooler motor drive
7. Variable Pump:	Capacity 125 LPM for continuous drive

WORKING PRINCPLE

DRIVING SYSTEM: -

WORK DRIVE: During work machine is driven by variable pump with variable speed 0 to 2 kmph. but satellite drive is proportional drive. the speed of satellite varies with the main frame speed.

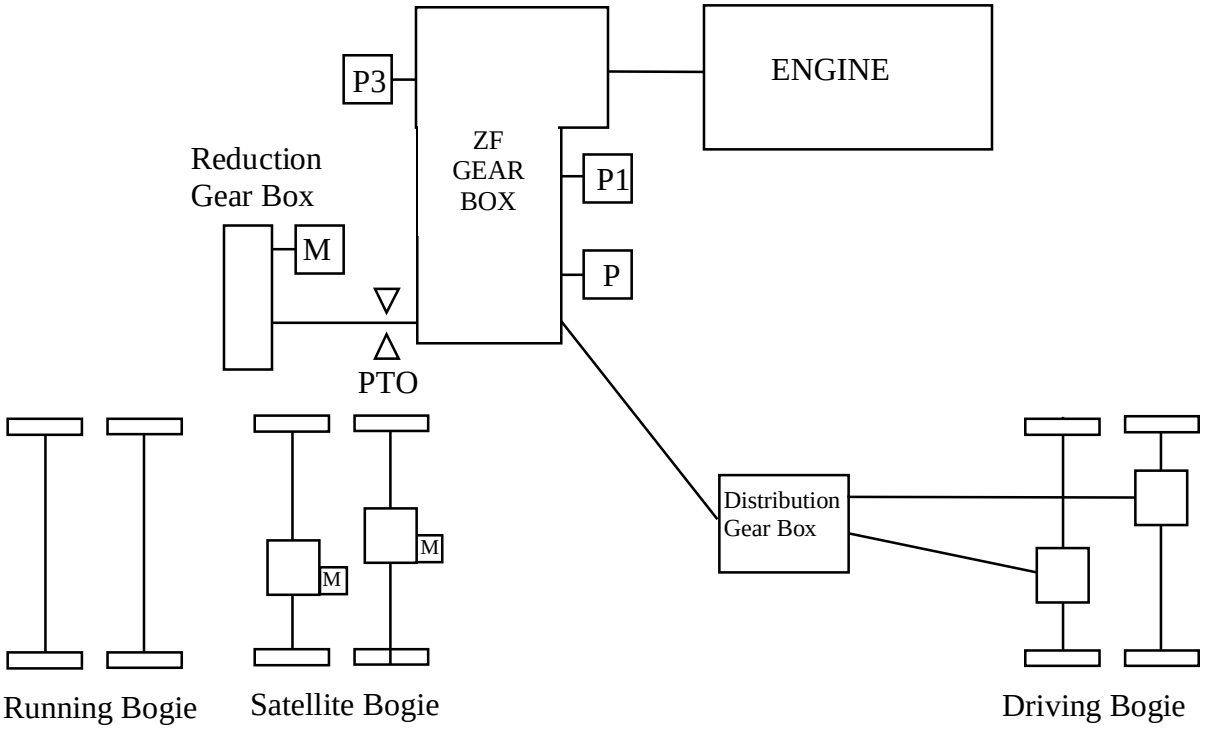
RUN DRIVE: - Hydro dynamics gear box (ZF) is provided on the machine.

LINING: - Single chord lining system is provided on 3x. alc is provided on this machine for measuring run and automatic data feeding .

LEVELING: - On this machine double chord fixed type leveling system is provided. this machine is designed for the twist correction for that rear pendulum is given.

RECORDER: - ALC is provided for recording the datas during the measuring run mode.

POWER TRANSMISSION:



SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lession –V:09-3X Tamping Express **Session-17:**Name of PCBs, their functions and Electrical System.

Sr. NO.	PART NO.	FUNCTION	QUANTITY
1	EK813SV00	DC to DC Converter	2 Nos
2	EK816SV00	DC to DC Converter	4 Nos
3	EK812SV00	DC to DC Converter	1 No
4	EK805SV00	DC to DC Converter	1 No
5	EK2343LV00	Front Input	1 No
6	EK2361LV00	Lining Control	1 No
7	EK2140LV00	Auxiliary Lining	1 No
8	EK526MC	Satellite Compensation	1 No
9	EK3069LV00	Track Lifting	2 Nos
10	EK2361LV00	Pendulum Control	1 No
11	EK1AP7-02	Tamping Unit UP/DOWN	4 No
12	EK2360LV00	Drive Pump Control	1 No
13	EK140V00	Squeezing Control	1 No
14	EK650P00	Programmer	1 No
15	EK651P00	Subroutine	5 Nos
16	EK652P00	Time Delay	6 Nos
17	EK653P00	Input/Output	28 Nos
18	EK654P00	Load Relay PCB	2 Nos
19	EK2324LV00	Satellite Control	1 No

ELECTRICAL SYSTEM:

BATTERY: FOUR BATTERIES ARE PROVIDED
TWO BATTERIES OF 12V/200AH
TWO BATTERIES OF 12V/70AH FOR ALC AND PROGRAMMER

ALTERNATOR: THREE ALTERNATORS
TWO ALTERNATORS ARE MOUNTED ON ENGINE I. CURRENT RATING 120A, BOSCH MAKE
ONE ALTERNATOR IS MOUNTED ON ENGINE II. CURRENT RATING 40A, LUCAS MAKE

SELF STARTER: TWO SELF STARTERS ARE PROVIDED ONE ON EACH

DEPTH TRANSDUCER: FOUR NUMBERS

HEIGHT TRANSDUCER: TWO NUMBERS

LINING TRANSDUCER: TWO NUMBERS

PENDULUM: THREE NUMBERS

SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lesson-VI:WST **Session-18:** Main features, Technical Data, Main assemblies and components..

MAIN FEATURES:

- Ø ZF HYDRODYNAMIC GEAR BOX IS PROVIDED INSTEAD OF MAIN GEAR BOX, DRIVE CLUTCH, REVERSING GEAR BOX, 6-SPEED GEAR BOX, PTO ASSEMBLY.
- Ø TWO TRIPLE HYDRAULIC PUMP & ONE DOUBLE PUMP PROVIDED.
- Ø ONE EMERGENCY PUMP PROVIDED FOR BACK-UP SYSTEM.
- Ø TWO HYDRAULIC MOTORS ARE PROVIDED FOR WORK DRIVE.
- Ø CENTRAL LUBRICATION SYSTEM IS PROVIDED.
- Ø SERVO VALVES ARE PROVIDED OR LINING & LIFTING
- Ø THE PROGRESS IS RELATIVELY MORE.
- Ø AIR DRYER IS PROVIDED IN PNEUMATIC SYSTEM.
- Ø CUMMINS ENGINE NTA855-L 380HP (280 KW) IS PROVIDED INSTEAD OF NT-743C IN OLD MODEL.

GENERAL DATA:

Ø OVERALL LENGTH	= 18940MM
Ø GAUGE	= 1676 MM
Ø HEIGHT FROM RAIL LEVEL	= 3350MM
Ø WIDTH	= 2900MM
Ø WHEEL DIA (NEW)	= 730MM
Ø WHEEL DIA (WORNOUT)	= 680MM
Ø MAXIMUM PERMISSIBLE SPEED (OWN POWER)	= 75 KM PH.
(TRAIN FORMATION)	= 80 KMPH.

MAIN UNITS:

ENGINE: CUMMINS NTA 855L HP: 380 HP @ 2100 RPM

CHASIS: Sturdy welded construction of welded steel girders and sheet provide utmost stability.

UNDER CARRIAGE: The machine is equipped with 2 axle bogies with rigid axles i.e. front & rear bogie.

SUSPENSION: It is done by bonded metal-rubber springs between axles & bogie frame and two rubber spring disc between bogies and machine frame, provides sufficient absorption of vibrations and smooth running of the vehicle.

AXLE BEARINGS: Axles are supported by means of cylindrical roller bearings (02 Nos. on each side) (NJ 2224 & NJP 2224) outside the wheels in separate bearing housing.

BRAKES: Pneumatic operated block brakes are applied on all wheels. During travel drive, brakes are operated by hand controlled valve i.e. brake valve. During work drive hydraulic operated brakes are operated automatically by working control.

DRIVE POWER TRANSMISSION: ZF hydrodynamic gear box model No. 4WG 65 II WK is provided to drive the machine in traveling mode

DRIVING:

RUN DRIVE: - BY HYDRODYNAMICS (ZF) IV SPEED GEAR BOX.

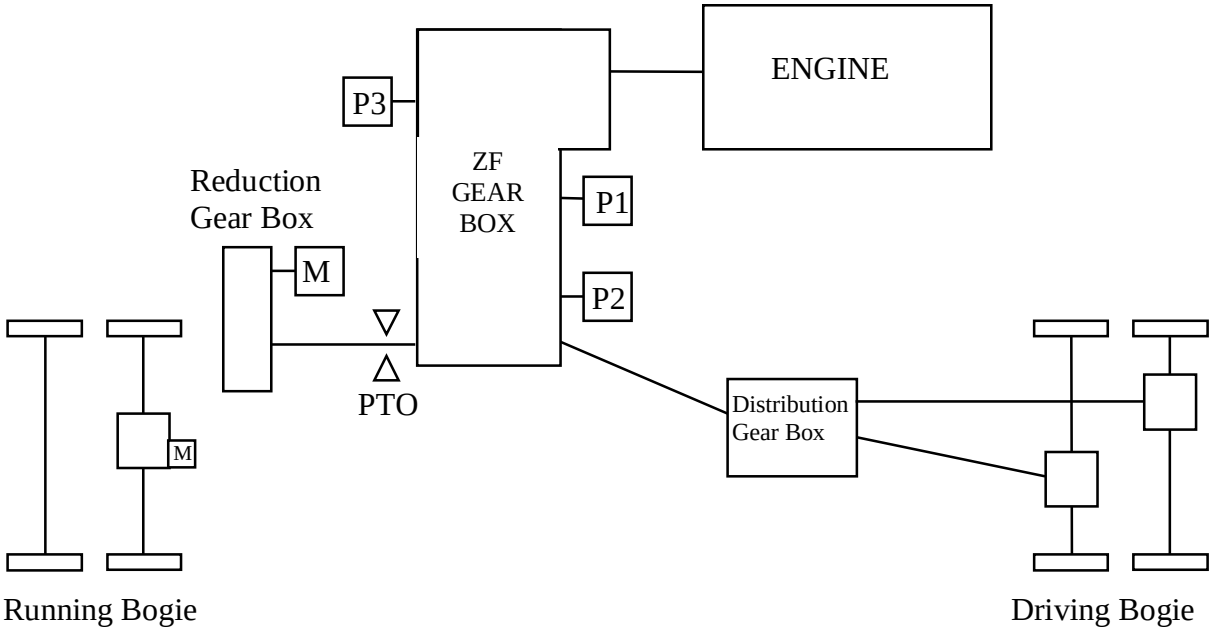
WORK DRIVE: - TWO HYDRAULIC MOTORS ARE PROVIDED. MACHINE WORKS IN CONSTANT SPEED.

LINING: SINGLE CHORD LINING SYSTEM.

LEVELLING:- DOUBLE CHORD FIXED TYPE SYSTEM AND CROSS-LEVEL

TAMPING UNIT: DUOMATIC TYPE (32 TOOLS) PROVIDED ON THE MACHINE

POWER TRANSMISSION:



SUB DESCIPLINE- TRACK MACHINE (LESSIONS-06 SESSIONS-18)

Lesson-VI:WST **Session-20:**Name of PCBs, their functions and Electrical System.

Sr. NO.	PART NO.	FUNCTION	QUANTITY
1	EK813SV00	DC to DC Converter	4 Nos
2	EK2039LV00	Front Input	1 No
3	EK28V00	MULTIPLEXER	1 No
4	EK176V00	Tamping Unit UP/DOWN Control	2 Nos
5	EK2041LV00	Track Lifting	2 Nos
6	EK2042LV00	Pendulum Control	1 No
7	EK2286LV00	Lining Control	1 No
8	EK2195LV00	Overslew	1 No
9	EK600P00	Programmer	1 No
10	EK652P00	Delayed Output	1 No
11	EK653P00	Input/Output	11 Nos
12	EK554P00	QL Plate	5 Nos
13	ELT631.00	Intercom	1 No
14	EK805SV00	DC to DC Converter	1 No

ELECTRIC SYSTEM.

1. BATTERY (12 V/ 180 AH) = 2 NOS COMBINED IN SERIES.
2. ALTERNATOR (28 V/55A) = 2 NOS BOSCH MAKE.
3. SELF STARTER = 1 NO
4. PENDULUM = 2 NOS
5. HEIGHT TRANSDUCER = 2 NOS
6. VERSINE TRANSDUCER = 2 NOS
7. TAMPING DEPTH TRANSDUCER = 2 NOS

SUB DESCIPLINE-BALLAST HANDLING MACHINE (LESSONS-05 SESSIONS-14)
Lesson-I: BCM: RM-76 **Session – 21:**Main Features Main Units & Their Functions

---

INTRODUCTION:
Ballast cleaning machine is to carry out cleaning of ballast by removing muck ,thereby improving drainage of track and elasticity of the ballast bed. basically the machine its excavates and picks up ballast by means of cutter chain and carries it to a set of vibrating screens where muck is separated and thrown out.
three types of ballast cleaning machines are available on indian railways

1. Plain Track Ballast Cleaning Machine – RM80
2. Point And Crossing Ballast Cleaning Machine – RM76
3. Shoulder Ballast Cleaning Machine – SBCM (FRM80)

RM76 - MAIN UNITS:

EXCAVATION UNIT
It consists of a excavating chain of 82 scraper shovels and 82 intermediate links. scraper shovel is fixed with 2 scraping fingers.

DISTRIBUTING UNIT
It consists of two ballast distributor belts on both sides of track to distribute clean ballast at desired locations.

MUCK DISPOSAL UNIT
This throws away the muck outside track through waste conveyor belt.

SCREENING UNIT
This consists of three sets of screens and the total screen area is 21 m^2. the unit has three square meshes of size 80 mm, 50 mm and 36 mm. the screens vibrate with hydraulic power.

SUB DESCIPLINE-BALLAST HANDLING MACHINE (LESSONS-05 SESSIONS-14)

Lesson-I: BCM: RM-76 **Session-22:** Power Transmission & Technical Data

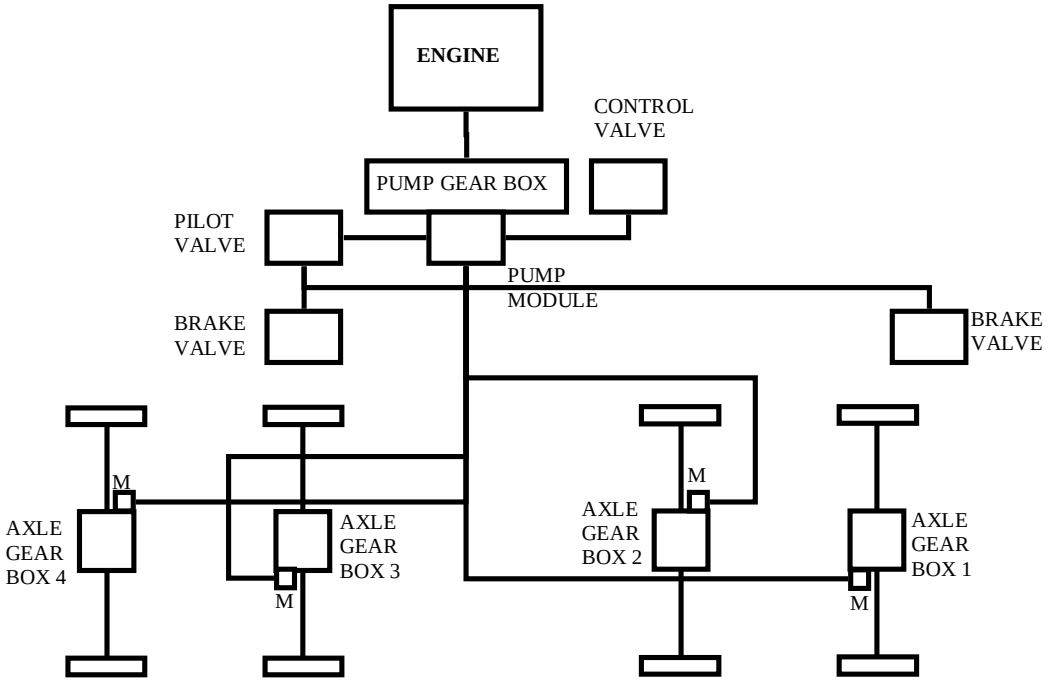
RM76 :

GENERAL DATA:

ENGINES	DEUTZ-BF12L 513C 396 HP AND 221 HP
LENGTH OVER BUFFERS	24730 MM
WIDTH	3130 MM
HEIGHT ABOVE RAIL TOP	4015 MM
BOGIE PIVOTS SPACING	19500 MM
WHEEL DIA	900 MM
TOTAL WEIGHT	71 TONNES
SPEED	40 KMPH

POWER TRANSMISSION:

BLOCK DIAGRAM OF POWER TRANSMISSION IN RM76



SUB DESCIPLINE-BALLAST HANDLING MACHINE (LESSONS-05 SESSIONS-14)
Lesson-I: BCM: RM-76 **Session-23:**Working Principle & Precaution during work

WORKING PRINCIPLE:
The excavating chain designed in pentagon shape cuts the ballast bed and carries the ballast and muck through the chain guides to the screening unit. The freely vibrating screen with linear vibration effects separation of ballast and muck. Underneath the vibrating screen, the muck falls on a conveyor belt which then carries this muck to a slewable conveyor belt (which can be folded also during travel). This slewable belt is called waste conveyor and it throws the muck outside the track. The cleaned ballast is led directly on to the distributor conveyor belts and from there, it is distributed over the entire ballast profile.

CAPABILITY OF MACHINE:

It is capable of disposing off muck along cess at a distance of more than seven metres from the centre of track. Lifting of track upto 100 mm and slewing upto $\pm$300 mm can be achieved.
The machine can deep screen 1 in 12 turnout in 1 hour, 30 minutes and can deep screen plain track upto 140-150 metres per effective working hour.

PRECAUTIONS DURING WORKING:

i. When the machine reaches site, the cutter bar should be lowered in the trench, both ends of cutter bar shall be connected to guides through links. For subsequent work, cutter bar is left under the track.
ii. When the machine starts working, cutter bar scarifies the ballast. Links of rotating chain push ballast in the inclined guides and lead the ballast to screening unit. One person on either side should move with the machine to watch for any obstruction to cutter chain, so as to arrange for stoppage of the machine immediately. Thereafter, the necessary corrective action should be taken.
iii. Screening should be stopped well before expiry of traffic block to permit proper closing of the work and packing before resumption of traffic.
iv. If the machine stops moving during work, it should be ensured that gates for clean ballast below screen are instantly closed. otherwise, the screened ballast will get heaped up at one place.
v. Utmost caution should be observed while manipulating movement of waste conveyor to avoid hitting against electrical mast/signal post. Safety switch provided to sense the mast should, therefore, be kept ‘ON’.
vi. All the staff working with the machine should wear safety helmets and masks to avoid inhaling dust.

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -05 SESSIONS -14)
Lesson-II: BCM: RM-80 **Session – 24**:Main Features, Main Units & Their Functions

---

MAIN FEATURE:

1. This machine is for plain track ballast cleaning.
2. Machine is powered by two independent power units
3. Front engine powers for all conveyor belt drives, lifting movement and driving.
4. Rear engine powers for excavations, chain drive and screen drive.
5. The chain speed is variable between 2.4 to 4 m/sec.

MAIN UNITS & THEIR FUNCTIONS

EXCAVATING UNIT

The excavation chain is guided in two slanted lateral channels and one horizontal channel. The top of the lateral guides are pivoted to the machine frame and hydraulically adjusted. The lower part of the chain guide is parallel to the machine body and is made of wear resistant steel. For protection against dust, noise and for safety reasons, the lateral guides are covered with solid rubber sheets which open by hinges.

At the beginning of work at a site, the cutter bar is inserted underneath the sleepers and connected to the lateral guides by quick action locks. Hydraulic hoists are provided for easy handling of the cutter bar. At the end of work at a particular site, the cutter bar is removed.

SCREENING UNIT

The screening unit consists of three vibrating sieves of the following square mesh sizes:
Upper screen: 80 mm
Middle screen: 50 mm
Lower screen: 36 mm
The vibrations are provided by the hydraulically driven rotating fly weights. In super-elevated curves, the entire unit is hydraulically adjusted by the operator to keep it horizontal.

CONVEYER SYSTEM FOR DISTRIBUTION OF BALLAST AND DISPOSAL OF MUCK

The distributing conveyors receive the cleaned ballast and distribute it evenly across the entire surface of track right behind the excavating chain.

From underneath the screening unit, the waste drops to the conveyor belt which carries it to a hydraulically adjustable belt controlled from the cabin. The waste can be discharged outside the track by means of the tilting waste conveyor.

TRACK LIFTING AND SLEWING UNIT

A track lifting and slewing unit is located next to the cutter bar for adjusting the excavation depth and for avoiding the obstacles.

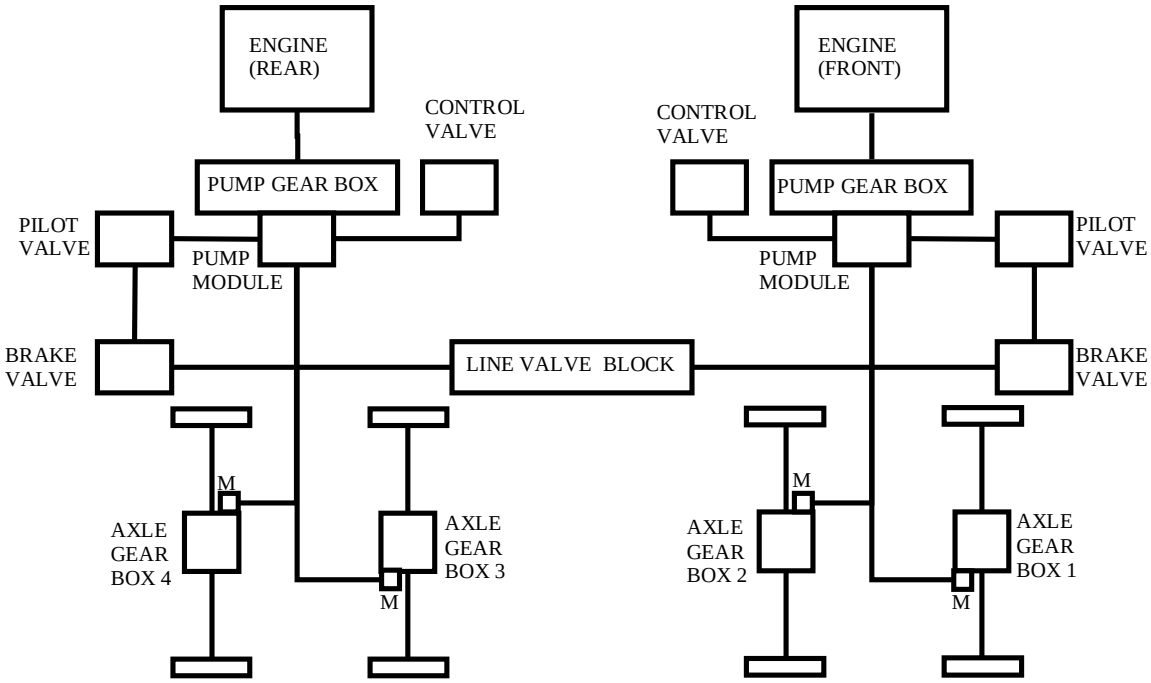
RECORDING UNIT

This is for recording the track parameter after the work.

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -05 SESSIONS -14)
Lesson-II: BCM: RM-80 **Session-25:** Power Transmission & Technical Data

---

POWER TRANSMISSION:



TECHNICAL DATA:

ENGINES	DEUTZ-BF 12L 513C, 453 HP, 2 NOS
LENGTH OVER BUFFERS	30600 MM
WIDTH	3050 MM
HEIGHT ABOVE RAIL TOP	4015 MM
BOGIE PIVOT SPACING	22200 MM
BOGIE WHEEL BASE	1830 MM
DIAMETER OF WHEELS:	
A) POWER	900 MM
B) IDLE	700 MM
SPEED:	
A) SELF PROPELLED	40 KMPH
B) IN TRAIN FORMATION	30 KMPH
TOTAL WEIGHT	91 TONNES
MAXIMUM AXLE LOAD	18.5 TONNES

WORKING PRINCIPLE:

The excavating chain designed in pentagon shape cuts the ballast bed and carries the ballast and muck through the chain guides to the screening unit. The freely vibrating screen with linear vibration effects separation of ballast and muck. Underneath the vibrating screen, the muck falls on a conveyor belt which then carries this muck to a slewable conveyor belt (which can be folded also during travel). This slewable belt is called waste conveyor and it throws the muck outside the track. The cleaned ballast is led directly on to the distributor conveyor belts and from there, it is distributed over the entire ballast profile.

PRECAUTIONS DURING WORKING:

i. When the machine reaches site, the cutter bar should be lowered in the trench, both ends of cutter bar shall be connected to guides through links. For subsequent work, cutter bar is left under the track.
ii. When the machine starts working, cutter bar scarifies the ballast. Links of rotating chain push ballast in the inclined guides and lead the ballast to screening unit. One person on either side should move with the machine to watch for any obstruction to cutter chain, so as to arrange for stoppage of the machine immediately. Thereafter, the necessary corrective action should be taken.
iii. Screening should be stopped well before expiry of traffic block to permit proper closing of the work and packing before resumption of traffic.
iv. If the machine stops moving during work, it should be ensured that gates for clean ballast below screen are instantly closed. Otherwise, the screened ballast will get heaped up at one place.
v. Utmost caution should be observed while manipulating movement of waste conveyor to avoid hitting against electrical mast/signal post. Safety switch provided to sense the mast should, therefore, be kept 'ON'.
vi. All the staff working with the machine should wear safety helmets and masks to avoid inhaling dust.

BCM WORKING AND THEIR LIMITATIONS

1. The stretches must be carefully surveyed and detailed planning must be made as to how the machine will tackle the features like level crossing, yards, platform lines, culverts, ballast walls side drains etc.

2. The detailed survey should be made of obstructions like S&T cable, OHE, bonds etc.

3. In case of BCM the judicious combination of lifting along with the deep screening must be pre-decided. For this rail and the formation, cross level have to be recorded in advance and the proposed rail level taking care of sags are to be decided. There are chances of formation cutting. The lifting is to be decided as such there is no resistance to the cutter bar & the cutting chain which will ultimately reduce the load on conveyer belt and increase the lengths of screened ballast per effective hour.

4. Major maintenance work to be planned in Monsoon season.

5. It is to be ensured that minimum time may be utilized for linking and de-linking of cutting chain and proper markings to be made.

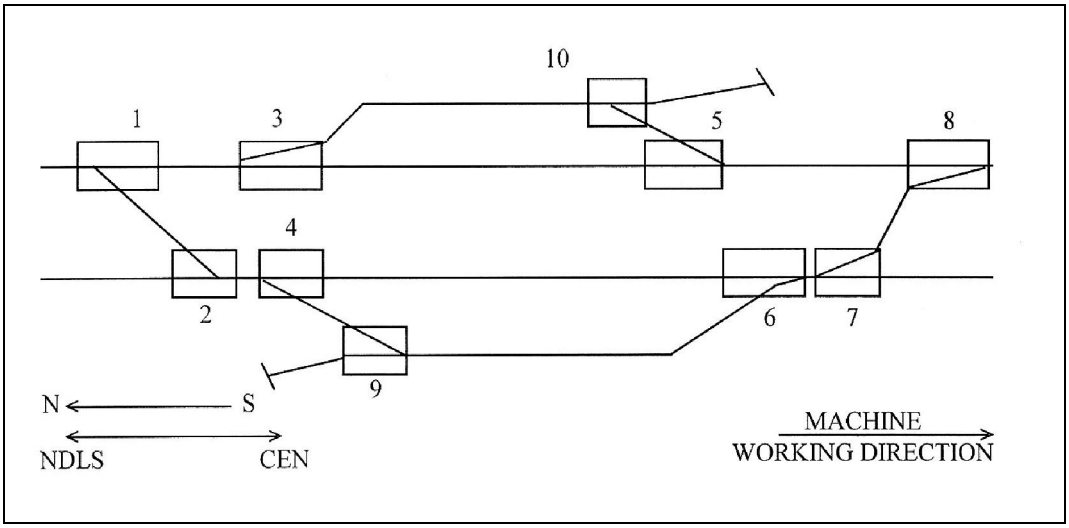
6. Proper siding of BCM to be decided at the divisional level for better maintenance i.e. non-OHE line. It is practically seen in the working of BCM Machines, proper sidings are not available due to which machine staff faces lot of difficulties to carryout machine maintenance work.

- While working with BCM Machine, minimum cushion of 250mm to 270mm may be ensured.
- It is always advisable to have longer block because maximum progress can be achieved in a longer block only.
- The range of lifting is 2" to 4". It is generally seen that PWI never allows for more than 2" of lifting as not to allow to raise the tail due to OHE restriction as in this case, further lifting is not acceptable where as the machine staff works happily if value for lifting is more than two inches as in this case more the trough is lifted, more will be the speed of cutting chain and progress thus achieved will be more and cutting chain speed will be very much smooth and normal.
- This should always be ensured that BCM should not be shifted frequently, which rather causes inconvenience to machine staff.
- Selection of proper siding is also necessary. On account of non-availability of proper siding, machine maintenance is badly hampered because lot of jobs are involved on top of machine which can be done only on non-OHE line.
- Proper survey of track is also required, because it has been seen during working of BCM embedded rail is found and their removal is necessary by means of Gas cutting. So by the time, the embedded rail is removed the machine stands idle and no progress is achieved. So optimum progress is not achieved.
- It is a general phenomenon that there happens to be difference of cross-level i.e. lot of variation takes place on account of BCM working. And for checking of Cross level difference, Galvanometer or pendulum is not provided. To ensure proper cross-level, ballast distribution is equally divided on each rail to have same cross-level difference. This is nothing but approximate way of correction of cross-level of track being screened while working on curve amount of ballast is changed by means of lifting plate/flap cylinder provided on the top of screen of machine this enable to keep the outer rail of curve at higher level. BCM (Plain or Turnout) are not able to work in track circuited, yard, because, at times it is seen if BCM's are deployed then it cuts the S&T cable and thereby resulting into signal failure and subsequently detention of trains.
- BCM does not screen on 500 to 600mm (8-10%) of ballast width of shoulder ballast. That needs deployment of manual labour to put this portion of ballast in screening zone of BCM or FRM to screen the same later on.
- BCM throws muck on the cess which is required to be spread on cess side for building up cess before raining season.
- BCM fails to screen the ballasted bridge where side walls come within 4100mm necessitating deployment of manual labour.
- Brooms provided on plough are not so much effective so BCM needs deployment of BRM or manual labour for profiling.
- BCM should be followed by DTS to compact ballast in layers, as it cannot stabilize track.

<u>DIFFICULTIES EXPERIENCED IN TURN-OUT SCREENING BY</u>

BCM MODEL RM 80-92U – A CASE STUDY

A typical double line station with 2 loops (one loop as common) is taken as illustrative example of deep screening requirements of turnouts as under.



Let us discuss the intricacies of deep screening of each turnout at this station. The details of difficulties encountered for deep screening each of the turnout in this station turnout wise is as under.

1. Presuming direction of working of machine as NDLS to CEN.

I. Turnout 1: (X-over RT hand type turnout)

a) Working is favorable but multiple pits for cutter bar extension pieces in 4 stages (for 1:12 & 1:16) 3 stages (for 1:8½) will be required to be done manually.

II. Turnout 2: (X-over machine facing X-ing first)

a) Work to be started from X-ing side.

b) Pit for entire width of extended cutter bar (7.5 mtrs to 8 mtrs depending upon type of turnout 1:8½, 1:12 and 1:16) to be dug. Additionally 5 sleepers (sleeper number 83 to 78) to be removed. Entire ballast in this zone to be removed manually to accommodate curve shaped (in plan) cutter bar.

III. Turnout 3: (Loop line turnout LHS type)

a) Favorable if BCM takes path of loop line track.

b) However Pit in 4 stages for cutter bar extension to be done manually.

c) Due to machine taking loop line track path while screening, ballast deficiency is likely to take place on main line (This depends upon total quantity of ballast available and net quantity of screened clean ballast). Please see drawing for details.

IV. Turnout 4: (Loop line turnout RHS type)

a) The only ideal and most favourable type turnout and orientation.

b) However multiple cutter bar extension pits to be done manually.

V. Turnout 5: (Loop line turnout RHS type but machine facing X- ing first)

a) Work can be started from X-ing side only.

b) Entire width of extended cutter bar to be provided initially (7.5 to 8 mtrs) long.

c) 5 long sleepers in crossing side (Sleeper Nos. 83-78) to be removed from track.

d) Ballast to be removed manually upto formation level in all these 5 galas for

both main and loop tracks.

VI. Turnout 6: (Loop line turnout LHS type but machine facing X- ing first)
   a) Work can be started from X-ing side only.
   b) Entire width of extended cutter bar to be provided initially.
   c) 5 long sleepers in crossing side (Sleeper nos. 83-78) to be remove from track to accommodate curve shaped cutter bar extended portion.
   d) Ballast to be removed manually upto format level in all these 5 galas for both main and loop tracks.

VII. Turnout 7: (X-over turnout LHS type)
   a) Favourable if BCM takes X-over track path.
   b) Pits in 4 stages for cutter bar extension to be done manually.
   c) Due to machine movement on X- over track, while screening, ballast deficiency is likely to take place on main line after screening.

VIII. Turnout 8: (X-over turnout LHS type but facing X-ing first)
   a) Work can be started from X-ing side only.
   b) Entire width of extendable cutter bar to be provided initially.
   c) 5 long sleepers in X-ing side (sleeper nos. 83-78) to be completely removed from track.
   d) Ballast in above area to be completely removed manually upto formation level.

IX. The intricacies of screening turnout '10′ are similar to '4′ and turnout '9 'are Similar to '2′.

2.
   a) So it is possible to screen only point 1 & 4 which are most favourable, allow switch side starting of screening and machine can take main line path while screening.
   b) In case of point no. 3& 7 although screening can be started from switch end, the BCM has to take loop line path and clean ballast distribution in main line gets effected. This results in ballast shortage and undesirable subsidence in main line track.
   c) In case of turnout no. 6&8 works has to be started from X-ing side and manual removal of sleepers, ballast in sleeper no. 78-83 area is necessary. The manual labour involved is so much and this type of screening is prohibitive. However machine can take path of main line in these 2 cases and even distribution of ballast can be ensured.
   d) In case of turnout no. 2 & 5 work to be started from X-ing end of turn out and machine has to take path of X-over and loop line track respectively. This will result in shortage of ballast on main line tracks.

It goes to say that out of 10 turnouts of a station, only 3 turnouts (numbered 1, 4&10) deep screening is feasible subject to other problems discussed in later stages of this paper.

3. As explained above only 1, 4 & 10 are the turnouts that can be screened starting from switch side and machine can take path of main line and screened clean ballast redistribution can be even.

4. Only if the direction of machine is reversed, point no. 5,2&9 will be convenient and assume position of point 1 , 4 &10 as explained in Para 3 above.

5. Conditions are vice- versa if screening is to be done with machine in reversed direction. So to complete deep screening of all turnouts in a station, the machine direction has to be reversed

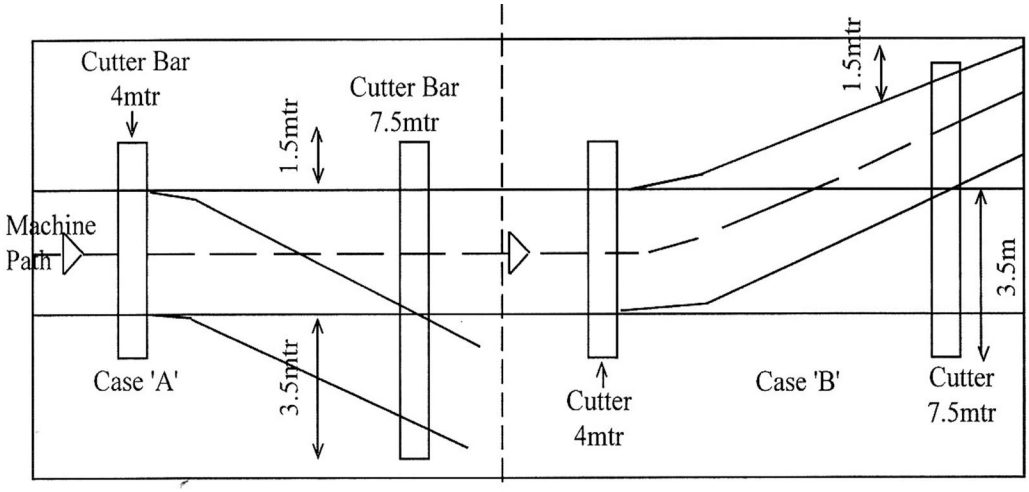
by taking it to any bypass line or loco reversing triangle. Normally loco reversing triangles are not having ends long enough to accommodate 32 mtrs length BCM.

6. Why machine has to take path of loop line / Cross over line, as the case may be, while screening point nos. 3&7 etc.

a) The BCM model no. RM 80 -92U is provided with extendable cutter bar to screen entire width of turnout which increases upto 8 mtrs at end of crossing. This is done by adding extension pieces 8 numbers in multiples of 0.5mtrs length each. Originally cutter bar along with trough width is 4 mtrs and the same can be extended upto 8 mtrs. However 7.5mtrs will be sufficient for 1:12 type turnout.

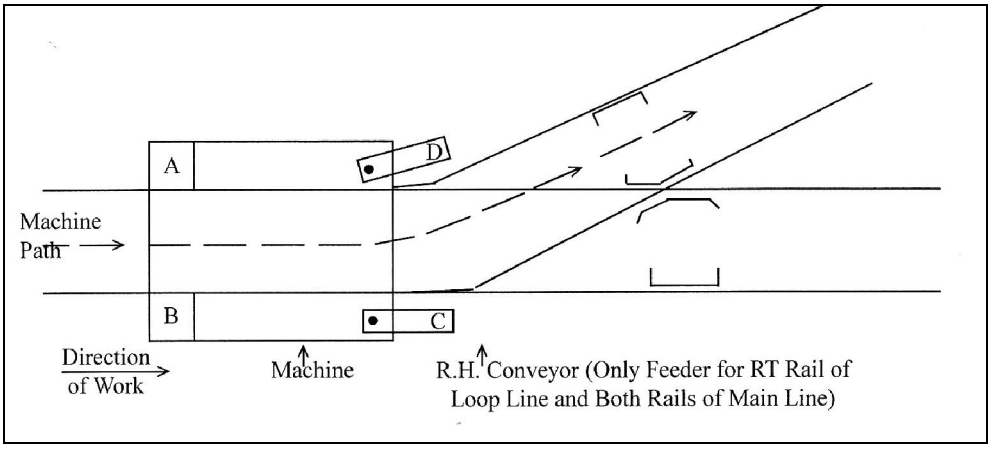
b) We have LHS and RHS type turnouts. But the machine is provided with hydraulic cylinders that can be extended by 1.5mtrs on the left and 3.5mtrs on the right side (approximately).

c) Hence while working from switch end, if the turnout is RHS type, machine can move on main line and complete screening of turnout. But it has to move on loop line track if turnout is LHS as given below.

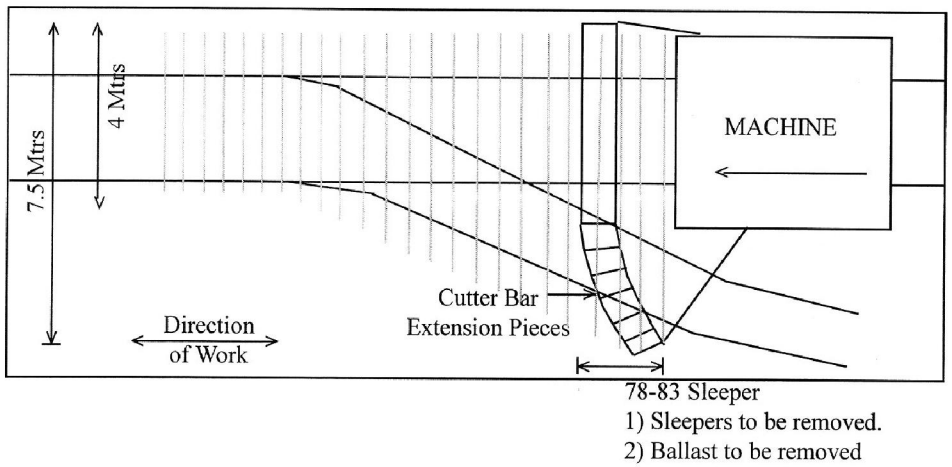


In 'Case A' machine takes path of main line and screening can be completed on the turnout.In 'Case B' machine occur on main line.

Please note that clean ballast is divided in 4 portions before it is dumped back to track. The 2 portions in rear will invariably be dumped in the track on which machine moves (location A&B). One portion of LHS distribution belt (location D) will be dumped in loop line LHS side. Only one portion of the RHS conveyor belt i.e (location C) can be diverted to main line track. This results in ballast deficiency as explained below.

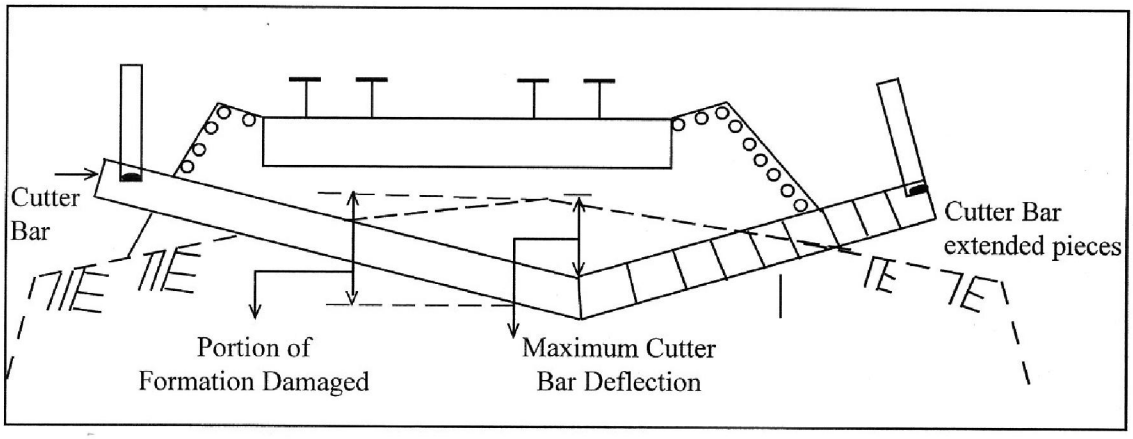


7. Why machine cannot start work from crossing side and progresses towards switch.
   a) The cutter bar for plain track including both sides connecting elbows of ascending trough will be 4 mtrs and absolute straight. But when extension pieces are connected to this cutter bar, it is in the shape of curve in plan as designed by Plasser.
   (b) So if 7.5mtrs or 8mtrs length cutter bar is to be introduced under the track at crossing end, removal of 5 sleepers(i.e number 78-83) and all the ballast in this zone upto formation level is necessary to insert cutter bar, extension pieces and chain under the track. The details are as under.

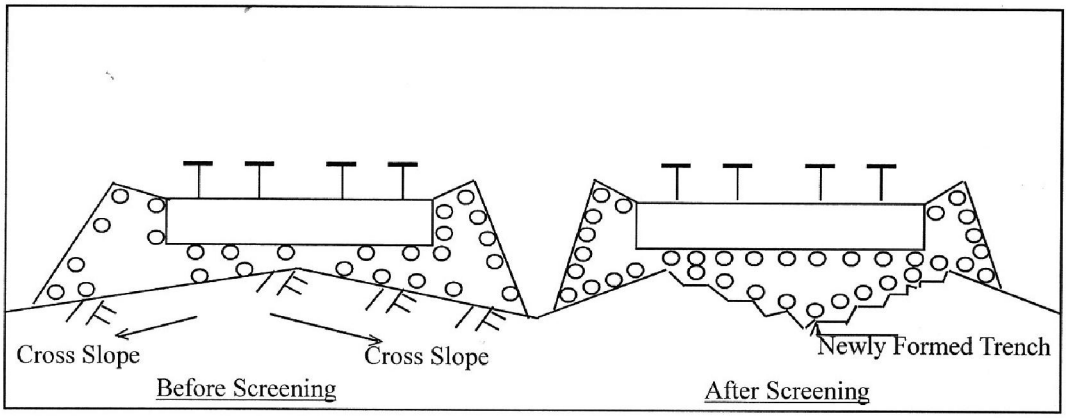


8. How turn-out deep screening spoils cross slope of formation:
   a) Normal cutter bar when used in plain track is in one piece, rigid and total width including elbows is 4mtrs. No deflection takes place in the cutter bar. Thus the cutting of ballast bed will be in one plane and does not penetrate into or spoil formation.
   b) When once the cutter bar width is increased by adding extension pieces, it deflects and sag increases proportionately to width of cutter bar. This deflection is even more than 30 Cms.
   c) So this extended cutter bar is a straight and curve in both plan and elevation as under. This will cause trenching in the center of formation and depth of trench increases progressively from switch towards crossing and maximum at crossing end.

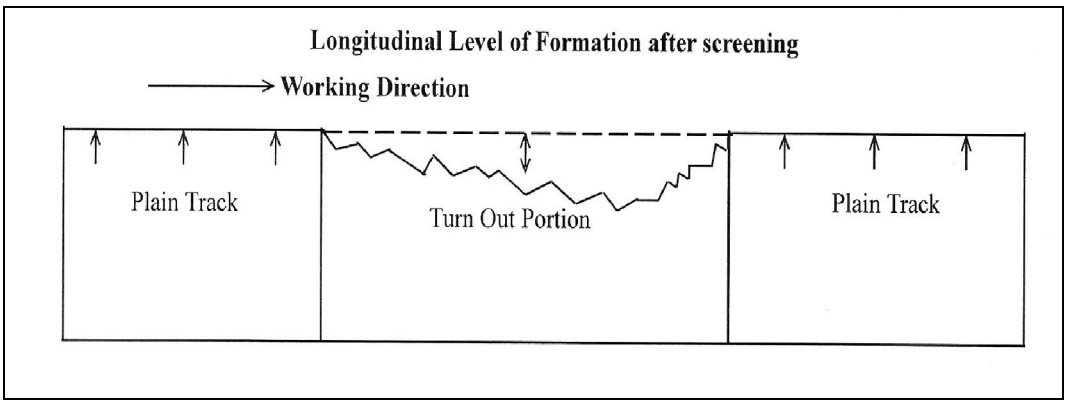
d) Cutter bar in action when extended



e) Formation of screened turnout before and after



9. How the turnout screening spoils the longitudinal level of track and formation.
   a) When Unimat machine tamps a turnout, to hold rail and lift in difficult locations like switch and crossing, lifting hooks are provided. This work is done by rail clamp discs in plain track packing machines.
   b) BCM is provided with rail clamp disc (Plain track type) to hold the track when the ballast bed underneath the track is excavated for screening. This will prevent sinking of track due to self weight and machine weight.
   c) There is no lifting hook type arrangement in BCM RM80-92 U. The roller clamp type lifting mechanism which is used in plain track is also removed from the track when once screening starts at turnout. Due to this track sinks in entire turnout portion and sleeper level also gets consequently lowered. The cutter bar which has to pass through below the sleeper, is lowered further by operator to avoid hitting of sleeper bottom by cutter bar's top edge. This results in excavation of formation. Thus both track and formation levels are lowered to unacceptable levels.
   d) However the track surface can be corrected by dumping additional ballast, lifting the track to desired level and packing. Thus turn- out surface can be brought to the level of, adjoining plain track on either side.
   e) However the damage to formation and disturbance to its longitudinal level is permanent. The longitudinal level of formation as be visualized as under.



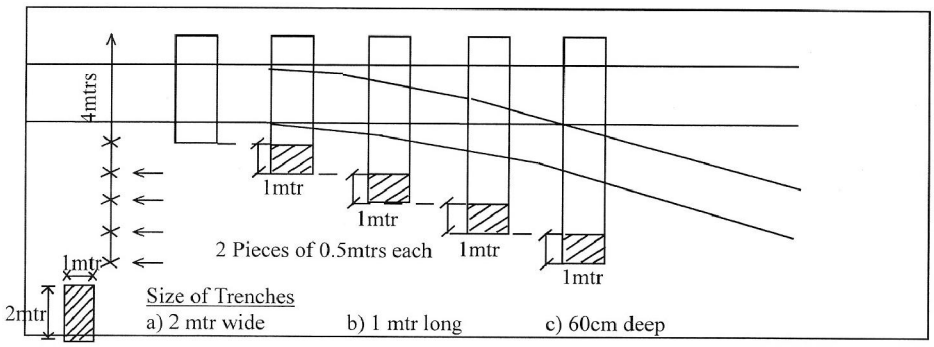
Portion of track where lifting units hold the rails to proper level and clean the ballast is dumped with jet force from conveyor belt as initial packing. Track subsidence is controlled and no excavation of formation takes place.	Turnout portion where track is not held by machine's lifting unit in present design. Heavy subsidence observed. Formation gets excavated by cutter bar Rail levels also get badly disturbed creating unsafe condition to resume traffic after block.	Portion of track where lifting units hold the rails to proper level and clean the ballast is dumped with jet force from conveyor belt as initial packing. Track subsidence is controlled and no excavation of formation takes place.

10. Why extra length pits are needed, to be opened manually in installments while Screening from switch end towards X-ing.

a) Initially the cutter width in plain track portion is 4 mtrs. After approaching switch we have to increase the width by 1 mtr duly attaching 2 extension pieces as first installment. At that point extra width pit to be dug to join 2 extension pieces. This pit has to be 2 mtrs wide approximately and deep enough to reach the actual level of cutter bar at that point. This will facilitate easy connection to cutter bar.

b) Similarly pits are required to be dug manually at 3 or 4 locations which depends on the type of turnout(i.e 1:8½, 1:12, 1:16)

c) This involves extra labour. The pits required are illustrated below



11. The progress & utilization of S.C.Rly BCMs in model RM 80 – 92 U.

Machine no.	Date recd	Months worked	Kms screened	Monthly average	Turnout screened
BCM 339	10/7/2003	36	236	6.5 km	2
BCM 346	8/9/2004	22	138	4.9 km	1

a) From above it is clear that machine's performance on plain track is very good. But due to the difficulties in operation, detrimental effects on track, field staff of track machine and P.way are not showing interest in turnout screening although this work is available in abundance.
b) This machine involves lot of manual labour and cumbersome for turnout screening.
c) Turnout can be screened only from switch end and machine needs reversing to complete work at each station.
d) Normal time required to complete screening of 1:12 turnout is not less than 4 hours. So the block required is more than 4 hours which is required for packing and S&T restoration works.
e) Machine's design is convenient only for RHS turnouts and not versatile.
f) To screen LHS turnout, machine has to take loop line path and ballast deficiency takes place on main line.
g) The cutter bar's extended portion is both horizontal and vertical curve in shape after assembly and damages formation permanently.
h) Lifting and holding of track in turnout portion is not possible in present design and causes undesirable subsidence.
i) Because of excavation of formation screens get chocked intermittently in block due to increased volume of muck entry and wetness in formation.
j) Present design of sleeper scraper cannot work in turnout portions of track.
k) Cross grade of formation is also spoiled. A deep trench whose depth is progressively increasing from switch end towards crossing forms while screening.
l) Additional ballast to be trained to screening spot in advance, failing which traffic cannot be restored after block.

12. CONCLUSION.

This model RM 80 – 92 U BCM is excellent for plain track screening and not fit for turnouts. Not only we encounter above problems to carryout turn-out deep screening, but also the total block time required is around 6 hours including P way and S & T works which discourages this operation. Normally these turnouts are being screened in parts in 2 days with two traffic block spells of 3 hours each. The turnout screening machine shall be exclusive in design and shall cater for all the defects noticed in present version as explained above. Lot of turnout screening is in arrears and we are aware of the fact that manual screening is not the answer. However the experiences of screening turn-outs in other railways and any remedial measures adopted by them to overcome the above difficulties may please be shared with all BCM RM 80-92U users please.

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-III: FRM-80 **Session-27:** Main features main units and their functions.

MAIN FEATURES:

This machine is for cleaning of shoulder ballast to improve the drainage of track. This machine is similar to RM80. This machine is provided with two excavating cutter chain, one on each side Each chain excavates and pick ups the shoulder ballast and direct to a set of vibrating screening

MAIN UNITS:

- Excavating wheel and scarifier
- Hopper assembly/bucket
- Screen drive assembly
- Broom assembly
- Conveyor system

Heavy duty scarifier breaks up the mud pockets underneath the sleeper ends to allow the track to drain. The ballast is transferred to the screening unit by the excavating wheel having hoppers/buckets. The reclaimed ballast is distributed back to shoulder area of the ballast profile. The machine completes the job by shaping the reclaimed ballast with the built-in shoulder regulator wings and then finally sweeps the sleepers by broom.

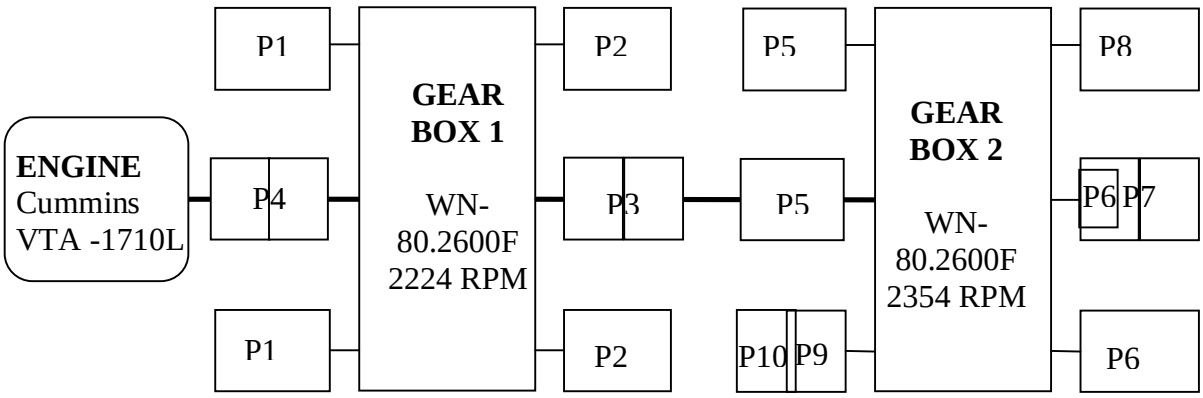
SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-III: FRM-80 **Session-28:** Power Transmission & Technical Data

---

TECHNICAL DATA:

ENGINE	DEUTZ TBD-234V-12, 470 HP CUMMINS VTA-1710L, 515 KW
LENGTH OVER BUFFERS	39470 MM
WIDTH 3135 MM	
HEIGHT ABOVE RAIL TOP	4260 MM
BOGIE PIVOTS SPACINGS:	
A) FRONT AND MIDDLE BOGIES	15000 MM
B) MIDDLE AND REAR BOGIES	16000 MM
BOGIE WHEEL BASE	1830 MM
WHEEL DIAMETER	900 MM
MAX. AXLE LOAD	20.0 TONNES
TOTAL WEIGHT	80 TONNES
SPEED:	
A) SELF PROPELLED	40 KMPH
B) IN TRAIN FORMATION	30 KMPH

POWER TRANSMISSION



P1-Cutter chain Pump (Axial Piston Type)-HY704X90R/EL/A350BAR=02 NO.
P2-Drive Pump (Axial Piston Type)-HY704X180L/EL/A380BAR=02 NO.
P3-Water Cooler + Two Oil Cooler Pump (Double Vane Pump)-HY830X08.05 L1=01 NO.
P4-Clutch Pump (Double Vane Pump)-HY830X06.06 RE=01 NO.
P5-Excavating Belt Pump (Axial Piston Type)-HY709X28 R=02 NO.
P6-Distributor Belt Pump (Axial Piston Type)-HY709X28 L=02 NO.
P7-Brush Box + General System Pump (Double Vane Pump)-HY830X7.06 RE=01 NO.
P8-Screen Drive Pump-HY712X60 L=01 NO.
P9 & P10-Main Conveyor + Waste Conveyor Pump-HY709X71 (65) R/FED=01+01=02 NO.
(Axial Piston Type)

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-III: FRM-80 **Session-29:** Working Principle & Precaution during work

---

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-IV: KSC-500 **Session-30:** Main features main units and their functions.

This machine is for cleaning of shoulder ballast to improve the drainage of track.This machine is similar to RM80.This machine is provided with two excavating cutter chain, one on each side. Each chain excavates and pick ups the shoulder ballast and direct to a set of vibrating screening.

MAIN UNITS:

- Ø ENGINE
- Ø CUTTING CHAIN UNIT
- Ø EXCAVATING CONVEYOR BELT
- Ø SCREENING UNIT
- Ø DISTRIBUTOR BELT UNIT
- Ø MAIN CONVEYOR BELT UNIT
- Ø WASTE CONVEYOR UNIT
- Ø SHOULDER PLOUGH UNIT
- Ø CENTRE PLOUGH UNIT
- Ø BROOMING UNIT
- Ø SCRAPPER UNIT

Heavy duty scarifier breaks up the mud pockets underneath the sleeper ends to allow the track to drain. The ballast is transferred to the screening unit by the excavating wheel having hoppers/buckets. The reclaimed ballast is distributed back to shoulder area of the ballast profile. The machine completes the job by shaping the reclaimed ballast with the built-in shoulder regulator wings and then finally sweeps the sleepers by broom

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-IV: KSC-500 **Session-31:** Power Transmission & Technical Data.

TECHNICAL DATA:

ENGINE	CUMMINS DIESEL ENGINE, VT28-P, 800 HP
LENGTH OVER BUFFERS	37340 MM
WIDTH	3081 MM
HEIGHT ABOVE RAIL TOP	3917 MM
BOGIE PIVOTS SPACINGS:	
A) FRONT AND MIDDLE BOGIES	15240 MM
B) MIDDLE AND REAR BOGIES	13720 MM
WHEEL BASE	2000 MM
WHEEL DIAMETER	839.8 MM
DIAMETER OF EXCAVATING WHEEL	2440 MM
TOTAL WEIGHT	99.7 TONNES
MAXIMUM AXLE LOAD	19.93 TONNES
SPEED:	
A) SELF PROPELLED	40 KMPH
B) IN TRAIN FORMATION	30 KMPH

POWER TRANSMISSION:

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson-IV: KSC-500 **Session-32:**Working Principle & Precaution during work .

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)
Lesson – V: BRM **Session – 33** : Main Features, Main Units And Their Functions

---

MAIN FEATURES:

1. Regulation of ballast to proper profile
2. Transfer of ballast from center to outwards either on both sides or on the desired side
3. Transfer of ballast from one side to the other or to the center.
4. Sweeping the sleepers and cribs
5. Cleaning the fasteners after ballast regulation
6. Transfer of surplus ballast from the place it is excess to the place it is deficient (optional)
7. The machine operates in either direction

MAIN UNITS AND THEIR FUNCTIONS:

1. **ENGINE:**
MODEL-CUMMINS- NT 743, 232 HP @ 1800 RPM
NO. OF CYLINDERS-6, FIRING ORDER 1-5-3-6-2-4
BORE-130 MM, STROKE-152 MM

2. Wings-LHS & RHS (shoulder plough) these are made of wear resistant steel assembled with pieces and fully operated hydraulically. These ploughs are provided one on each side. These are pressed down keeping margin for ballast profile and held firmly against the shoulder for achieving the desired ballast profile in new paces. The plough blades can be adjusted along with the plane of the shoulder angle in conjunction with the centre plough. Large heaps of ballasts at sides are raked up to the track. Shoulder plough angle varied from about 70^o to 0^o from the cabin as desired. On Kershaw ballast regulating machine the shoulder plough is in trough shape. It can be locked up side down to the top frame of the machine. This trough shaped plough is lowered sideways and activated with hydraulic cylinder.
To pull ballast from bank slopes, this plough can be bend to suit the site.

3. **CENTRE PLOUGH**
On Kershaw machine the plough has been provided in the front of the machine there are two templates operated independently by hydraulic cylinder. A number of shifting operations may be executed with the centre plough.

4. **BROOM (SWEEPER CONVEYOR SYSTEM)**
The sweeper unit consists of rotating drum fitted with flexible hyd. Hose pieces of designated length and mounted inside a steel plate housing. While rotating it throws surplus ballast via a guiding duct on to two lateral conveyors. These takes to a steep conveyor belt which takes it to a Hooper for collection. Broom is rotated by hydraulic motor.

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -5 SESSIONS -14)

Lesson – V: BRM **Session-34:** Power Transmission, Technical Data, Working Principle & Precaution during work.

POWER TRANSMISSION:

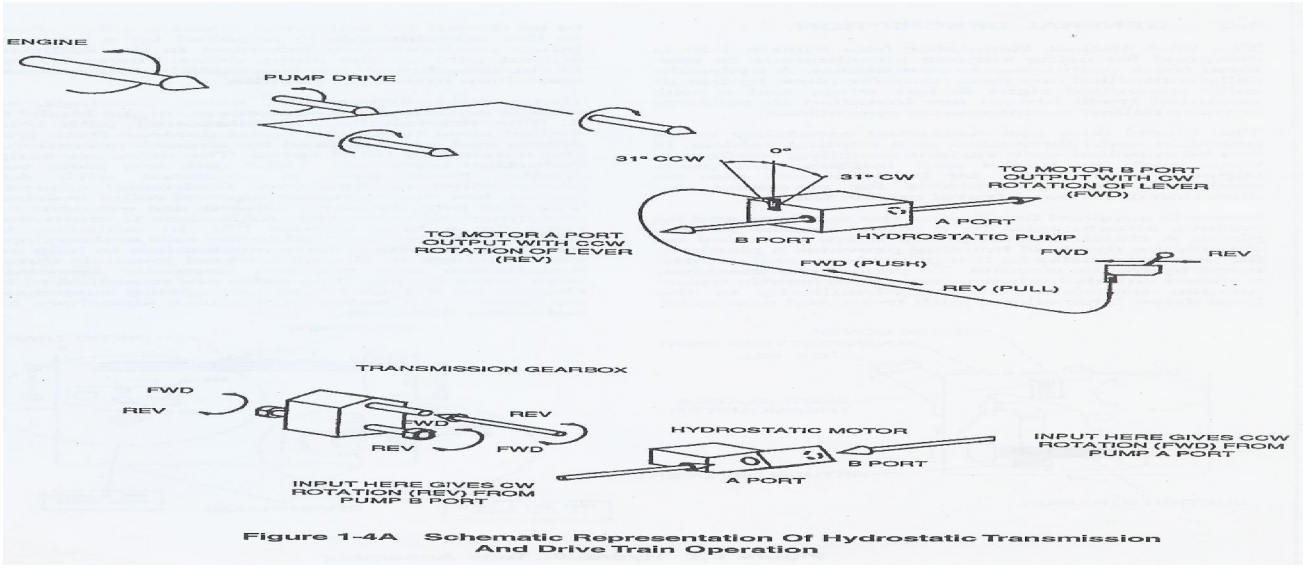


Figure 1-4A Schematic Representation Of Hydrostatic Transmission And Drive Train Operation

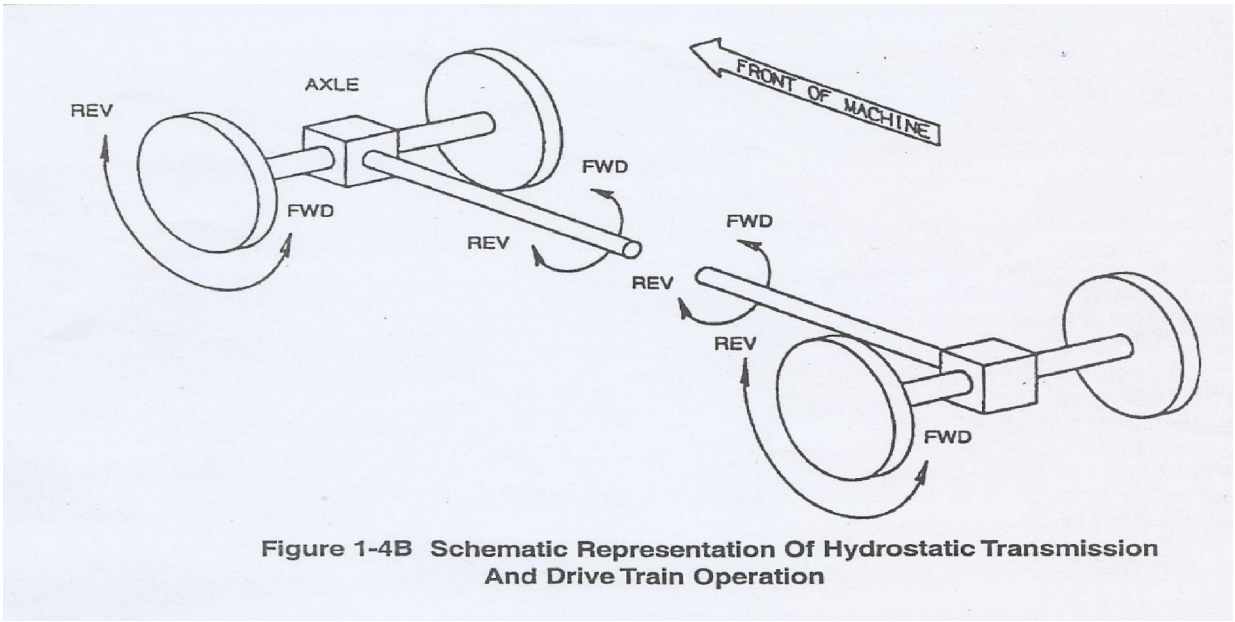


Figure 1-4B Schematic Representation Of Hydrostatic Transmission And Drive Train Operation

TECHNICAL DATA:

MODEL 66-4

ENGINE	CUNNINS MODEL, NTA 743P DIESEL
ENGINE,	265 HP @ 1800 RPM
LENGTH OVER BUFFERS	10389 MM
WIDTH	3166 MM
HEIGHT ABOVE RAIL TOP	3617 MM
WHEEL BASE	4725 MM
WHEEL DIA	838.2 MM

AXLE LOAD	10.66 TONNES
SPEED:	
A) SELF PROPELLED	50 KMPH
B) IN TRAIN FORMATION	40 KMPH

MODEL 56-3

ENGINE	CUNNINS MODEL, NTA 743P DIESEL
ENGINE,	
	250 HP @ 1800 RPM
LENGTH OVER BUFFERS	12344 MM
WIDTH	3122 MM
HEIGHT ABOVE RAIL TOP	3810 MM
WHEEL BASE	5791 MM
WHEEL DIA	832.0 MM
AXLE LOAD	12.97 TONNES
SPEED:	
A) SELF PROPELLED	60 KMPH
B) IN TRAIN FORMATION	40 KMPH

.

MAIN FEATURES:

i. The damage to the concrete sleepers is avoided because of mechanized handling of the sleepers by PQRS equipment.
ii. The work done is of better quality, as the track obtained has better alignment and the sleepers are laid to correct spacing.
iii. The concrete sleepers can be laid radially on curves with the help of PQRS equipment, which is not possible in manual relaying.
iv. No pre-fabrication of panels is necessary as the work of laying the sleepers at the correct spacing and linking of track is done directly at site.
v. The double handling of the concrete sleepers is avoided as the BFRs loaded with concrete sleepers are taken directly to the site.
vi. Deep screening can be done ahead of relaying with the help of ballast cleaning machine in shadow blocks, thereby giving clean ballast cushion below the track.
vii. The track can be packed with heavy 'on track' tie tampers immediately following the track relaying equipment, thereby giving better quality of track and restoring the speed to normal in a lesser time.
viii. The requirement of labour is very much less, thereby not affecting the progress of work due to seasonal shortage of labour.
ix. The method may work out to be economical on a long term basis, particularly if long blocks are available and there is shortage of labour.

MAIN UNITS AND THEIR FUNCTIONS

1. SIDE FRAMES:
The machine contains two vertical side frames that house two vertical sliding frames.

2. BRIDGE:
Sliding frames are joined together with horizontal cross frame known as bridge. The motive power, hydraulic and electrical assemblies are installed over the bridge. The whole bridge is raised/lowered to facilitate lifting of panels.

3. SLEEPER GRIPPER:
On the underside of the bridge, gripper to pick up sleepers is provided. Gripping of sleepers by its end is done by two angles welded to the gripper.

4. RAIL CLAMPS:
On the end side of the frame, scissors type clamps are provided to hold the rails/panels.

5. TURN TABLES:
To facilitate turning of portal crane for placing it on the BFR and off tracking in mid section, a turn table is provided. On the BFR, a wooden platform is provided to support the turn table.

SUB DESCIPLINE - BALLAST HANDLING MACHINE (LESSONS -03 SESSIONS -08)

Lession – I :PQRS **Session – 36:**Yard Activities, Fabrication Of Panels, Rake Formation, Amenities At Base Depot

---

YARD ACTIVITIES:

i. Unloading of PSC sleepers from the rake and stacking.
ii. Fabrication of new panels.
iii. Unloading of released panels from PQRS rake.
iv. Dismantling of released panels.
v. Loading of pre-fabricated new panels.
vi. Formation of PQRS rake.
vii. Maintenance of machines.
viii. Dispatch of released material.
ix. Loading/unloading of ballast, if the Base Depot is also to be used as ballast depot.

FABRICATION OF PANNELS:

i. Concrete sleepers are laid by portal cranes almost at correct spacing and minor adjustment about spacing is done manually.
ii. The rails in suitable lengths are then placed in position and fixed to sleepers with proper fittings and fastenings.
iii. For the sake of easy handling the Pre-assembled panels are of 9.1 metre length so that one portal crane of 5 tonnes capacity can handle one panel conveniently.
iv. These fabricated panels are loaded in 3 to 4 tier to form a PQRS Rake including empty BFRs.

RAKE FORMATION:

A complete material train having the following rake is taken to site along with one loco motive:

1. Engine
2. Camping coach
3. BFR carrying the portal cranes
4. BFR (As required) loaded with new fabricated panel
5. 2 empty BFRs for released panel.

AMENITIES AT BASE DEPOT:

i. For smooth working, the Base Depot should have at least three sidings of 500 metres each connected to a shunting neck of 350 metres.
ii. Of these, at least two sidings should be provided with auxiliary track for movement of portal cranes.
iii. It is desirable to illuminate the Base Depot so that the activities listed in item (i) above can be undertaken safely at night.
iv. To strengthen depot working, it is desirable to install a few hand-operated/motorized gantry cranes moving on auxiliary tracks in addition to the third portal crane in the depot.
v. Some of these gantry cranes can be of 6.5 metres height from rail level to facilitate repair of portal cranes.

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 03 SESSIONS - 08)

Lesson – I :PQRS **Session-37:** Working Principle, Auxiliary Track and Mode of working.

WORKING PRINCIPLE:

1. Panels are fabricated with new sleepers and service rails in a Base Depot. These panels are loaded on BFRs in 3 or 4 layers.
2. The existing rails in track are cut in lengths of 13 m.
3. Auxiliary track is laid to proper line and level with the new rail panels, if rail renewal is also to be carried out as part of track renewal. Otherwise, service rails are used for making auxiliary track.
4. PQRS rake is brought to site of relaying after getting proper traffic and OHE block.
5. Following three methods of laying of new panels are used depending upon site conditions:
   - Ø Pulling the PQRS rake
   - Ø Pushing the PQRS rake
   - Ø Parting the PQRS rake
6. Portals are unloaded on the auxiliary track.
7. Old panels are removed and loaded on PQRS rake, ballast bed is scarified manually and new panels are laid at site by using portal cranes.
8. Proper ramp is provided at the beginning and at the end of the day's work.

AUXILIARY TRACK:

i. Auxiliary track should be laid at 3400 mm gauge keeping the centre line same as that of main line track.
ii. CST-9 plates or wooden blocks of size 560 X 250 X 125 mm should be used at 1.5 to 2.0 metres distance for laying the auxiliary track.
iii. The length of the auxiliary track should match with the daily progress of work.
iv. The level of auxiliary track should be same as that of existing main line track and must have proper longitudinal and cross levels to avoid derailment of portal cranes.
v. In no case, the auxiliary track should be more than 50 mm higher than the existing track.

MODE OF WORKING:

PULLING METHOD:
When engine leads in the direction of work and the work is done in the leading direction, it is called pulling.

PUSHING METHOD:
When engine is opposite to the direction of work and the work is done in trailing direction, it is called pushing.

TRAIN PARTING METHOD:
In case of non availability of proper length of auxiliary track PQRS rake is parted in two portions at site, and it is called 'Train Parting.' In this case, lot of time is wasted for parting and coupling and therefore this method is not very economical.

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 3 SESSIONS - 8)
Lesson – II: TRT **Session – 38**: Main Features, Main Units & Their Functions

---

MAIN FEATURES:

i. There is no need to prefabricate panels.
ii. No auxiliary track is to be laid.
iii. Concrete sleepers loaded on BRHs are directly taken to site and relayed one by one.
iv. New rails unloaded at site on shoulders and duly paired or fishplated are exchanged with old rails along with sleeper renewals.

MAIN UNITS & THEIR FUNCTIONS:

TRT consists of the following:

BEAM CAR (22.34m Length):
The beam car is hinged with handling car and has one common bogie and one independent bogie. Below this car, all the working units like old sleeper pickup, dynamic plow, sleeper, flipper, indexing wheel, new tie conveyor, self guiding roller for guiding in and guiding out rails, are provided. If sleeper spacing is to be changed, this can be achieved by changing the indexing wheel. Sled is hung from this car when not in use.

HANDLING CAR (21.05m Length):
This car has one independent bogie and one common bogie with beam car. All the conveyors are provided on this car.

POWER CAR (14.81m length):
This is a four axle vehicle. TRT power unit is provided on half the length of this car and remaining half is utilized for loading of sleepers. Power unit is Cummins NTA-855 turbo-charged, 6 cylinder diesel engine, maximum rating 360 hp at 2100 rpm, continuous rating 295 hp at 1800 rpm.

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 3 SESSIONS - 8)
Lesson – II: TRT **Session – 39:**Yard Activities, Modified BRHs & Rake Formation

---

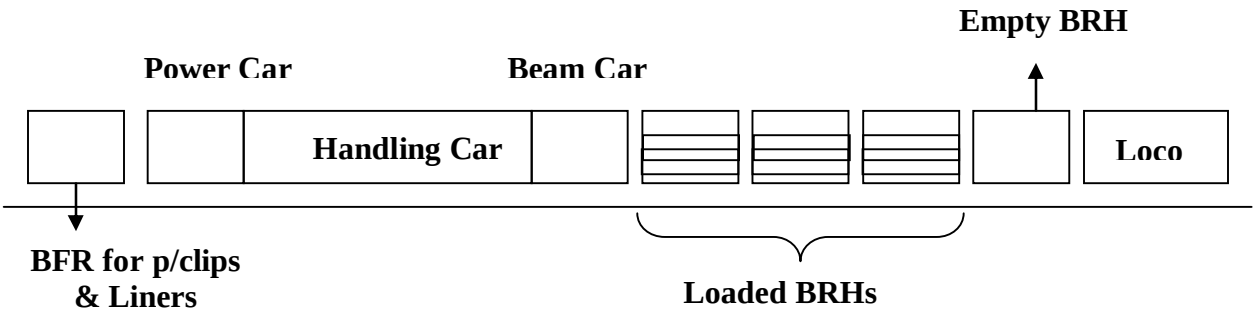
YARD ACTIVITIES:

i. Ensure proper selection of Base Depot site. The Base Depot for TRT should be centrally located (30-40 kms. Lead) in the area of working.
ii. Provide sufficient stock of new sleepers, elastic rail clips/fastenings, liners and rail pads in the Base Depot.
iii. Ensure proper line and level of auxiliary track for 3400/3700 mm gauge for portal working.
iv. 30 nos. BFRs should be modified for one set of TRT. 160 sleepers are loaded in one BFR and about 1500-2000 sleepers should be loaded as required during block.
v. Load rail fastening like elastic rail clips, liners and rail pads as required during block.

MODIFIED BRHs:

On both side of BFR, for running of gantries, plates are welded, which makes gantry track. The gauge of this track is kept 3050 mm. Due to this modification these BFRs are called modified BRH.

RAKE FORMATION:



In working direction, first vehicle is locomotive which is used to take the TRT rake, then we provide 1 or 2 empty BRH & then loaded BRH, on which new PRC sleepers are loaded. The number of loaded BRH depends on the traffic block.
As we know it very well that the progress of TRT is app. 10 sleepers per effective minute. Hence we can calculate the number of sleepers required for the block. 80 minutes is deducted for total block time for reaching at site, clearing section and setting & closing of diff. units. Remaining time is effective time. On one BRH 160 sleepers (20X4X2) are loaded.

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 3 SESSIONS - 8)
Lesson – II: TRT **Session-40:** Working Principle & SRs after relaying.

WORKING PRINCIPLE:

i. Removal of fastening: the fastenings of old rails to sleepers are removed in advance of track renewal work.
ii. Placement of new rails: the new rails are placed in advance on either side of the track duly welded or fish plated at a distance of 1.5 metres from the track.
iii. Positioning of the track: the main vehicle is now positioned on the track to be renewed. The design of the machine is such that with the help of 'guidance sled', the machine is located in the track at three points: the front and rear bogies and the sled at the centre. The guidance sled rests on the old sleepers at the point made free by the removal of the old rails. This design ensures an accurate reproduction of the old track layout without the need for an external machine guidance system.
iv. Lifting of old rails: the old rails which are already free from fastenings, are lifted and properly guided, with the help of 'Rail lifting and guidance frame.' The machine continuously lifts the old rails and deposits them on either side of the track.
v. Picking up of old sleepers: the old sleepers are picked up with the help of sleeper pick up system and these are placed upright on the conveyor system. With the help of chain conveyor belts, the old sleepers are carried and stored on the train in stacks of 4 layers separated by Dunn age with the help of handling gantry.
vi. Leveling & Compaction of ballast bed: Following the old sleeper pick up position is a vibratory plough and compactor. This plough levels the ballast ready to accept the new sleepers.
vii. Laying of new sleepers: The new sleepers are already stacked on the train in wagons. New sleepers are now placed automatically at a specified distance by using a wheel of specific circumference. The wheel send a signal after each revolution to the sleeper spacing mechanisms giving accurate sleeper positioning. Because of the unique geometry of this mechanism, the system ensures that sleepers are laid square and at specified distance.
viii. Laying of new rails: The new rails, which are already lying along the track, are then lifted and put in the position on the sleepers.
ix. Fixing of insulators & elastic rail clips: Attached behind the P811 S machine is a wagon containing elastic rail clips and insulators. Two labours place these adjacent to each sleeper. Two additional labours then position the rail clips and insulators in the correct position on the sleeper. Following this wagon is a clip applicator which fits the elastic rail clip into position, thereby, capturing the rail.
x. Picking up of old rails: the final operation is to remove the old rails. It is necessary prior to rail pick up to cut the rail into 39m lengths for proper handling. There wagons towed by utility vehicle (UTV), containing a mobile crane then pick up the old rails and place them onto the wagons for transporting to the depot.

SRs AFTER RELAYING:

First day relaying & tamping	: 40 kmph
Second day, second tamping & welding	: 60 kmph
Third day, third & final tamping	: 80 kmph
Fourth day	: Full Speed

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 3 SESSIONS - 8)
Lession – III: T-28 **Session-41:** Main features main units and their functions

---

MAIN FEATURES:

i. These are special bridge trains with adjustable span and height.
ii. These are equipped with crawlers and rail beams.
iii. These can lift and handle turn-outs as well as plain tracks.

MAIN UNITS & THEIR FUNCTIONS:

The important assemblies of T-28 are

I. Portal Cranes:
The portal crane permits adjustment of span and height and is equipped with both circular and flanged wheels. A set of two cranes can lift and handle a complete turnout. It can also be used to handle normal track. When working with a set of two portal cranes, the connection is provided by the turnout or track portion which is being handled.

II. Trolleys:
The trolleys are used to transport the turnout assembly on track. The motorized trolleys have the facility to move laterally by 300 mm on either side and lift vertically by 300 mm. one such trolley is placed below each of the crossing portion and switch portion and is used for shifting the turnout laterally or vertically for clearing any obstructions e.g. signal post, OHE mast, platform etc while transporting the turnout.

III. Jib Crane:
Pre-stressed concrete (PSC) sleepers for turnouts require careful handling to avoid damages during loading/unloading, assembling and laying. The sleepers loaded on BFRs are unloaded either at assembly depot or in yards near to the site of laying. Thereafter the PSC sleepers have to be spread at proper spacing for linking of turnout assembly. The jib crane is used for unloading and placement of PSC sleepers.

SUB DESCIPLINE – TRACK LAYING MACHINES (LESSONS – 3 SESSIONS - 8)
Lesson – III: T-28 **Session-42:** Power Transmission and Working Principle.

POWER TRANSMISSION:

WORKING PRINCIPLE:

SUB DESCIPLINE – DYNAMIC TRACK STABLIZER (LESSONS – 1 SESSIONS - 2)
Lesson – I:DTS/DGS **Session -43:-** Main Features, Main Units & Their Functions And Technical Data

---

The application of the dynamic track stabilizer anticipates the initial settlement in a controlled manner without altering the track geometry. After tamping the DGS lowers the track as required, gripping the rail heads with roller clamps and serving the track into horizontal oscillations. And at the same time each rail is automatically pressed down in accordance with the readings of the leveling device and Super – elevation Gauge.

DGS is a firm and proven part of the track maintenance. By this we can achieve horizontal stability along with rise in safety and earlier removal of speed restriction as it also improves the lateral stability.

MAIN FEATURES:

- Ø Elimination of initial differential settlements which are caused by the impact of passing trains.
- Ø The track geometry achieved by tamping machines is retained for a longer duration.
- Ø Homogenous structure of ballast bed is built up.
- Ø Lateral track resistance increases resulting in enhanced safety against track buckling.
- Ø Speed restrictions are relaxed faster.

MAIN UNITS & THEIR WORKING:

STABILIZER UNITS:
The machine has two dynamic stabilizer units which run on the track beneath the main frame, make contact with the rail heads through eight flange rollers on the inside and four roller discs on the outside. The two synchronized vibration units cause the track to vibrate horizontally. The frequency is adjustable from 0 to 45 Hz from the cabin. Two centrifugal force, independent of the frequency, can be up to 320 kN.

RECORDING AND MONITORING SYSTEM:
A proportional chord-leveling device enables controlled settlement of the track. A steel chord is spread over each rail between the sensor rods which are jointed to the inside axles of the bogies. They form the reference base of the recording system of the longitudinal level. By means of a sensor rod between the stabilization units, on which a recording value transmitter is attached to the left and rigt hand side, the settlement is recorded and monitored.

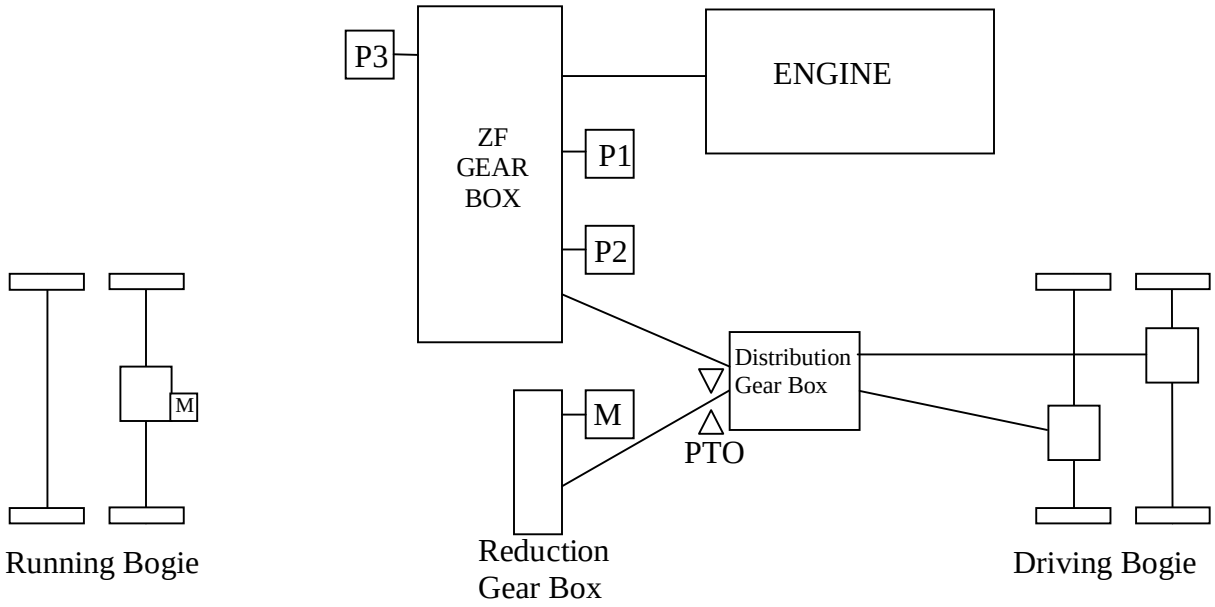
TECHNICAL DATA:

ENGINE:		
	(OLD STOCK)	DEUTZ-BF-12L-513C 460 BHP (AIR COOLED)
	(NEW STOCK)	KTA-1150L FROM KCL 473 BHP AT 2200 RPM
LENGTH OVER BUFFER		17250 MM
WIDTH		2800 MM
HEIGHT ABOVE RAIL		3790 MM
BOGIE PIVOTS SPACING		12000 MM
BOGIE WHEEL BASE		1500 MM
WHEEL DIAMETER		730 MM

WEIGHT	57 TONNES
AXLE LOAD:	
(I) FRONT AXLE LOAD	14.5 TONNES
(II) REAR AXLE LOAD	14.0 TONNES
SPEED:	
(I) SELF PROPELLED	60 KMPH
(II) IN TRAIN FORMATION	50 KMPH

SUB DESCIPLINE – DYNAMIC TRACK STABLIZER (LESSONS – 1 SESSIONS - 2)
Lesson – I:DTS/DGS **Session-44:** Power Transmission, Name of PCB's and their function.

POWER TRANSMISSION:



NAME OF PCB'S AND THEIR FUNCTION:

PCBs used in DGS (New)			PCBs used in DGS (Old)	
1.	Levelling Control (L&R)	EK 2186LV	Levelling Control (L)	EK 2031LV
2.	Peak Value measuring control	EK2155LV	Levelling Control (R)	EK2032LV
3.	Servo control vibration	EK 2683LV	Amplitude control	EK 2033LV
4.	Servo control working drive	EK2684LV	Pendulum compensation	EK97V
5.	Safety drive circuit	EK182LV	Power supply	EK813SV
6.	Relay circuit	EK603E	Encoder PCB	ELT5034
7.	Processor PCB	EK650PX	Processor	EK501P
8.	Input-Output	EK653P	Input-Output	EK553P
9.	QL	EK654P	QL	EK554P
10.	Time delay	EK657P	Measurement Display PCB	ELT 5144
11.	Power supply	EK813SV		
12.	Power supply	EK805SV		
13.	Servo adjustment	VT3005		
14.	Encoder PCB	ELT 5348		
15.	Distance delayed Analogue value	EK152.00		
16.	Measurement Display PCB	ELTELT5353 &ELT5354		
17.	Servo Adjustment	VT3005G-5032-A822		

SUB DESCIPLINE – QUALITY CONTROL (LESSONS – 3 SESSIONS - 4)
Lesson-I: Tamping Machines **Session-45:**Pre-requisites, Pre-tamping Operations.

PRE-REQUISITES:

i. A minimum cushion of 150 mm of clean ballast is recommended for the proper functioning of the machine. Adequate ballast should be available in shoulders and cribs to allow for required lift (about 20 mm in each tamping operation) and retention of packing after tamping.
For this purpose, planning and execution of deep screening of ballast as well as training out of ballast should be done well in advance.
ii. Sanction of Commissioner of Railway Safety for working of the concerned tamping machine shall be available.
iii. Traffic blocks of adequate duration shall be planned.
iv. The sleepers shall be uniformly spaced.

PRE-TAMPING OPERATIONS:

i. Field survey should be carried out to determine existing profile of track and to decide the general lift. In case of design mode working, the survey should be done as per guidelines.
ii. The beginning and the end of curves/ transition curves should be marked on sleepers. Super-elevation and slew should be marked on alternate sleepers to act as guide for the operator.
iii. Ballast shall be heaped up in the tamping zone to ensure effective packing. However, sleeper top should be visible to the operator and the ballast should not obstruct the lifting rollers.
iv. Hogged, battered and low joints shall be attended.
v. Low cess should be made-up.
vi. Track drainage should be improved for better retentivity of packing. Pumping locations should be attended. Rounded ballast should be replaced with clean and angular ballast.
vii. Deficient fittings and fastenings should be made good and all fittings and fastenings like fishbolts, keys, cotters, loose jaws, elastic rail clips, pads etc should be properly tightened. Worn out fittings should be replaced.
viii. Broken and damaged sleepers shall be replaced.
ix. Sleepers should be squared, correctly spaced and gauge corrected.
x. Destressing of rails, adjustment of creep, expansion gaps in joints, buffer rails and SEJs etc, if necessary, shall be carried out.
xi. Guard rails at the approach of bridges and check rails shall be removed temporarily.
xii. All obstructions such as rail lubricators, signal rods and cable pipes which are likely to obstruct the tamping tools should be clearly marked and made known to the operator before the start of work.
xiii. Wooden blocks and joggled fishplates shall be removed temporarily ahead of tamping.
xiv. In electrified sections, the earthing bond should either be removed or properly adjusted for tamping.

SUB DESCIPLINE – QUALITY CONTROL (LESSONS – 3 SESSIONS - 4)

Lesson-I: Tamping Machines S**ession-46:**Operations during tamping and Post tamping operations..

OPERATIONS DURING TAMPING:

i. The gap between top edge of the tamping blade and the bottom edge of the sleeper in closed position of the tamping tool should be adjusted depending upon the type of rail and sleepers. The gap for different types of sleepers will be as under:
   a. Metal sleeper : 22-25 mm
   b. Flat bottom sleeper : 10-12 mm

ii. The tamping (squeezing) pressure should be adjusted according to the type of sleeper as under:
   a. CST-9 sleeper : 90-100 kg/sq.cm.
   b. ST or wooden sleeper : 100-110 kg/sq.cm.
   c. PSC sleeper : 110-120 kg/sq.cm.

iii. Care should be taken to ensure that tamping tools are inserted centrally between the sleepers into the ballast to avoid damage to sleepers. The number of insertions of the tamping tool per sleeper varies with the type of sleeper and the amount of track lift to be given. While tamping, following guidelines should be adopted:-
   a. CST-9 sleepers and steel trough sleepers may require double insertion before passing on to the next sleeper.
   b. Wooden sleepers require one insertion upto 20 mm lift and two insertions for lifts above 20 mm.
   c. One additional insertion for joint sleepers will also be required.
   d. Concrete sleepers require one insertion upto 30 mm lift. Two insertions may be required for lifts above 30 mm.

iv. For maintenance packing, squeezing time of 0.4 second to 0.6 second should normally be adequate. Higher squeezing time may be required for track with caked up ballast.

v. The machine should have full complement of tamping tools. The tamping tools should not be loose or worn out. The wear on the tool blade should not be more than 20% of its sectional area.

vi. A ramp of 1 in 1000 shall be given before closing the day's work and obligatory point. The next day's work shall begin from the point of commencement of previous day's ramp.

vii. If work is to be done during night, sufficient lighting at work site should be ensured.

viii. Care shall be taken to provide for slew and lift compensation as necessary. Heavy slewing or lifting should normally be done in steps of not more than 50 mm. for LWR/CWR track, the relevant provisions of LWR manual shall be adhered to.

ix. During tamping, the parameters of tamped track should be checked immediately after tamping for cross level and alignment, and necessary corrective action should be taken.

POST TAMPING OPERATIONS:

i. Checking and tightening of loose fittings.
ii. Replacement of broken fittings.
iii. The ballast shall be dressed neatly. Proper consolidation of ballast between the sleepers shall be done.
iv. Final track parameters should be recorded with the help of recorders provided on the tamping machine. A copy of this record should be kept with the Section Engineer (P.Way) and the recorded values should not exceed the following limits:-

Parameter	Not more than 10 peaks per km to exceed this value	Any peak exceeding this value
Alignment	± 4 mm	± 6 mm
Cross level	± 6 mm	-
Unevenness	6 mm	10 mm

If the recorder is not available, then track parameters of at least four stretches of 25 sleepers each per kilometer of tamped track should be recorded. In addition, the versines and super-elevation of curves shall be recorded for atleast ten stations at a specified chord length.

v. While working in LWR territory, the provisions of Manual of Instructions on Long Welded Rails – 1996 should be followed.
vi. The fixtures like check rails removed during pre-tamping operation should be restored.

SUB DESCIPLINE – QUALITY CONTROL (LESSONS – 3 SESSIONS - 4)

Lesson-II: BCM **Session-47:** Pre-requisites, Operations prior to deployment, Operations during Traffic Block and Post Block Operations.

FOR BCM & SBCM:

PRE-REQUISITES:

i. The cutter bar will cut the formation and form channel under the track if minimum 250 mm ballast cushion (caked and clean) is not available. If the availability of cushion is less, the track can be temporarily lifted up to 100 mm by BCM itself during working. If this temporary lifting is inadequate, the track shall be lifted up to desired level in consultation with Traction Distribution branch in electrified areas.
ii. Since the cutter bar moves continuously below the track, the machine can not work if there is any lateral or vertical infringement. For such locations, either some special preparations are required or work has to be done manually.
iii. Since the setting and closing time of the machine is longer, a block of at least four hours is necessary to effectively utilize the machine.
iv. Adequate arrangements for supply and training out of ballast shall be ensured.
v. While working in LWR territory, provisions of Manual of Instructions on Long Welded Rails-1996 should be followed.

OPERATIONS PRIOR TO DEPLOYMENT:

i. Foot by foot survey of the section shall be conducted to see the condition of track components, ballast, cess width and availability of land for waste disposal.
ii. Requisite survey shall be carried out and the longitudinal profile and alignment shall be finalized as per the relevant provisions in the Indian Railways Permanent Way Manual-1996 and Schedule of Dimensions-1939.
iii. Depth of cutting/magnitude of lifting of track should be decided on the basis of proposed rail level. The longitudinal section showing formation level, existing and proposed rail levels should be plotted on a graph sheet. Otherwise, aid of computer along with suitable software may be taken. The final rail level shall be transferred on pegs or traction masts.
iv. The pockets of ballast beyond the reach of cutter chain shall be transferred in its cutting width before commencement of deep screening.
v. It should be ensured that there is no obstruction in the width of 4100 mm to avoid infringement to cutter chain. Rail pegs of LWR, creep posts etc should be removed. Pucca drain wall, if infringing, should be dismantled, alternatively the track can be slewed temporarily.
vi. In electrified section, distance of mast foundation from track centre will have to be accurately measured to ensure free movement of cutting chain.
vii. Any signal rodding or cable which is likely to interrupt the work should be temporarily removed.
viii. Approaches to bridges which can not be screened by the machine should be screened manually in advance of the machine working.
ix. Level crossings should be opened in advance so as to enable machine to work.
x. Sleepers should have all the fittings intact so that no sleeper becomes loose and come in the way of cutter chain while the ballast is being excavated. The broken tie bar and ST sleepers should be replaced.
xi. Gas cutting equipment should be available at site to cut any obstruction like rail pieces, pipes etc, which might get entangled with cutting chain.

xii. Spoil disposal units should be attached with the machine while working in station yards, cuttings or multiple lines section where dumping of the spoil along the cess is not feasible. If waste is to be disposed off across any adjacent track, the adjacent track shall also be blocked for traffic.

xiii. A trench of 30 cm depth and one metre width should be made for lowering cutter-bar by removing one sleeper or re-spacing of sleepers.

OPERATIONS DURING TRAFFIC BLOCK

i. When machine reaches site, the cutter bar should be lowered in the trench, both ends of cutter bar shall be connected to guides through links. For subsequent work, cutter bar is left under the track.

ii. When the machine starts working, cutter bar scarifies the ballast. Links of rotating chain push ballast in the inclined guides and lead the ballast to screening unit. One person on either side should move with the machine to watch for any obstruction to cutter chain, so as to arrange for stoppage of the machine immediately. Thereafter, the necessary corrective action should be taken.

iii. Screening should be stopped well before expiry of traffic block to permit proper closing of the work and packing before resumption of traffic.

iv. If the machine stops moving during work, it should be ensured that gates for clean ballast below screen are instantly closed. Otherwise, the screened ballast will get heaped up at one place.

v. Utmost caution should be observed while manipulating movement of waste conveyor to avoid hitting against electrical mast/signal post. Safety switch provided to sense the mast should, therefore, be kept 'ON'.

vi. All the staff working with the machine should wear safety helmets and masks to avoid inhaling dust.

POST BLOCK OPERATIONS:

i. At the end of work, about five sleeper spaces are left without ballast. These should be filled manually with the clean ballast.

ii. The vertical and lateral clearances for OHE, signal post and any other structure should be checked and adjusted before clearing the BCM block.

iii. Ballast recoupment activity should synchronize with deep screening activity so as to enable raising speed to normal after necessary packing.

iv. One watchman should be posted at the location where cutter bar and chain are left whenever considered necessary.

v. It is desirable that one round of tamping along with DTS should be carried out immediately after deep screening to resume traffic at a speed of 40 kmph.

The combining of BCMs, training out of ballast and DTS in the same block should be considered for opening of track at 40 kmph while clearing the block.

SUB DESCIPLINE – QUALITY CONTROL (LESSONS – 3 SESSIONS - 4)

Lesson-III: PQRS, TRT & T-28 **Session-48:** Pre-requisites, Operations prior to deployment, Operations during Traffic Block and Post Block Operations

---

PRE-REQUISITES:

i. A well organized and properly laid out Base Depot is the back bone of relaying by portal cranes. Smooth functioning of the Base Depot will ultimately reflect in efficiency and productivity of the relaying work. The Base Depot is required to cater to the following activities:-
   a. Unloading of PSC sleepers from the rake and stacking.
   b. Fabrication of new panels.
   c. Unloading of released panels from PQRS rake.
   d. Dismantling of released panels.
   e. Loading of pre-fabricated new panels.
   f. Formation of PQRS rake.
   g. Maintenance of machines.
   h. Dispatch of released material.
   i. Loading/unloading of ballast, if the Base Depot is also to be used as ballast depot.

ii. It is desirable to locate the Base Depot at a central place such that the distance of remotest work site on either side does not exceed 60-70 kilometers. At the same time, the site selected should be accessible by road, there should be electric power supply and watering facilities. The Base Depot may have facility of entry and exit on both sides from the running line.

iii. For smooth working, the Base Depot should have at least three sidings of 500 meters each connected to a shunting neck of 350 meters. Of these, at least two sidings should be provided with auxiliary track for movement of portal cranes.

iv. It is desirable to illuminate the Base Depot so that the activities listed in item (i) above can be undertaken safely at night.

v. To strengthen depot working, it is desirable to install a few hand-operated/motorized gantry cranes moving on auxiliary tracks in addition to the third portal crane in the depot. Some of these gantry cranes can be of 6.5 meters height from rail level to facilitate repair of portal cranes.

OPERATIONS PRIOR TO DEPLOYMENT

i. The requisite survey shall be carried out and the longitudinal profile and alignment shall be finalized as per relevant provisions in the Indian Railways Permanent Way Manual 1986 and Schedule of Dimensions-1939.

ii. Track may be deep screened one or two days in advance of relaying.

iii. Auxiliary track should be laid at 3400 mm gauge keeping the centre line same as that of main line track.

iv. The level of auxiliary track should be same as that of existing main line track and must have proper longitudinal and cross levels to avoid derailment of portal cranes. In no case, the auxiliary track should be more than 50 mm higher than the existing track.

v. Removal of ballast from the crib and shoulders up to the bottom level of the sleepers should be ensured.

vi. Full fittings of the old sleepers should be ensured to avoid their falling off while lifting released panels.

vii. All broken sleepers should be removed or replaced.

viii. In case a level crossing is to be encountered, it should be opened in advance.

ix. Proper planning and insertion of Switch Expansion Joints at correct locations should be ensured.

x. Cutting of LWR/SWR to single rails should be ensured for lifting released panels. Otherwise, replace the existing running rail by service rails for the stretches which are to be relaid during the next day.
xi. Temporarily disconnect or remove any other permanent obstructions.
xii. The following equipments should be available during working:
    a. One set each of rail cutting and gas cutting equipment.
    b. Two sets of rail closures of the each rail section being laid, in various sizes from 0.5 m to 3 m lengths.
    c. 4 sets of junction fish plates with bolts.

OPERATIONS DURING TRAFFIC BLOCK

i. After the train has reached the site, first of all the portals are unloaded from BFR on the auxiliary track.
ii. Both the portals have to go to that point from where the work has to be started.
iii. Both portal cranes will lift the released panel and keep them on empty BFR.
iv. After the old track is removed, the ballast section is leveled up manually and brought to the required level.
v. In second round, both the portal cranes will come without new panel and pick up old panels.
vi. In third round, both the portal cranes will bring pre-fabricated panels and lay these panels on working place.
vii. These operations are repeated until the last panel is laid.
viii. At the end of block, proper ramp is provided.
ix. Block is then cleared as the thus the track is already linked.

POST BLOCK OPERATIONS:

i. Clearance of track from any obstructions before removal of traffic block.
ii. Complete track fittings including their correct positioning and tightness.
iii. Proper lifting, packing, ballast regulating and compaction/stabilization of track to raise the speed of the different stretches.
iv. Training out of adequate quantity of ballast over the newly relayed track to full ballast section.
v. Picking up of left over released materials.
vi. Dismantling of auxiliary track and relaying the same in advance for the next day's work.
vii. Restoration of cables and other fixtures e.g. guard rails on bridges and check rails on level crossings which were removed temporarily.
viii. Tie tamping machines, BRM and Dynamic Track Stabilizer should be deployed to enable raising of speed to normal.
ix. Provision of SEJs as per approved plan, in-situ welding of panels and distressing of LWR should be done after welding of panels.

FOR TRT:

OPERATIONS PRIOR TO DEPLOYMENT:

i. Base Depot
   a. Ensure proper selection of Base Depot site. The Base Depot for TRT should be centrally located (30-40 kms. Lead) in the area of working.
   b. Provide sufficient stock of new sleepers, elastic rail clips/fastenings, liners and rail pads in the Base Depot.
   c. Ensure proper line and level of auxiliary track for 3400/3700 mm gauge for portal working.
   d. 30 nos. BFRs should be modified for one set of TRT. 160 sleepers are loaded in one BFR and about 1500-2000 sleepers should be loaded as required during block.
   e. Load rail fastening like elastic rail clips, liners and rail pads as required during block.

ii. All corroded and broken steel/CST-9 sleepers should be marked.

iii. There should be no infringement within one metre of sleeper ends.

iv. Adequate ballast should be available before relaying operations start.

v. Deep screening should be carried out in advance wherever feasible.

vi. Check-rails of level crossings falling in the range of work should be removed in advance.

vii. New rails should be unloaded, paired, fishplated or welded in one piece and set at about 1.5 metres from track centre.

viii. All longer wooden sleepers from joints be either removed or cut to size in advance.

ix. Interlaced sleepers of height different from remaining sleepers should be removed.

x. In case of CST-9 sleepers, gauging should be done in advance to avoid hitting of sleepers by sled assembly during lifting of CST-9 sleepers.

xi. Seven wooden sleepers should be laid in track at a location five sleepers behind the rail cut and ballast around them removed for easy placement of plow.

xii. The new location should be planned that it matches with the new rail end for threading at the start of work.

xiii. At location where relaying is to start, two rail pieces of 7.3 metres length are cut and connected together using well greased fishbolts to enable quick opening during block.

xiv. Plan the location of cut in the old track at the closing of work site so that it matches with the rail end of new rail panel.

xv. Ensure availability of S&T staff to connect any wire/rodding disturbed during the block, and OHE staff for opening of temporary bonds and bonding back after the work.

xvi. Ensure earth bonding of new rail panels.

xvii. Ensure removal of alternate keys in case of CST-9 sleepers and inside alternate keys in case of ST sleepers.

xviii. Existing small nos. of PSC sleepers should be replaced with wooden sleepers to avoid loss of time while working.

xix. High temperature distressing of the old track should be carried out as provided in Manual of Instructions on Long Welded Rails-1996.

OPERATIONS DURING TRAFFIC BLOCK

i. Shield hydraulic pipes and other moving parts of the TRT so that in case of any mishap, these do not hit OHE mast.

ii. Take OHE block, if staff is required to climb on top of the machine for repairs etc, in case of any breakdown.

iii. Ensure proper track protection at the site of work, look-out men and hooter in good working order to give warning for train approaching on the other line.

iv. Utmost caution should be taken while lowering and raising Clamp in order to avoid infringement to the adjacent line.

POST BLOCK OPERATIONS:

i. Ballasting of the track should be done immediately after track relaying operation.
ii. Then, Ballast Regulator, Tie Tamping machine and Dynamic Track Stabilizer should be deployed to enable raising of speed to normal in shortest possible time.
iii. In-situ welding of isolated joints should be done before restoration of speed to normal.
iv. Switch Expansion Joints should be provided at locations as per approved LWR/CWR plans.
v. Check rails should be provided at Level Crossings after final tamping of the track.
vi. Destressing of LWR should be done immediately after welding the rail panels to long welded rails.

FOR T-28:

PRE-REQUISITES:

PRE-BLOCK OPERATIONS:

i. New turnout should be assembled using Jib Crane near the site of turnout to be replaced. The fittings of assembled turnout should be complete and properly tightened. If suitable location is not available nearby, assembly may be done away from site and then transportation can be done with the help of trolleys. Infringements on the way should be checked and movement with slewing accordingly may be planned.
ii. The assembled turnout should be loaded on trolleys for transportation.
iii. Rails on either side of existing turnout should be of the same section as that of new turnout.
iv. Deep screening of turnout portion should be done. Ensure required cushion and proper drainage. Rail levels should be taken for sufficient length on either side of turnout. Proposed rail profile should be plotted both for main line and loop line.
v. Point machines should be disengaged and turnout should be non-interlocked before taking up its replacement.
vi. Ballast from crib and shoulder of sleepers should be removed up to sleeper bottom for full turnout length.
vii. 60 wooden blocks, each approximately 60 cm long, should be kept ready for facilitating passage of crawler on the obstacles.
viii. 4 nos. of rail pieces, each 70 cm long, should be kept ready for housing below the rail wheels of the crane.
ix. Jumpering of both ends of the turnout should be done by electrical staff before lifting and removing of existing turnout.
x. Adequate arrangements should be made for protection of the line involved and adjacent lines while the machine is working.
xi. Fishbolts should be lubricated and worked to facilitate easy removal during block.
xii. Location where clamp of each crane will hold the crossing and switch portions for lifting should be marked on the assembled turnout.

OPERATIONS DURING TRAFFIC BLOCK

i. Immediately after getting traffic block, the fishbolts of existing turnouts should be opened.
ii. Both cranes should be traversed and brought in position for handling the existing turnout at the demarcated position.
iii. Old turnout should be lifted by cranes and traversed to suitable location for further dismantling after the block.
iv. The cranes should be traversed to the pre-assembled concrete sleeper turnout and both the cranes should be taken to demarcated positions on turnout.
v. Simultaneously, the gangs should scarify the ballast from the location where the turnout has been removed. The ballast bed is lowered to accommodate extra height in case of concrete sleepers.
vi. The crawler side frame of the cranes should be spread suitably in stages to accommodate the length of the turnout sleepers on their demarcated locations for each crane.
vii. Pre-fabricated turnout should be held by the cranes. The cranes with the turnout be traversed across in stages and brought to the location of laying. The turnout is laid in position and fishplates are bolted to the existing track.
viii. One crane is traversed on the track and the second is utilized for final alignment of turnout. After placing the turnout, gangs should fill back the ballast manually.

POST BLOCK OPERATIONS:

i. Ballast deficiency should be made good by putting additional ballast. Profiling and boxing of ballast should be done.
ii. The turnout should be tamped with the help of UNIMAT machine. Both alignment and levels should be corrected while tamping the turnout.
iii. The turnout may be interlocked and point machine engaged immediately after laying the turnout.
iv. Damage to the cess during machine operation should be made good.
v. Provision of proper earthing points should be ensured by the electrical staff.

SUB DESCIPLINE – MAINTENANCE SCHEDULE (LESSONS – 4 SESSIONS - 4)

Lesson – I: Tamping Machines **Session - 49**Maintenance Schedules Of Tamping Machines

---

MAINTENANCE SHEDULES OF TAMPING MACHINES:

SCHEDULE-I
(TO BE DONE DAILY)
DURATION-ONE HOUR

i. Check and top up the hydraulic oil tank, if required.
ii. Check the level of tanks for lubrication of guide columns and top up with hydraulic oil, if required.
iii. Lubricate eye and fork end of every squeezing cylinder with grease.
iv. Change the worn out tamping tools.
v. Check the tightness and infringement of tamping tools with one another.
vi. Check locking device of all units.
vii. Lubricate all the lining roller pins with grease.
viii. Check leakages from hydraulic hose connections.
ix. Check for any air leakage from the system.
x. Check the air brake pressure.
xi. Check for any unusual sound from machine.
xii. Record the maximum hydraulic temperature of the day's work.
xiii. Observe the leakage from all gear boxes.
xiv. Check the level of tank for lubrication of tamping arm and main bearings.
xv. Check the level of main gear box.
xvi. Lubricate the vibration shaft bearing with grease.
xvii. Check the tightness of cardon shaft bolts.
xviii. Check the brake application.

SCHEDULE-II
(TO BE DONE AFTER 50 HOURS OF ENGINE RUNNING)
DURATION-TWO HOURS

i. Check the condition of brake shoes.
ii. Check the oil level of all gear boxes and top up, if required.
iii. Lubricate the axle gear box flange cover with grease.
iv. Lubricate the guide bushing of front and rear feeler with engine oil
v. Grease all cardon shaft.
vi. Grease flange of driving axle.
vii. Lubricate all link rods, pivots and rocker bearing of all assemblies.
viii. Grease lifting/lining unit assembly.
ix. Check the tightness of 55 mm and 35 mm pin.
x. Check bolts/welding of holding brackets of tamping units.
xi. Check nuts and bolts of suspension block of tamping units.
xii. Check/clean air breather of tamping units and gear boxes.
xiii. Lubricate the feeler rods with grease.
xiv. Clean and lubricate the guide rods of lining trolley with engine oil.
xv. Lubricate all other moving parts except above with oil or grease.
xvi. Check and clean the air oiler and fill up with new hydraulic oil.
xvii. Check air leakage from pneumatic system.
xviii. Check all lights for proper functioning.
xix. Check the bolts of cover plate of squeezing cylinders for tightness.

SCHEDULE-III

(TO BE DONE AFTER 100 HOURS OF ENGINE RUNNING)
DURATION-ONE DAY

i. Inspect the hydraulic pumps for any abnormal sound.
ii. Inspect the hydraulic motor for any abnormal sound.
iii. Inspect the water separator for proper functioning.
iv. Lubricate the tamping unit lateral adjusting cylinder guide rod with grease.
v. Examine the expiry date of the fire extinguisher.
vi. Check tightness of tamping unit lifting/lowering cylinder piston rod.
vii. Inspect main gear box cover through inspection window.
viii. Check hydraulic system pressure.
ix. Check vibration pressure.
x. Check squeezing pressure.

SCHEDULE-IV
(TO BE DONE AFTER 200, 400, 600 & 800 HOURS OF ENGINE RUNNING)
DURATION-TWO DAYS

i. Replace the hydraulic oil of reservoir for lubrication of vibration shaft main bearing.
ii. Lubricate the pre load cylinder of front tightening, lining and measuring trolley with grease.
iii. Lubricate the lifting cylinder of lining and measuring trolley with grease.
iv. Replace the proportional valve filter element.
v. Replace the return line filter element.
vi. Change the oil of distributor gear box.
vii. Change the oil of drive intermediate shaft and main gear box.
viii. Change the oil of six speed gear box.
ix. Change the oil of reversing gear box.
x. Change the oil of axle gear boxes.
xi. Change suction filter.

SCHEDULE-V
(IOH)
(TO BE DONE AFTER 1000, 3000 & 5000 HOURS OF ENGINE RUNNING)
DURATION-7 DAYS

i. Send the hydraulic oil for chemical testing.
ii. Clean the hydraulic oil tank.
iii. Clean the hydraulic oil through 10μ if found OK in chemical testing otherwise fill new oil.
iv. Check the bearings of all the axles and lubricate with grease.
v. Check the condition of meggi springs and replace them if required.
vi. Recondition the worn out wheels of all trolleys, if required.
vii. Check bearing of trolley wheels and lubricate them with grease.
viii. Clean and check the air reservoir for rated air pressure.
ix. Overhaul/Replace the tamping units, if required.
x. Overhaul/Replace the lifting units, if required.
xi. Replace the hydraulic hoses, which are damaged.
xii. Replace the seals of leaking hydraulic cylinders.
xiii. Overhaul all the transducers.
xiv. replace the defective transducer fork.
xv. Thoroughly clean all the panel boxes with pressurized air.
xvi. Check the wire connections in panel boxes.
xvii. Replace the missing or defective lights.
xviii. Calibrate the sensing trolleys.
xix. Strengthen the machine frame where cracks have been developed.

xx. Test the machine on track for all functions.
xxi. Replace the brake shoes.

SCHEDULE-VI
(IOH)
(TO BE DONE AFTER 2000 & 4000 HOURS OF ENGINE RUNNING)
DURATION-45 DAYS

Replace the seal of brake cylinders.
Clean and repair the hydraulic oil cooler, if it is blocked more than 20% or badly leaking.
Check the hydraulic motors for rated delivery and replace if required.
Replace the damaged and chocked pneumatic pipes.
Overhaul all the pneumatic valves and change unserviceable ones.
Replace the seals of all pneumatic cylinders.
Check the machine wheels for tyre defects. Reprofile or replace if required.
Replace the defective switches and potentiometer.
Calibrate the machine on track for all functions.

SCHEDULE-VII
(POH)
(TO BE DONE AFTER 6000 HOURS OF ENGINE RUNNING)
DURATION-90 DAYS

i. Replace all hydraulic pumps.
ii. Replace all the hydraulic motors.
iii. Check and recharge the hydraulic accumulators.
iv. Replace the hydraulic cylinders on condition basis otherwise replace all the seals.
v. Replace all the D.C. and pilot operated valves.
vi. Get calibrated the proportional valve, if possible, otherwise replace it with new ones.
vii. Replace all pressure control valves.
viii. Check the functioning of all stopcock and flow control valves, if anyone found defective then replace it with new ones.
ix. Replace all hydraulic hoses along with crimped fittings.
x. Clean the hydraulic tank. Inside to be painted with approved quality paint.
xi. Flush the complete hydraulic system.
xii. Replace all pneumatic hoses.
xiii. Test the air tank for rated air pressure.
xiv. Replace all pneumatic valves.
xv. Replace the pneumatic cylinders on condition basis, which were creating the frequent trouble during work. Otherwise replace seals only
xvi. Overhaul the brake cylinders and replace the seals if cylinder is o.k.
xvii. Overhaul the sensing trolleys.
xviii. Re-profile all the trolley wheels.
xix. Replace the axle bearings.
xx. Overhaul all the gear boxes.
xxi. Overhaul the cardon shafts.
xxii. Repair or replace the defective PCB’s.
xxiii. Check the limit switches and replace on condition basis.
xxiv. Overhaul the pendulums.
xxv. Overhaul the panel boxes and provide thimbles as required.
xxvi. Replace the defective switches and indicator lights.
xxvii. Check and replace the defective LED’s of solenoids if required.
xxviii. Calibrate all the potentiometers for zero correction.
xxix. Calibrate the machine in all respects.
xxx. Paint the complete machine with approved quality paint.

SUB DESCIPLINE – MAINTENANCE SCHEDULE (LESSONS – 4 SESSIONS - 4)
Lession – II:BCM & FRM **Session – 50:**Maintenance Schedules Of RM-76, RM-80, FRM-80, FRM-85 & KSC-600

SCHEDULE-I
TO BE DONE DAILY
(DURATION-ONE AND HALF HOURS)

i. Check hydraulic oil level in tank and top up if required.
ii. Check oil level in vibration screen drum.
iii. Check proper locking of all units.
iv. Check the function and condition of conveyor belt, belt tension, scrapers of conveyors and look out for damages.
v. Check anti collision device of waste conveyor and cutting unit.
vi. Screening mesh should be checked in order to have proper size of ballast.
vii. Check for any unusual sound from machine.
viii. Check air brake pressure.
ix. Check and lubricate corner rollers of excavating chain.
x. Check the safety screw, scraper fingers and safety bolts of the excavating chain.
xi. Check the connection between connecting elbow and cutter bar.
xii. Check brake parts of idling bogie and powered bogie.
xiii. Check for any air leakage.
xiv. Check leakage in hydraulic circuit and do needful.
xv. Check tightness of cardon shaft bolts.
xvi. Record the max. hydraulic oil temperature of the day.
xvii. Check for proper axle clutch pressure.
xviii. Lubricate the cutting chain and excavating conveyor bearing.
xix. Check for any rubbing of hoses and loose clamping etc.
xx. Check and top up bottle for lubricating conveyor chain and ensure that lubrication system is working properly.
xxi. Check the safety items, emergency tools and spares.
xxii. Check the filter indicators of axle gear box clutch.
xxiii. Check the filter indicator of suction filters.
xxiv. Check the ballast distributing chutes.
xxv. Clean the slots next to the joint of the hydraulic cylinders.
xxvi. Check oil level of pneumatic lubricator.

SCHEDULE-II
TO BE DONE AFTER 50 ENGINE HOURS
(DURATION-TWO HOURS)

i. Check brake linkage and lubricate the pivots and gear teeth of hand brake with grease.
ii. Check guide rollers of conveyor belts.
iii. Check the condition of the cutter chain and replace worn-out parts.
iv. Lubricate axle gear box flange cover of driving bogie with grease.
v. Lubricate screen guide plates with grease.
vi. Lubricate all cardon shaft with grease.
vii. Lubricate bearing for main and distributing conveyor chain and adjust if required.
viii. Clean complete machine.
ix. Check wear on ballast distribution chutes.
x. Inspect wear plates of chain trough.

xi. Top up the bottle for lubrication of king pin pivot.
xii. Clean excavating conveyor sliding frame.
xiii. Check the tension of excavating conveyor chain and adjust if required.
xiv. Grease guide columns, plow pivots broom units and sliding planes of cutter unit.
xv. Check rubber bearing fitted under screen meshes and change if broken.
xvi. Check all working lights and do needful.
xvii. Check brake shoe clearance and adjust if required.
xviii. Check the oil level and top up both main gear boxes, if required.
xix. Check oil level of axle gear boxes and top up, if required.
xx. Lubricate the chain guide of excavating chain.
xxi. Check the oil level of conveyor belt gear box A1 and B1.
xxii. Check oil level of main gear box.

SCHEDULE-III
TO BE DONE AFTER 100 ENGINE HOURS
(DURATION-ONE DAY)

i. Check all the idler rollers of conveyor for free rotation.
ii. Check guide rollers and bushes of cutter chain.
iii. Check bushes, pressure separating rings and grooves of axle clutch shaft.
iv. Check the functioning of back up system.
v. Check the condition of torque arm bearing.
vi. Lubricate all cardon shaft.
vii. Check brake lining and brake block play

SCHEDULE-IV
TO BE DONE 200 ENGINE HOURS
(DURATION-TWO DAYS)

i. Check function of all limits switches.
ii. Check up rubber element of torque plate suspension and do needful.
iii. Check the excavation chain sprocket and change if required.
iv. Clean breather filter of hydraulic oil tank.
v. Change the filter s of axle gear box clutch.
vi. Repair ballast screens.
vii. Replace scraper shovel and intermediate links, if required.
viii. Lubricate hand brake gear with grease.
ix. Change oil in the axle gear boxes and replace clutch filter.
x. Change oil in the main gear boxes.
xi. Change oil in the waste conveyor gear box.
xii. Check the clutch pressure and adjust if required.
xiii. Clean the hydraulic oil with the help of hydraulic pump for about one hour.
xiv. Change hydraulic suction and return filters.
xv. Check and lubricate the sleeper scraper.
xvi. Check filter of hydraulic tank.
xvii. Check the function of the lifting device, Clean and lubricate.
xviii. Check the support rollers of the conveyor belts and lubricate them.
xix. Check draw bars and lubricate it.
xx. Check and lubricate pivot and side bearing of bogie.
xxi. Replace the filter cartridge and granule element of air dryer.
xxii. Change oil of conveyor belt A1 and B1.
xxiii. Check the main supply cable.

SCHEDULE-V
TO BE DONE AFTER 1000, 3000 & 5000 HOURS
(DURATION-7 DAYS)

i. Check meggi spring and change oil required.
ii. Lubricate the axle bearings of the bogies with grease.
iii. Clean and lubricate sliding surfaces and bolts of torque supports with oil.
iv. Change oil in screen drive drum and replace filter element.
v. Change hydraulic oil on condition basis through lab test.
vi. Change the chute wear plates.
vii. Check shock absorber fro proper functioning and do needful.
viii. Check universal joints for play and replace if required.
ix. Replace all conveyor belts on condition basis and overhaul the driving stations.
x. Overhaul the complete plow.
xi. Replace the worn out broom sticks, if required.
xii. Repair the missing and defective hand tools.
xiii. Clean water separator.
xiv. Check tappet clearances and adjust if required.
xv. Check the cover plate bolts of all hydraulic cylinders.
xvi. Lubricate the turn table with grease.
xvii. Check foundation bolts of brake cylinders.
xviii. Check all pressure settings.
xix. Check wear of brake shoes.
xx. Check condition of trough plates and replace if required.
xxi. Change the chute wear plates.
xxii. Check condition of hydraulic and pneumatic hoses and replace as required.
xxiii. Check the functioning of pressure switch of axle clutch and adjust if required.
xxiv. Check wheel and axle cracks by magnifying glass.
xxv. Replace the defective lights.
xxvi. Paint the screen area and chain trough.
xxvii. Replace excavating belts, supports pipes and chains of excavating units & acrylic strip.
xxviii. Replace distributing conveyors and waste conveyor.
xxix. Replace main conveyor, support pipes and chains. And replace acrylic strip.

SCHEDULE-VI
TO BE DONE AFTER 2000 & 4000 ENGINE HOURS
(DURATION-45 DAYS)

i. Check wheel tyre defects and do needful.

SCHEDULE-VII
TO BE DONE AFTER 6000 ENGINE HOURS
(DURATION-90 DAYS)

i. Check hydraulic pumps, valves, motors in the test bench for rated output and replace if necessary.
ii. Clean the hydraulic oil tank. Paint the surface of tank with approved quality of paint and fill new oil.
iii. Change scraper rubber plates of excavating unit.
iv. Change the rear frame, chute box and wing frame.
v. Overhaul the gearboxes.

vi. Check the bogie pivot for wear and attend as necessary.
vii. Change the scraper pads and skirt rubbers of all conveyors.
viii. Check all the direct acting and pilot operated direction valves and change if necessary.
ix. Check all the pressure control valves and change if necessary.
x. Check all the stopcocks and flow control valves and change if required.
xi. Check shock absorber and replace/repair as necessary.
xii. Replace defective switches and potentiometers.
xiii. Repair/replace screen frame.
xiv. Overhaul screen vibration drum and replace bearings.
xv. Replace bearing of cutting chain drive gearbox.
xvi. Replace bearing of excavating unit.
xvii. Check the wheel tyre profile.
xviii. Check the brake system.
xix. Replace pneumatic cylinder seals or cylinders as required.
xx. Replace all the hydraulic hoses along with clamps.
xxi. Check all hydraulic cylinders, change if necessary.
xxii. Clean hydraulic oil cooler.
xxiii. Replace air unloader.
xxiv. Test air tank.
xxv. Check all pneumatic valves and change if necessary.
xxvi. Check all the pneumatic cylinders and do needful.
xxvii. Change all the brake shoes.
xxviii. Check the axle bearing and grease them. Change if required.
xxix. Change mounting pad of all gearboxes.
xxx. Overhaul the bogies.
xxxi. Check the calibration of all the indicative instruments and replace the defective ones.
xxxii. Replace all the limit switches on condition basis.
xxxiii. Check the LED of all solenoids.
xxxiv. Overhaul all the panel boxes.
xxxv. Arrange insulation test of main cables and replace the defective ones.
xxxvi. Provide missing thimbles.
xxxvii. Replace the defective PCBs.
xxxviii. Strengthen the machine frame where cracks have developed.
xxxix. Flush the complete system.
xl. Fill new oil after replacing return line and suction filters.
xli. Check the function of all assemblies.
xlii. Test the machine for one week before it is put for actual working in section on regular basis.
xliii. Overhaul the cutting unit.
xliv. Replace excavating belts, supports pipe and chains of excavating units &b acrylic strip.
xlv. Replace distributing conveyors and waste conveyor.
xlvi. Replace main conveyor, support pipes and chains. And replace acrylic strip.

SUB DESCIPLINE – MAINTENANCE SCHEDULE (LESSONS – 4 SESSIONS - 4)
Lession – II:DTS & BRM **Session** - 51maintenance Schedules Of DTS & BRM

MAINTENANCE SCHEDULES OF DTS:

SCHEDULE-I
TO BE DONE DAILY
(DURATION-ONE HOUR)

i. Check tightness of cardon shaft bolts.
ii. Check leakage from all gear boxes and do the needful.
iii. Check vibration frequency and adjust it if necessary.
iv. Drain water separator.
v. Check air-brake pressure on locking position.
vi. Check for any air leakage and do the needful.
vii. Check brake system before going into section for its effectiveness.
viii. Check leakage in hoses, valves and joints. Rectify if required.
ix. Check hydraulic oil level in tank and do the needful.
x. Record the max. hydraulic temperature of the day.
xi. Check for any rubbing of hoses, loose clamping etc. and do the needful.
xii. Check for any unusual sound from any section of machine.
xiii. Ensure proper functioning of parking brakes.
xiv. Clean complete machine.
xv. Check all hydraulic and pneumatic pressures.

SCHEDULE-II
TO BE AFTER 50 ENGINE HOURS
(DURATION-TWO HOURS)

i. Lubricate the king pin pivots of driving and idle bogies with grease.
ii. Check and top up oil of axle gear box, Drive intermediate shaft, ZF gear box, distribution gear box and vibration gear box
iii. Lubricate both axle guides/Stabilizing unit rollers with grease.
iv. Lubricate clamp pivot pins with grease.
v. Lubricate link rod bearings with grease.
vi. Lubricate roller clamp housing with grease.
vii. Lubricate front, middle and rear feeler roller guide bushes and guide pulleys.
viii. Check bolts and nuts of all hydraulic cylinders.
ix. Check wear on brake shoes and do needful.
x. Adjust the gap between brake shoes and wheels, if required.
xi. Check horizontal swing of the unit.
xii. Lubricate the stabilizing unit guide column.
xiii. Lubricate axle gear box flange cover with grease.
xiv. Lubricate guide pulleys.
xv. Lubricate front and rear tightening trolley lifting cylinder pivot.
xvi. Lubricate front and rear tightening trolley preload cylinder pivot.
xvii. Check working of stabilizing unit derailment protection mechanism.
xviii. Lubricate the guide rod sleeve of vibration unit.
xix. Check all locking device for proper functioning.

SCHEDULE-III
TO BE DONE AFTER 100 ENGINE HOURS
(DURATION-ONE DAY)

i. Grease all cardon shafts.
ii. Lubricate both brake linkage and torque arm pivot.
iii. Clean hydraulic oil cooler by blowing air from opposite direction.
iv. Check all working lights, push buttons, switches etc. and do needful.

SCHEDULE-IV
TO BE DONE AFTER 200 ENGINE HOURS
(DURATION-TWO DAYS)

i. Change suction and return line filter elements.
ii. Change proportional filter element.
iii. Check pneumatic valves for proper functioning and change if required.
iv. Grease sliding surfaces, guide column surface and bolts of torque supports.
v. Check foundation bolts of brake cylinders. Tighten them if required.
vi. Replace the oil of ZF-gear box.
vii. Replace the oil filter of ZF-gear box.
viii. Change the oil of working drive clutch.
ix. Change oil of distributor gear box.
x. Change oil of axle gear box.
xi. Change the oil of drive intermediate shaft.
xii. Change the oil of vibration gear box.
xiii. Check all the spares and tools for emergency.
xiv. Check for safety items.

SCHEDULE-V
TO BE DONE AFTER 1000 ENGINE HOURS
(DURATION-7 DAYS)

i. Change grease of hand brake gear.
ii. Grease the axle bearings of the bogies.
iii. Change hydraulic oil. (Before replacement, check quality through lab test).
iv. Check leakage from all hydraulic cylinders and replace the seals on condition basis.
v. Check condition of roller clamps and do the needful.
vi. Check function of opening and closing cylinder for roller clamps.
vii. Check function of lifting cylinders of vibration unit.
viii. Replace defective lights.
ix. Check meggy springs and replace if required.
x. Check wheel tyre defects and do needful.
xi. Inspect all electrical connections and do the needful.
xii. Check meggy flexi washer of axle gear box, torque plate for damage. Replace if required.
xiii. Lubricate hand brake gear with grease.
xiv. Repair the defective hand tools or replace them.

SCHEDULE-VI
TO BE 2000 HOURS
(DURATION-45 DAYS)

i. Replace damaged hoses along with clamps.
ii. Clean the hydraulic oil tank. Paint the surface of tank with approved quality of paint.
iii. Thoroughly clean all panel boxes.
iv. Provide missing thimbles.
v. Replace defective switches and potentiometers.
vi. Replace defective indicative instruments.
vii. Check the function of all assemblies after maintenance.
viii. Test the machine for one week near the workshop before it is put for normal working in section on regular basis.

SCHEDULE-VII
TO BE DONE AFTER 6000 ENGINE HOURS
(DURATION-90 DAYS)

i. Replace all the hydraulic hoses along with clamps.
ii. Check all hydraulic pumps and motors on the test bench for rated output. Replace if necessary.
iii. Check all hydraulic cylinders change if necessary.
iv. Clean hydraulic tank, inside surface is to be painted with approved type of paints.
v. Fill new oil after replacing all the hydraulic filters.
vi. Clean hydraulic oil cooler. If it is blocked more than 20% during service or badly leaking, it should be replaced.
vii. Check all the direct acting and pilot operated direction valves and change if necessary.
viii. Check all the pressure control valves and change if necessary.
ix. Check all the stop cocks and flow control valves and change if required.
x. Flush the complete system.
xi. Change all pneumatic valves.
xii. Check all the pneumatic cylinders and change on condition basis.
xiii. Check brake cylinder bore for corrosion. If corroded, the inner bore should be chrome-plated and ground to standard size.
xiv. Change all the brake shoes.
xv. Strengthen the machine frame where cracks have developed.
xvi. Check the wheels for any tyre defects. Reprofile or change if required.
xvii. Check the axle bearing and grease them. Change if required.
xviii. Change mounting pad of all gear boxes.
xix. Overhaul all the gear boxes except ZF-gear box.
xx. Replace the cardon shaft or these may be overhauled.
xxi. Replace the shaft coupling and holding nuts & bolts on condition basis.
xxii. Overhaul the driving and idle bogies. Replace the defective parts.
xxiii. Replace the defective PCBs.
xxiv. Check the calibration of all the indicative instruments.
xxv. Arrange insulation test of main cables and replace the defective ones.
xxvi. Overhaul the panel boxes.
xxvii. Change all the defective switches and lights.
xxviii. Check the LED of all solenoids and replace if required.
xxix. Replace all the limit switches.
xxx. Check tightness of the frame of stabilizing unit.

xxxi. Change stabilizing unit roller.
xxxii. Check stabilizing unit guide column. Change if required.
xxxiii. Change clamp pivot pins.
xxxiv. Change link rods with their bearings.
xxxv. Overhaul derailment protection mechanism.
xxxvi. Check chassis side members, cross frames, buffer beams and welded joints etc. if damaged, it should be repaired.
xxxvii. Check bogie side frame, springs, shock absorbers, wheel's torque supports, shackles, brakes and rod linkage. If any damage is noticed, it should be changed.
xxxviii. Check all electrical and emergency switches and do the needful.
xxxix. Attend complete painting of the machine.

MAINTENANCE SCHEDULES OF BRM:

SCHEDULE-I
TO BE DONE DAILY
(DURATION-ONE HOUR)

i. Check oil leakage from both the main gear boxes.
ii. Check tightness of cardon shaft bolts.
iii. Check oil level of axles gear boxes and top up, if required.
iv. Check air brake pressure.
v. Check for air leaks, after shutdown the engine and do the needful.
vi. Check leakage in Hydraulic circuit and do the needful.
vii. Check hydraulic oil level in tank and top up if required.
viii. Record the maximum hydraulic temperature of the day.
ix. Check for any rubbing of hoses, loose clamping etc. and do the needful.
x. Check all hydraulic pressure for rated settings and adjust if necessary.
xi. Check functioning of power pack/emergency backup pump.
xii. Check the tightness of sweeping elements on broom.
xiii. Check chain for proper deflection.
xiv. Check for any unusual sound from machine section.
xv. Check all the spares and tools for emergency.
xvi. Check safety items.
xvii. Ensure proper functioning of parking brakes.
xviii. Check all locking devices for proper functioning.
xix. Grease rollers, universal joints and propeller shaft coupler.
xx. Check level of two-speed transmission fluid. Drain/flush/clean magnetic drain plug and refill with recommended oil.
xxi. Clean complete machine.
xxii. Check all the functions of machine before block working.

SCHEDULE-II
TO BE DONE AFTER 50 HOURS OF ENGINE RUNNING
(DURATION-TWO HOUR)

i. Grease axle gear box flange cover of bogies.
ii. Check gear oil of transmission gear box.
iii. Lubricate all cardon shafts with grease.
iv. Check all pressure control valves for rated setting.
v. Check bolts and nuts of all hydraulic cylinders.

vi. Lubricate the wing ballast box pivot pins with grease.
vii. Lubricate the wing lift frame, brake arm and wing pivot with grease.
viii. Lubricate wing mounting with grease.
ix. Lubricate the broom reel bearing with grease.
x. Check conditions of room wheel bearing, bushes and grease it.
xi. Check broom drive chain housing for oil level. Fill up if required.
xii. Check for water in oil. If water is present, check cover seal and repair. Drain and refill with new oil.
xiii. Check wear on brake shoes. Adjust gap between brake shoe and wheels.
xiv. Check all grader blade for proper tightness and replace if required.
xv. Lubricate the hopper door hinges with grease.
xvi. Lubricate the lift frame locks front and rear.
xvii. Lubricate the brake arms with grease.

SCHEDULE-III
TO BE DONE AFTER 100 HOURS OF ENGINE RUNNING
(DURATION-ONE DAY)

i. Lubricate hand brake gear with grease.
ii. Lubricate all cardon shafts.
iii. Clean filters of axle gear box clutch.
iv. Lubricate bogie pivot bearing and clutch lever shaft.
v. Lubricate guide column surface and bolts of torque supports.
vi. Check foundation bolts of brake cylinders.
vii. Lubricate the broom chain and plough rollers with grease.
viii. Check condition of broom sticks and do needful.
ix. Check tightness of chains fitted with broom unit.
x. Check working of the manual lever arrangement for disconnecting engine to gear box working.
xi. Check hinges of wing assembly for cracks and do needful.

SCHEDULE-IV
TO BE DONE AFTER 200, 400, 600 & 800 HOURS OF ENGINE RUNNING
(DURATION-TWO DAYS)

i. Check function of shock absorber.
ii. Lubricate hand brake linkage.
iii. Change oil in the axle gear boxes. Replace clutch filter.
iv. Check condition of hydraulic and pneumatic hoses. Replace if required.
v. Check effectiveness of the brake both manually and pneumatically.
vi. Change pump drive oil.
vii. Check all working lights, push buttons, switches etc. replace the defective/missing ones.
viii. Check working of water separator.
ix. Check all pressure gauges for proper working.
x. Check foundation and bracket bolts of compressor.
xi. Lubricate the bearing of sweeping element with grease.
xii. Check broken/crack brake shoes and do the needful.
xiii. Check universal joint for play and replace if required.
xiv. Check hydraulic pressures.
xv. Change oil in the axle gear boxes. Replace clutch filter.
xvi. Change oil of main gear box.

xvii. Change return line filter element.
xviii. Change Suction filter element.
xix. Replace the oil of transmission gear box.

SCHEDULE-V
TO BE DONE AFTER 1000, 3000 & 5000 HOURS OF ENGINE RUNNING
(DURATION-7 DAYS)

i. Grease axle bearing of the bogies.
ii. Flush and drain entire hydraulic oil from the system.
iii. Grease sliding surfaces.
iv. Change air cleaner filter above the hydraulic tank.
v. Send the hydraulic oil fro chemical testing and refill it after filtering it by 10μ porta filter if found O.K. otherwise, replace with new oil.
vi. Clean breather and magnetic drain plug.
vii. Clean the hydraulic tank.
viii. Check function of shock absorber.
ix. Grease the bogie pivot.
x. Replace defective lights.
xi. Change sensors if required.
xii. Replace defective seals of pneumatic cylinder, pipe joints and hoses, if required.
xiii. Check pneumatic cylinders for their proper working.
xiv. Check revolution of the sweeping unit. It should be 244 rpm.
xv. Check condition of idler sprocket for its correct revolution and proper functioning of broom.
xvi. Check wheel tyre defects and do needful.

SCHEDULE-VI
(IOH)
TO BE DONE AFTER 2000 & 4000 HOURS OF ENGINE RUNNING
(DURATION-45 DAYS)

i. Check all gear boxes and repair, if required.
ii. Check the wheel tyre profile and do the needful.
iii. Replace old hoses along with clamps on condition basis.
iv. Clean the hydraulic oil tank. Paint the surface of tank with approved quality of paint and fill new oil.
v. Thoroughly clean all panel boxes.
vi. Replace defective switches and potentiometers.
vii. Replace defective indicative instruments.
viii. Replace defective pneumatic cylinders.
ix. Replace damaged hoses.
x. Replace pneumatic valves, if required.
xi. Overhaul broom reel bearing and bushes.
xii. Overhaul broom chain.
xiii. Change all fittings of rubber elements if found defective.
xiv. Change worn out rubber pads provided at broom.
xv. Repair/replace missing and defective hand tools.
xvi. Check function of all assemblies after IOH.

SCHEDULE-VII
TO BE DONE AFTER 6000 HOURS OF ENGINE RUNNING
(DURATION-90 DAYS)

i. Strengthen the machine frame where cracks have developed.
ii. Check the wheels for any tyre defects. Re-profile or change if required.
iii. Check the axle bearing and grease them. Change, if required.
iv. Change mounting pad of all gear boxes.
v. Overhaul all the gear boxes.
vi. Replace/overhaul the propeller shafts.
vii. Overhaul the bogies.
viii. Dismantle the clutch assembly. Inspect all parts for wear/damage etc. and replace defective parts.
ix. Replace all the hydraulic hoses along with clamps.
x. Replace all hydraulic pumps and motors.
xi. Check all hydraulic cylinders. Change, if required.
xii. Clean hydraulic tank, inside surface is to be painted with approved type of paints.
xiii. Replace the hydraulic oil.
xiv. Check all the pressure control valves and change, if required.
xv. Check all the stopcocks and flow control valves and change, if required.
xvi. Flush complete hydraulic system.
xvii. Test air tank for rated pressure.
xviii. Check all pneumatic valves and change, if required.
xix. Check all the pneumatic cylinders and do the needful.
xx. Check brake cylinder bore and do the needful.
xxi. Change all the brake shoes.
xxii. Check calibration of all the indicative instruments.
xxiii. Arrange insulation test of main cables and replace the defective ones.
xxiv. Overhaul the panel boxes.
xxv. Change all the defective switches and lights.
xxvi. Change sensors, if required.
xxvii. Change worn out sweeping element.
xxviii. Change bearing of the broom unit.
xxix. Replace blade graders.
xxx. Replace chains fitted for broom unit in order to correct revolution of unit.
xxxi. Check the bogie pivot for wear and attend as necessary.
xxxii. Change oil pump of drive gear box.
xxxiii. Paint complete machine with approved paint.
xxxiv. Test the machine working for one week near POH Workshop, before it is put for actual working in the section on regular basis.

SUB DESCIPLINE – MAINTENANCE SCHEDULE (LESSONS – 4 SESSIONS - 4)
Lession – IV:UNIMAT Session – 52: Maintenance Schedules Of 08-275 2S & 3S

MAINTENANCE SCHEDULES OF 08-275 2S & 3S:

SCHEDULE-I
TO BE DONE DAILY
(DURATION-ONE HOUR)

POWER TRANSMISSION:

- Ø Check in running condition (at 1000 rpm), the oil level of ZF gear box (Servo-Ultra 10-W) and top if required, after stopping.
- Ø Check oil level of axle gear boxes through sight glasses & top up. (G.OIL SAE90).

TAMPING BANKS:

- Ø Check & top up oil level of tank for lubrication of main pin bearing of 55 mm dia and monitor while working. (Oil same as hydraulic oil used on the machine).
- Ø Check & top up oil level of tank for lubrication of guide columns.

LIFTING & LINING UNIT:

- Ø Check locking and unlocking of lifting and lining unit.
- Ø Grease all lining rollers.
- Ø Check for oil leakage from pipes.

MEASURING DEVICES:

- Ø Apply lube oil on bush bearing.
- Ø Lubricate all ball & socket, pivot joints.
- Ø Lubricate all ball & socket, pivot joints of trolleys.

ELECTRICAL:

- Ø Check all lights, to be in working order.
- Ø Check battery charging from ammeter. It should be positive.
- Ø Check all PCB’s. They should be properly housed in sockets.

HYDRAULIC:

- Ø Check hydraulic hoses and valves for leakage.
- Ø Check hydraulic oil level in tank and top up if required.
- Ø Check all system pressure.

PNEUMATIC:

- Ø Drain air reservoirs after the day’s work.
- Ø Top up air oiler.
- Ø Check pressure on Dual Air Pressure Gauge.

GENERAL:

- Ø Clean complete machine.
- Ø Check for any unusual sound from tamping units, gear boxes, engine & hydraulic pumps.

SCHEDULE-II
TO BE DONE AT 50 P & C OF WORK DONE OR APPROX. 50 ENGINE HOURS (WHICHEVER IS EARLIER)

TAMPING UNIT:

- Ø Check and tighten shoe plate bolts of guide column.
- Ø Check and tighten squeezing cylinder cover plate bolts.
- Ø Lubricate radial tilting guide plates and rollers.

TRACK LIFTING & LINING UNIT:

- Ø Grease lining cylinder pivots.
- Ø Grease rail clamp pivot pins.
- Ø Check and tighten clamp roller locking bracket bolts.
- Ø Grease the following points of the 3rd rail lifting unit (UNIMAT-3S)
    a. Cylinder pivot pins
    b. Rope pulley
    c. Sliding plate
    d. Rollers
    e. Telescopic slide

MEASURING DEVICES:

- Ø Grease pendulum bridge pivots.
- Ø Check for play in feeler rollers of middle trolley.
- Ø Check lifting transducer carrier rod, for excessive wear or damage.
- Ø Check tension of wire cord for leveling & lining.

PNEUMATIC:

- Ø Check foundation bolts of brake cylinders.
- Ø Clean water separator filter.
- Ø Check function of water oiler.

HYDRAULIC:

- Ø Check all hoses for twisting, rubbing and replace leaking hoses.
- Ø Check functioning of tank level indicator, tank breather and temperature sensor.
- Ø Clean the fins of ZF Gear Box and System Oil Coolers, by blowing air in opposite direction.

DRIVING AND IDLE BOGIE:

- Ø Grease king pin pivot of drive & idle bogies.
- Ø Grease axle gear box flange cover of driving bogie.
- Ø Grease torque arm pivots of driving bogie.
- Ø Grease link rods.

POWER TRANSMISSION:

- Ø Check and tighten bolts of cardon shafts.
- Ø Check for oil leakage of other gear boxes.
- Ø Check oil level of working drive reduction gear box and top up.
- Ø Grease all cardon shafts.

ELECTRICAL:

- Ø Clean battery plugs.
- Ø Clean battery terminals and apply petroleum jelly.

SCHEDULE-III
TO BE DONE AFTER 100 P & C OF WORK DONE OR APPROX. 100 ENGINE HOURS (WHICHEVER IS EARLIER)

MISCELLANEOUS:

- Ø Change proportional valve filter element.
- Ø Change servo valve filter element.
- Ø Check calibration of cross level.
- Ø Check calibration of lining.
- Ø Check calibration of tamping unit depth.
- Ø Check universal joints of Cardon Shaft for play and replace in case of excessive play. Visually examine for fracture, distortion & twist of splines of Cardon Shaft.
- Ø Grease hand brake gear.

SCHEDULE-IV
TO BE DONE AFTER 250 P & C OF WORK DONE OR APPROX. 250 ENGINE HOURS (WHICHEVER IS EARLIER)

MISCELLANEOUS:

- Ø Change gear oil of hydraulic drive reduction gear box.
- Ø Check oil of intermediate drive shaft.
- Ø Change Z-F Gear Box filter.
- Ø Change oil of axle gear boxes.
- Ø Inspect all cardon shafts.
- Ø Change vibration shaft housing oil
- Ø Change suction filter (after 500 hours during alternative Schedule)
- Ø Change inner and outer elements of air cleaner filter.
- Ø Grease water pump bearing and pulley bearings.
- Ø Clean diesel tank.
- Ø Check RPM of the engine radiator fan.

SCHEDULE-V
TO BE DONE AFTER 625 P & C OF WORK DONE OR APPROX. ONE YEAR (WHICHEVER IS EARLIER)

MISCELLANEOUS:

- Ø Check bearings of all axles and grease them.
- Ø Check meggy springs and replace, if required.
- Ø Check wheel discs tyre defects and take necessary remedial action.
- Ø Check backlash of drive axle pinions.
- Ø Recondition worn-out wheels of all trolleys.
- Ø Check bearings of trolley wheel and grease them.
- Ø K and clean air reservoir.
- Ø Inspect wires of all transducers.
- Ø Replace/overhaul taming unit, if required.
- Ø Change batteries.
- Ø Overhaul water pumps.
- Ø Recondition roller clamps and lining rollers.
- Ø Check hooks vertical/horizontal guide bushes and replace if necessary.

SCHEDULE-VI
IOH AFTER
A) 1250 P & C OR 2 YEARS WHICHEVER IS EARLIER
B) 2500 P & C OR 4 YEARS WHICHEVER IS EARLIER

HYDRAULIC:

- Ø Check the hydraulic pumps for rated delivery on the test bench and replace if it is less than the demand of circuit.
- Ø Check the hydraulic motors for rated torque and replace, if required.

HOSES:

- Ø Replace the Hydraulic hoses which are damaged by external abrasion & corrosion.
- Ø Replace the hoses which have developed cracks in external and internal plies.

PNEUMATIC

- Ø Clean cooling coils.
- Ø Replace/overhaul air unloader.

MECHNICAL:

- Ø Replace/overhaul the tamping units if required.
- Ø Overhaul the lifting units.
- Ø Overhaul the trolleys and wheels of all the feeler rollers.
- Ø Strengthen the machine frame, where cracks have developed.

ELECTRICAL:

- Ø Thoroughly clean all panel boxes.
- Ø Provide missing thimbles.
- Ø Replace defective switches and potentiometers.
- Ø Replace defective indicative instruments.
- Ø Replace the batteries.

GENERAL:

- Ø Check the function of all assemblies after IOH.
- Ø Calibrate the sensing equipments.
- Ø Test the machine for one week near the workshop, before it is put for work in regular section.
- Ø Update lo book entries indicating all the works done till on date.
- Ø Update the Machine history book.

SCHEDULE-VII
POH AFTER 3750 P & C OR APPROX. 6 YEARS WHICHEVER IS EARLIER
(OR)
ON CONDITION BASIS WITH SPECIAL PERMISSION FROM COMPETENT AUTHORITY

HYDRAULICS:

- Ø Change all Hydraulic pumps, motors and cylinders.
- Ø Replace all hydraulic hoses.
- Ø Clean hydraulic tank, inside to be painted with approved quality of paint.
- Ø Fill new oil after replacing return line and suction filters.

PNEUMATIC:

- Ø Replace cooling coil, air unloader.
- Ø Test air tanks.
- Ø Replace water separator and air oiler.
- Ø Change all pneumatic hoses & valves.
- Ø Change pneumatic cylinders, brake cylinders and clapper cylinders.
- Ø Overhaul the air compressor.
- Ø Change all the brake shoes.

MECHANICAL:

- Ø Replace tamping units.
- Ø Overhaul the lifting units.
- Ø Overhaul the trolleys, wheels & feeler rollers.
- Ø Strengthen machine frame where cracks have developed.
- Ø Axles may be replaced if the bearings are loose on the journal.
- Ø Replace the propeller shaft or these may be overhauled.

GENERAL:

- Ø A diesel driven portable filter should be installed on the machine.
- Ø Through the above power pack, emergency back up system should be provided on the machine.
- Ø Update all log books entries, recording all the works done till on date.

ELECTRICAL:

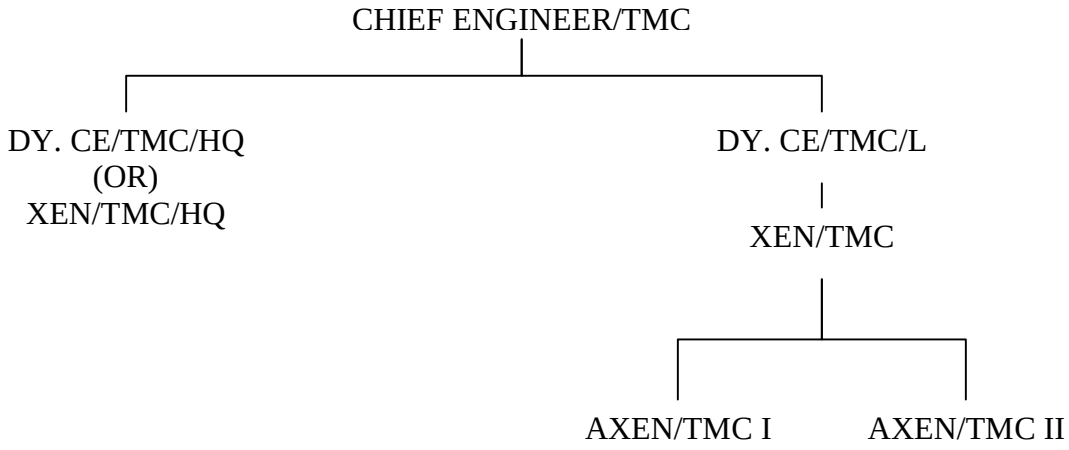
- Ø Replace the defective PCBs.
- Ø Replace the limit switches.
- Ø Calibrate all the indicative instruments.
- Ø Overhaul the pendulums.
- Ø Overhaul all the transducers.
- Ø Calibrate the machine for lifting and alignment on zero setting for leveling and alignment.

SUB DESCIPLINE – IRTMM (LESSONS – 1 SESSIONS - 3)
Lesson – I: Introduction To IRTMM RDSO Reports **Session-53:** Ch 1: Track Machine Organization & Duties of AEN, SSE, Operator & Technician.

TRACK MACHINE ORGANISATION:
The organization shall be under the overall charge of Chief Track Engineer (Machines) of the Railway who shall be reporting to the Chief Engineer through Chief Track Engineer. The organization shall be responsible for the following functions:

i. Field operation of track machines,
ii. Repair and maintenance of machines,
iii. Supervision and technical services including training, and
iv. Planning and deployment of machines.

To carry out each of the above functions, chief Track Engineer (Machine) shall be assisted by one or more Deputy CE (Machine). As given below:



DUTIES OF AEN:

GENERAL:
The Assistant Engineer is responsible for maintenance and efficient working of all the track machines in his charge.

IMPORTANT DUTIES:

- Ø Inspection and maintenance of all machines.
- Ø Ensure adherence to stipulated maintenance schedules.
- Ø Ensure availability of necessary staff for operation.
- Ø Ensure achievement of stipulated target.
- Ø Ensure adequate availability of consumables and spares.
- Ø Initiate proposals and plans for major schedule of work.
- Ø Ensure co-ordination with other units of engineering department.
- Ø Verification of store.
- Ø Ensure maintenance of various records.
- Ø Ensure availability of tools.

TRAINING OF PROBATIONERS
STAFF MATTERS
All the section engineers and other staff working under him receive proper training in maintenance practice.

SERVICE AND LEAVE RECORDS
WITNESSING PAYMENTS TO STAFFS
KNOWLEDGE OF RULE & REGULATION
INSPECTION BY HIGHER OFFICERS

INSPECTION OF MACHINE BY ASSISTANT ENGINEER

- Ø Inspection of machines by the Assistant Engineer shall be carried out in detail covering necessarily the following aspects and keep in view the Check List Maintenance Schedule issued by RDSO:
- Ø Health of engine.
- Ø Condition of hydraulic, pneumatic, electrical and electronic systems.
- Ø Condition of transmission/brake system.
- Ø Performance of the machine.
- Ø Staff accommodation.
- Ø Availability of the spares with the machine.

EXECUTION OF WORKS

DUTIES OF (SENIOR) SECTION ENGINEER/TMC:

i. The (Senior) Section Engineer/Track Machines shall be responsible for the satisfactory operation, maintenance and productivity of the machines under his charge and quality of work.
ii. He shall be well acquainted with the working systems, operating instructions, maintenance schedules, specifications of the oils/lubricants to be used, critical components etc of machines under his charge.
iii. He shall have thorough knowledge of the rules and regulations and procedures concerning his work and duties as laid down in this Manual, G&S Rules, IRPWM, Engineering Code and other departmental codes, extant orders and circulars issued from time to time.
iv. He shall have in his possession up-to-date copies of the rule books/documents/manuals pertaining to the safe, efficient and trouble-free working of the machines and also other codes and books applicable and needed for the day-to-day working.
v. He shall maintain the records pertaining to the machines under his charge and submit the prescribed returns regularly.
vi. He shall ensure discipline among the staff working under his within the framework of rules and endeavour to keep their moral high and look after their welfare.
vii. He shall ensure proper handing over/taking over of the charge when transfer/change of portfolio is effected.
viii. He shall plan and ensure timely execution of the maintenance schedules of the machines within the specified time.
ix. He shall keep himself abreast of the various methods and techniques of reconditioning of components and availability status of spares at the Base Depot for efficient recommissioning of the machine during breakdowns.
x. He shall investigate major failure of the machine critically for corrective actions/remedial measures and for fixing responsibilities in case of failures occurring due to lapses of staff.

xi. He shall be conversant with the provisions in various Service Agreement/Contracts and organize the visits of Service Engineers (scheduled or breakdown).

DUTIES OF MACHINE OPERATORS:

Each machine shall be under the direct charge of Section Engineer/Junior Engineer hereinafter called the operator. He shall ensure the following:

i. Operation and maintenance of the machine.
ii. Carrying out pre-block maintenance and making the machine fit for working.
iii. Initial setting out for the block working and closing the work of the machine including ramping in/ramping out of general lift to the track as in case of tie-tamping machine.
iv. Proper functioning of all the systems and components and keeping a watch on the controls/indicators/gauges.
v. Taking precautions for special Design Mode operations such as curve slewing etc in case of tamping machine.
vi. Posting of fitters/khalasis at respective places around the machine for monitoring the work of various systems, carrying out during block maintenance (greasing, oiling, tightening of bolts etc.) and also to attract attention of the main cabin Operator and assist him in the event of any problem of malfunctioning of the machine or due to track obstructions.
vii. He shall ensure safe working of the machine and staff.

When there are more than one Operators on the machine, the senior-most Operator shall be the Machine Incharge. In addition to his normal work as an Operator he shall be responsible for the following functions in which he will be assisted by other Operators/staffs:

i. Carrying out the prescribed schedule of maintenance and keeping proper records of the same.
ii. Safe custody, accountal and replacement of the spares, Tools & Plants and consumables issued for the machine and returning of released spares to base depot for reclamation/condemnation.
iii. Keeping systems of the machine in working condition and ensuring the target output, duly maintaining quality.
iv. Maintaining log books and other records, sending daily and other periodical reports/statements using appropriate fastest mode of communication.
v. Liaisoning with the Divisional Officials for efficient working of his unit, coordination with the Permanent Way staff and planning daily programme of machine work and interacting with the Permanent Way staff for working in design mode, slewing of curve etc.
vi. Actively associating during visit of firm's Service Engineer, furnishing of such information as may be needed for proper examination of the machine and taking necessary follow up action.

DUTIES OF TECHNICIAN:

The main functions of Track Machine Fitters/Mechanics are:

i. To attend to the daily and weekly maintenance schedules of machine and record the compliance in log book.
ii. To extend help during other maintenance schedules/service checks by the Service Engineers.
iii. To keep in his custody the various tools and equipment necessary to attend repairs and ensure their working condition.
iv. To remain vigilant during movement and working of machine and to inform the operator of any abnormalities.
v. To guide and supervise the semi-skilled/unskilled staff in attending to the maintenance/repairs.
vi. To ensure safety of the machine and men from approaching trains on adjacent lines.
vii. Any other work assigned to him by the machine incharge.

SUB DESCIPLINE – IRTMM (LESSONS – 1 SESSIONS - 3)

Lesson – I: Introduction TO IRTMM And RDSO TM reports **Session-54:** Ch 4 & 5: Rules for Movement & Working of Track Machines and Planning, Operation & Monitoring of Track Machines, Unit cost.

RULES FOR MOVEMENT:

GENERAL:

- Track machines are self propelled machines. These machines shall be worked as a train except when attached in the rear of a train, they will be treated as part of that train. However, when self propelled, there is no need of guard or breakevan.
- When more than one machines are required to work within the same block section, they may be allowed under one authority. In such situation, all the track machines must leave and enter the section simultaneously one after another keeping adequate distance among them and with proper authority.
- In case of run through movement from one station to another, upto three machines may be allowed under one authority to enter in a section with ruling gradient not steeper than 1 in 100. For gradients steeper than this only one machine shall be allowed at a time.
- Whenever the track machines are working in an integrated traffic block where other railway agencies are also working, the relevant instructions for integrated block working should be followed.

INCHARGE OF MACHINE:

- Each machine shall be under the direct charge of Section Engineer/Junior Engineer (Machine) hereinafter called the 'Operator'. Number of railway staff on driving cab of each machine shall not exceed five. The operator shall have valid competency certificate.
- The track machine shall work under the direct supervision of an Engineering official, not below the rank of Section Engineer/Junior Engineer (P.Way), who will be responsible for taking the traffic block and for protection of the line while working and also timely clearance of block after completion of work.

COMPETENCY OF OPERATOR:

- The operator shall be fit in A-3 medical category. If wearing spectacles, he shall carry and extra pair while on duty.
- The operator shall undergo training in train working rules at the Zonal Training Centre/IRTMTC, Allahabad. On successful completion of training, he shall be examined and if found competent, shall be issued with the competency certificate by Dy. Chief Engineer incharge of the machines which shall be valid for three years and shall be kept in the personal custody of the operator. The certificate shall be produced promptly when required.
- The operator shall apply to the Dy. Chief Engineer incharge of machines well in advance of the date of expiry for renewal of the competency certificate. The officer shall renew the certificate for further period of three years at a time after holding a test. The operator shall, however, be required to go for a Refresher Course in Zonal Training Centre/IRTMTC, Allahabad, within a period of 6 years.

SAFETY EQUIPMENTS:

The following safety equipments must be available in good working condition in the machine:

i. Two red and one green hand signal flags,
ii. Two tri-colour hand signal lamps,
iii. Two chains with padlocks,
iv. Two clamps with padlocks,
v. Twelve fog signals (detonators) in a tin case,

vi. A copy of the working time table of the section where the machine is working,
vii. G&SR book with upto date amendment slips,
viii. One 4 cell flasher light,
ix. One portable field telephone,
x. Two banner flags,
xi. One first aid box,
xii. Two skids,
xiii. Petromax/LPG lamps,
xiv. Safety helmets for all machine staff,
xv. Protective clothings, safety shoes and safety gloves,
xvi. Track Machine Manual, and
xvii. Accident Manual

HEAD & TAIL LIGHTS:
Each track machine must be equipped with prescribed head and tail lights, marker lights and flasher lights as per GR 4.14, 4.15 & 4.16 and SRs thereof.

The following equipments should be available on the machine during block working to meet the exigencies:

i.	Fire extinguisher	-	one
ii.	Hooter (manual)	-	two
iii.	Jack 50 t	-	two
iv.	Wooden blocks	-	four
v.	Crow bars	-	four
vi.	Trifor (3t)	-	four
vii.	Hydraulic hand pump	-	one
viii.	Emergency pneumatic/hydraulic hose of sizes suiting different machines (complete with end fittings)	-	one
ix.	Wire rope with close loops at both ends 2 metres & 9 metres for BCM	--	one each

RULES FOR OPERATION:

GENERAL:
- Ø When the track machines are stabled at a station, necessary precautions against rolling down such as pinning down hand brakes, chaining and provision of skids, shall be taken.
- Ø No track machine shall be moved between a running line and the siding/stabling line without the written permission of Station Master on duty in the form of shunting order/shunt signals.
- Ø When the track machine is required to move from one block station to another block station, the operators shall run the machine only with proper authority to proceed.

SINGLE LINE SECTION-WORK AND PROCEED:
- Ø Station master will obtain line clear, take off dispatch signals and issue special caution order indicating the number of machines permitted and the work in block section, Junior/Section Engineer (P.Way) shall move thereafter with token if any, shunting key, OPT form etc, ensuring piloting if due. He shall travel in the last machine, in case proceeding ahead.
- Ø One completion of the work, the machines will be received by lowering reception signals.
- Ø Station porter shall display green signal at the foot of first stop signal till the last machine enters the station.

- Ø At the station in advance, the token and the key etc, if any, shall be handed over after the last machine has cleared the block section. The Junior/Section Engineer (P.Way) shall certify the fitness of track, then only the Station Master will clear the line for normal trains.

SINGLE LINE SECTION-WORK AND RETURN:

WITH TOKEN TABLET INSTRUMENTS:

- Ø Station Master will obtain line clear from station in advance, lower last stop signal, issue special caution order indicating the number of track machines permitted to work within the block section, the station where they will return etc.
- Ø On completion of the work, the machines will be received by lowering reception signals.
- Ø Station porter shall display green signal at the foot of first stop signal till the last machine enters the station.
- Ø At the station, the token and the special caution order etc, shall be handed over after the last machine has cleared the block section. The Junior/Section Engineer (P.Way) shall certify the fitness of track, then only the Station Master will clear the line for normal trains.

WITH TOKENLESS BLOCK INSTRUMENTS:

- Ø Station Master will block back the section, take out the shunting key, issue a special caution order indicating the number of track machines permitted to work within the block section to Junior/Section Engineer (P.Way).
- Ø On completion of the work, the machines will be received by lowering reception signals.
- Ø Station porter shall display green signal at the foot of first stop signal till the last machine enters the station.
- Ø At the station, the shunt key and the special caution order etc, shall be handed over after the last machine has cleared the block section. The Junior/Section Engineer (P.Way) shall certify the fitness of track, then only the Station Master will clear the line for normal trains.

DOUBLE LINE SECTION-WORK AND PROCEED:

VIA RIGHT DIRECTION:

- Ø Station Master will obtain line clear from station in advance, lower last stop signal, issue special caution order indicating the number of track machines permitted to work within the block section, the station where they will return etc.
- Ø On completion of the work, the machines will be received by lowering reception signals.
- Ø Station porter shall display green signal at the foot of first stop signal till the last machine enters the station.
- Ø At the station, the special caution order etc, shall be handed over after the last machine has cleared the block section. The Junior/Section Engineer (P.Way) shall certify the fitness of track, then only the Station Master will clear the line for normal trains.

VIA WRONG DIRECTION:

- Ø Station Master will take the line clear from station in rear on block telephone indicating the number of track machines which will work from that station upto the next station, prepare paper line clear ticket, issue special caution order. Both will be handed over to Junior/Section Engineer (P.Way) who shall travel on the last machine.
- Ø The machine shall be piloted out of the station with a written authority by the Station Master after all the facing points are correctly set and locked and trailing points are set correctly.
- Ø After completion of work, the operator will stop the machine at the first stop signal of the right line or last stop signal of the wrong line (which they are running) at the next station.
- Ø The Station Master will send a railway staff in uniform to pilot them into the station on a written authority.

- Ø After all the machines reaches the other end of the block section, Junior/Section Engineer (P.Way) will return the paper line clear ticket, special caution order to Station Master. He will also certify that the track is fit and then only the Station Master will close the line and normal train running can be resumed.

DOUBLE LINE SECTION-WORK AND RETURN:

VIA RIGHT DIRECTION:

- Ø Station Master will block forward the section. He will take out the shunt key if available and issue special caution order to the Junior/Section Engineer (P.Way) along with the shunt key.
- Ø In addition , requisite written authority will be issued for passing the last stop signal at danger.
- Ø After completion of work, the operator will stop the machine at the first stop signal of the right line or last stop signal of the wrong line (which they are running) at the next station.
- Ø The Station Master will send a railway staff in uniform to pilot them into the station on a written authority.
- Ø After all the machines reaches the station, Junior/Section Engineer (P.Way) will return the paper line clear ticket, special caution order to Station Master. He will also certify that the track is fit and then only the Station Master will close the line and normal train running can be resumed.

VIA WRONG DIRECTION:

- Ø Station Master will block back the section. He will take out the shunt key if available and issue special caution order to the Junior/Section Engineer (P.Way) along with the shunt key.
- Ø The machine shall be piloted out of the station with a written authority issued by the Station Master.
- Ø On completion of the work, the machines will be received by lowering reception signals.
- Ø Station porter shall display green signal at the foot of first stop signal till the last machine enters the station.
- Ø At the station, the special caution order and shunt key, shall be handed over after the last machine has cleared the block section. The Junior/Section Engineer (P.Way) shall certify the fitness of track, then only the Station Master will clear the line for normal trains.

PLANNING:

GENERAL:

i. Working of all track machines in a zonal railway shall be centrally controlled and managed by the Chief Track Engineer in-charge of track machines hereinafter called CTE (MC).

ii. In drawing the programme, the following aspects shall be taken into consideration:
    - Ø Base depot locations,
    - Ø Loco requirements and loco power availability,
    - Ø Block requirements and block availability,
    - Ø Ballast needs and supply prospects,
    - Ø Speed restrictions,
    - Ø Working season,
    - Ø Output of individual machines,
    - Ø Effective availability of machines, taking into account slots for POH/IOH, on line repairs, etc,
    - Ø Priorities/targets for completion of projects/works,
    - Ø Coordination with and requirements of S&T and TRD branches, and
    - Ø Any other factor having a bearing on machine utilization.

iii. The divisions and construction units on receipt of the draft deployment plan shall initiate all preliminary works such as development of base depots, execution of contracts, arranging blocks, ballast collection, procurement of consumables like diesel oil etc. so that no time is wasted once the machines reach site.
iv. The machines on arrival in the divisions/construction units shall be deployed as per the approved deployment programme, their progress closely monitored, works completed in time and machines handed over to the next worksite as per programme.
v. The concerned Sr. DEN/DEN shall arrange for expeditious movement of machines as per the approved programme. Timely completion of preparatory works in the section/division where the machine is due to arrive, shall be ensured.

PROJECT WORKS:

i. The quality of relaying will be better by using PQRS cranes.
ii. Keep "Panel assembling locations" or base depot as close as possible to the work site.
iii. Adequate availability of service rails and labour for allied activities shall be ensured for uninterrupted working of machines.
iv. The initial standards of ballast cushioning, track linking and packing shall be such as to ensure safe and efficient working of on-track machines.
v. The availability of a gang to work along with tampers, spot calculation of versines for design lining and advance work for design mode of tamping for longitudinal surface with a knowledgeable supervisor are essential for the working of machines.
vi. Adequate availability of critical spares and consumables and a mobile workshop with a welding plant and gas cutting equipment shall be ensured.
vii. A separate "Imprest" for urgent requirement of spares and undertaking on the spot repairs shall be kept handy to help intensive utilization of machines.
viii. An SEN/AEN exclusively nominated may monitor the working of machines and coordinate with Construction branch for safe, efficient and uninterrupted working of machines.

INTER RAILWAYS DEPLOYMENT:

i. Inter-Railways transfer of machines will be done with the approval of Railway Board only.
ii. When machines are deployed to work in other railways for short duration, the "Owning Railway" shall send the machine staff required for their working.
iii. The Railway receiving the machine shall associate its staff to pilot the machine movement in its jurisdiction.
iv. The requirements of oils and consumables shall be supplied by the railway using the machines.
v. The user railway shall be responsible for the optimum utilization of the machines and keep appropriate records for future use.
vi. Output of the machine shall however be reported by the "Owning Railway" only in its performance report.

OPERATION:

i. The machine staff and P.Way staff shall work as a team towards the common goal of ensuring optimum utilization of the machine and manpower.
ii. The machine staff shall ensure adequate attention to the machine in time as prescribed in RDSO manuals and manufacturer's manuals in respect of their machines and keep the machines ready for availing stipulated blocks.
iii. The machine shall be berthed in the sidings safely as stipulated in the G&SR and the P.Way staff shall arrange for watchman for the machine during the non-working shift.

iv. The machine incharge on arrival shall check up the condition of the machine and report any unusual features observed by him such as disturbance to the machine at the berthing place, missing of parts etc and initiate appropriate action as per extant rules.
v. The machine incharge and Junior Engineer/Section Engineer (P.Way) shall jointly inspect and finalize the week's. work in advance and discuss the day's programme and share with each other all information required for the working.
vi. The Junior/Senior Engineer (P.Way) of the section shall be responsible for the block working of the machine.
vii. The Junior/Senior Engineer (P.Way) of the section shall be responsible for all the machine related track works.
viii. The Junior/Senior Engineer (P.Way) of the section shall be responsible for arranging necessary lighting etc for night works with the association/involvement of other divisional staff such a Signal/OHE etc.
ix. It should be ensured by the machine incharge that no person climbs to the top of any machine without OHE block in electrified sections.
x. The machine incharge shall ensure that all precautionary measures are taken for safety of the staff while working on double/multiple line block section against the danger of trains moving on adjacent lines. The Junior/Section Engineer (P.Way) should provide Lookout-men at the site of machine working as per requirements.
xi. SM will liaison with Section Controller/Controller to ensure that at the end of work, the machine is brought to the base station and placed in the nominated berthing line at the earliest to enable post block maintenance of the machine being undertaken.

MONITORING OF TRACK MACHINES:

TRACK MACHINE CONTROL:
A Track Machine Control office shall function in the headquarter of railway under control of JA Grade/Sr. Scale officer of the Track Machine Organization to co-ordinate between the divisions and headquarter, as also between field units and the base depot/zonal workshops.

FUNCTIONS OF TRACK MACHINE CONTROL:
i. Contacting the Divisional Engineering Controls for obtaining and recording the daily progress details, to co-ordinate between the divisions and headquarter, as also between field units and the base depot/zonal workshops.
ii. Recording details of failures.
iii. Recording assistance required.
iv. Obtaining next day's programme etc.
v. Communicating essential instructions from HQ to division/field units.

REPORTS AND DOCUMENTS:

I. T.M. ORGANIZATION'S REPORTS:
i. A daily performance report compiled by the Track Machine Control based on the information collected from all divisional engineering controllers/field staff. A register shall be maintained by Track Machine Control for serving as a "Master Record" for all relevant data.
ii. A daily report from the machine incharge to SEN incharge of field incorporating block details, performance, schedules done/overdue, consumables/spares used, repair and failure, shall be made out and submitted every ten days.
iii. The machine incharge will submit a report to Dy. CE/SEN incharge on every breakdown of the machine resulting in failures exceeding half an hour on the proforma.
iv. Monthly Appreciation reports from the machine incharge on performance furnishing:

a. Number of days worked
b. Number of days no t worked with reasons
c. Blocks availed
d. Target
e. Output
f. Reasons for less output
g. Other remarks
h. Consumables/spares used and cost thereof
i. Failures/repairs with spares and cost particulars

v. A summarized monthly performance report from SEN/AEN/MC (line) showing schedules of inspections done, health of machine, failure analysis, adequacy of allied track works etc of the machines under their control to Headquarter/Dy. CE/CE (Machines).

vi. A summary of availability of each machine for a period of 3 years shall be maintained at the machine and Zonal Depot showing at a glance the availability, breakdowns, schedule repairs and POH of machine.

II. DIVISIONAL REPORTS:

i. A daily report from the P.Way incharge to the Divisional Engineering Control giving the following details:
   a. Block details
   b. Output kms
   c. Ineffective time
   d. Remarks on quality of work

ii. A monthly report giving
   a. Details of blocks availed
   b. Output
   c. Reasons for deficiencies etc.

   shall be prepared by the Divisional Engineer incharge of the section.

iii. A monthly joint report from the Section Engineer incharge of the section and the machine incharge furnishing the details of work done by the respective machine shall be sent to SEN/MC and Sr. DENs concerned.

iv. A monthly joint report signed by Sr. DEN and Sr. DOM should be submitted to CTE (Machines) giving position of blocks demanded, the blocks actually made available and the blocks actually utilized.

MONITORING SYSTEMS:

Monitoring of machine work involves the aspects of the following:

- Performance
- Failure
- Consumption of oils and consumables
- Consumption of spares
- Cost of machine working and financial control
- Tamping cycle

UNIT COST:

PROCEDURE FOR CALCULATING UNIT COST:

i. The unit cost of working shall be calculated taking capital recovery factor with interest rate of 12% from the tables in Annexure-C of Indian Railways Finance Code (1982 edition).

ii. Life of the machine in terms of gross units of work done, unit cost of the machine, weightage for different types of machines for proportionate distribution of overheads on technical and general supervision and works units between IOHs.

iii. The life of machines has been given in terms of kilometers. This divided by annual output will be the life of machine in years. The maximum life should be limited to 15 years.

iv. The proportionate expenditure on IOH/POH should be as follows:

$$\frac{4 \text{ X cost of IOH + Cost of POH}}{15}$$

v. Unit cost of working for different machines shall be worked out for every financial year.

UNIT COST OF TAMPING DONE BY CSM:

1. **DATA**

Initial cost of the machine	:	Rs. 3.1 crores
Rate of interest	:	12%
Life of machine	:	7500 kms
Expenditure on IOH (at 1200 kms)	:	Rs. 15 lakhs
Expenditure on POH (at 3750 kms)	:	Rs. 30 lakhs
Expenditure on annual machine maintenance.		
Ø Spares (actual)	:	Rs. 3.0 lakhs
Ø Staff (actual)	:	Rs. 0.7 lakh
Expenditure on annual machine operation		
Ø Consumables	:	Rs. 2 lakhs
Ø Staff	:	Rs. 2.6 lakhs
Overheads (Proportionate)	:	Rs. 1.2 lakhs

2. ANNUAL COST OF WORKING

Ø Actual tamping done in the year	:	500 kms
Ø Life of machine (7500/500)	:	15 years
Ø CRF (Capital Recovery Factor)	:	0.14682
Capital recovery	:	Rs. 45,51,420
Proportional expenditure on IOH/POH $\frac{(4 \text{ X } 15 + 30)}{15}$ lakhs	:	Rs. 6,00,000
Annual maintenance expenditure	:	Rs. 3,70,000
Operation expenditure	:	Rs. 4,60,000
Overheads	:	Rs. 1,20,000
	:	Rs. 61,01,420

3. UNIT COST OF TAMPING (= $\frac{61,01,420}{500}$) : RS. 12,203/KM.

SUB DESCIPLINE – IRTMM (LESSONS – 1 SESSIONS - 3)

Lesson-I : Introduction to IRTMM and RDSO TM Reports **Session-55:** Brief on other Chapters of IRTMM and RDSO TM Reports.

BRIEF ON OTHER CHAPTERS OF IRTMM:

CHAPTER-6: PERIODICAL REPAIR AND MAINTENANCE OF MACHINES:

This chapter deals with types of maintenance schedules, types of workshops, central periodical over hauling workshop (CPOH), intermediate overhauling workishop/zonal base depot, satellite depot, mobile workshop-cum-transport van and camp coach workshop.

CHAPTER-7: DUTIES OF DIVISIONAL OFFICERS AND STAFF INCHARGE OF P.WAY:

This chapter deals with the duties of incharge SSE/SE/JE (P.Way), duties of Assistant Engineer (Open Line) and duties of Sr. DEN/DEN.

CHAPTER-8: STAFF REQUIREMENT AND OTHER INFRASTRUCTURAL FACILITIES:

This chapter deals with the requirement of staff for machine working, training of track machine personnel and other infrastructural facilities such as storage & carrieage facilities for fuel and oil, transport of spare parts, communication facilities, etc.

CHAPTER-9: STORES: This chapter deals with store depot, inventory control, procedure for procurement of materials, procedure regarding approved suppliers of indigenous spares, procedure for inspection and acceptance of materials, cash imprest, emergency purchase, purchase of items for which DG S&D rate contract exists, purchase of items through running rate contract, annual maintenance contracts, other modes of repairs through contracts and inventory management.

LIST OF TM REPORT ISSUED BY RDSO UPTO 30.06.2009

S. No.	Name of Machines	Maintenance Schedule		Inspection Check List		Trouble Shooting	
		Report No.	Date of Issue	TM Report No.	Date of issue	TM Report No.	Date of issue
1	09-CSM	TM-69(F)	22/27.07.04	TM-74(F)	10.12.04	TM-62(F)	10.03.04
2.	Unimat	TM-80(F)	01.03.05	TM-71(F)	2/6.09.04	TM-99(F)	31.03.2006
3	BCM	TM-77(F)	18.01.05	TM-73(F)	4/8.11.04	TM-42(F)	30/31.01.02
4.	FRM-80	TM-79(F)	22.02.05	TM-91(F)	21.09.05	**TM-47(P)**	30-7/2.08.02
5.	DGS	TM-90(F)	31.08.05	TM-92(F)	28-10/14.11.05	**TM-41(P)**	22.01.02
6.	**BRM**	TM-87(F)	20/28.06.05	TM-96(F)	01.02.06	TM-70(F)	29-7/5.8.04
7	T-28	TM-102(F)	23/31.08.06	TM-103(F)	11.10.06	TM-110(F)	26.04.07
8	PQRS	TM-101(F)	28.07.06	TM-108(F)	March-07	TM-128(P)	12/13.03.09
9	MP	TM-100(F)	30.06.06	TM-105(F)	06.12.06/ 27/28.12.06	Not issued	
10	DUO	TM-84(F)	13/17.05.05	TM-111(F)	29.06.07	TM-89(F)	18-7/30.08.05
11	UNO	TM-83(F)	06.05.05	TM-76(F)	22.12.04	TM-88(F)	14.07.05
12	TRT	TM-104(F)	31-10/ 13.11.06	TM-107(F)	23/27.02.07	TM-93(P)	Nov.-2005
13	09-3X	TM-85(F)	27/1-5/6.05	TM-106(F)	19/25.01.07	Not issued	

14	WST (08-32)	TM-130(F)	31/03 - 02/.04.09	TM-129(F)	March-2009	TM-117(F)	29-02/ 05.03.08
15	FRM-85	TM-119(P)	25.03/ 01.04.08	Draft	25/26-03. 08	Not issued	
16	UTV	TM-121(F)	21.07.08	TM-127(P)	6/12.02.09		

Note: ***F = FINAL***

P = PROVISIONAL

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

Lesson-I : Lining **Session-56:** Principle of Lining, Single chord system, Type of lining i.e. 4 Point & 3 Point lining.

PRINCIPLE OF LINING:

- Ø Machine measures only one rail and rectify that rail i.e. datum rail.
- Ø Other rail is fixed with the sleeper hence that is also rectified.
- Ø If there is a gauge problem that will remain there.
- Ø During alignment machine corrects versine.
- Ø The versine of straight track is zero and
- Ø Versine on curved track depends on radius of curves, measuring chord length and measurement method.

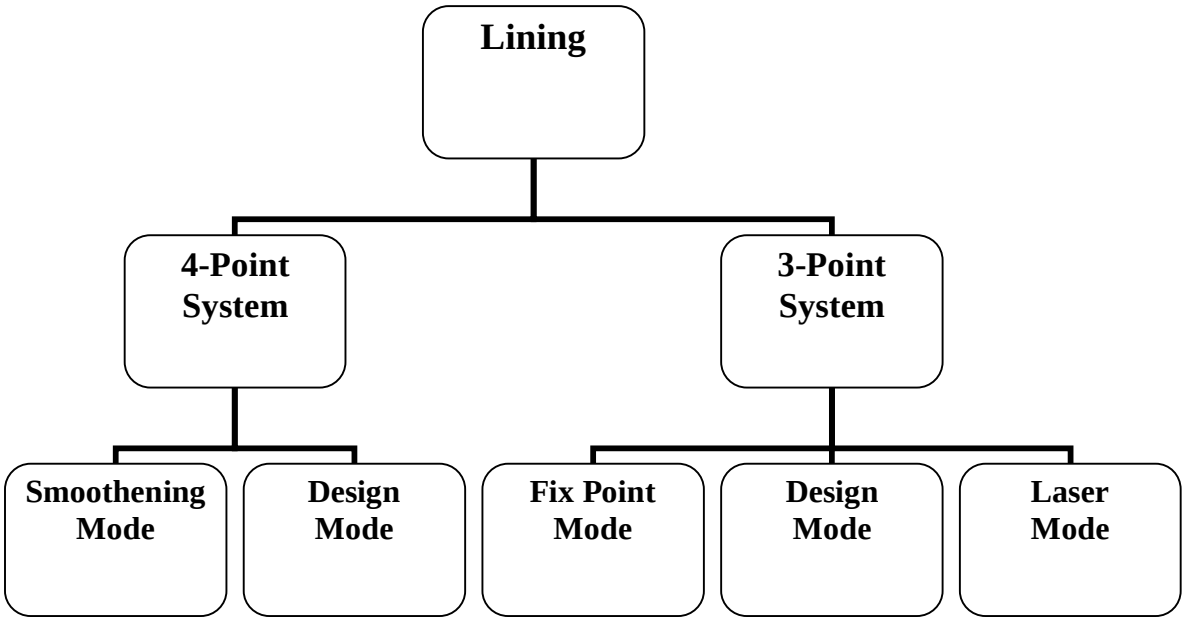
SINGLE CHORD SYSTEM:

On UT machine double chord lining system was used. In this system, two chords i.e. long chords and short chords was used for measuring the versine. But in single chord lining system, one chord is used to measure the versine. This system is used in all machine except UT.

TYPE OF LINING:

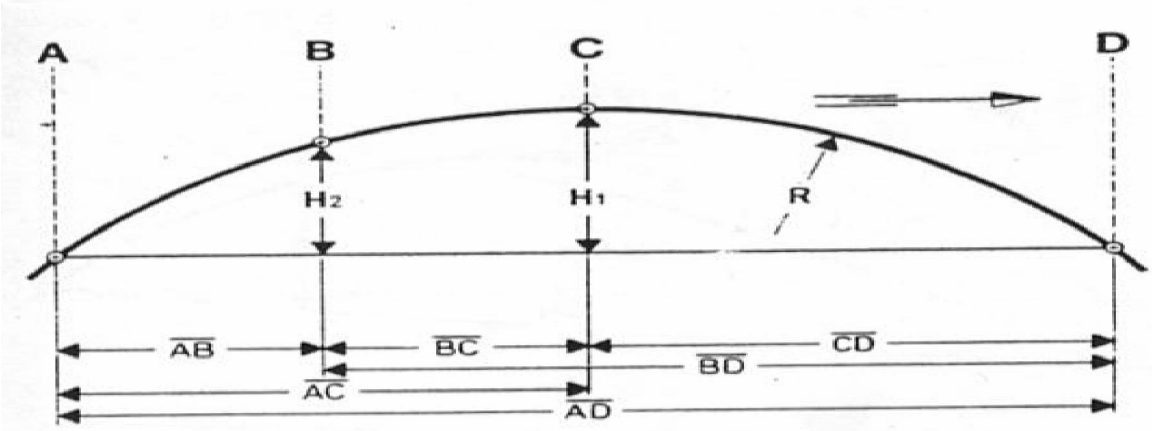
In single chord system there are two methods of lining.

.



FOUR POINT LINING SYSTEM:

- **GEOMETRICAL PRINCIPLE OF 4 - POINT LINING SYSTEM:**
  - In a circular curve, two Versines of a chord are related in a ratio, depending on the measuring point distance. This Versine ratio is independent of the radius of the circular curve and is always constant. It is also valid for a straight, which may be considered as a curve with infinite radius. In 4 - point lining system, the track is measured at 4 points (A, B, C & D) and Versines at two points are compared (B & C) to control the lining. The existing errors are reduced or eliminated by means of the Hydraulic Lining System.



From the above figure,

Existing Versine $H_1 = \frac{AC \times CD}{2R}$

Theoretical Versine $H_2 = \frac{AB \times BD}{2R}$

Versine Ratio $i = \frac{H_1}{H_2} = \frac{AC \times CD}{AB \times BD}$

$H_1 = i \times H_2$

- Hence, lining is done at Point C until Versine H_1 is in the correct ratio to H_2 ($H_1 = i \times H_2$) at Point B. **Versine Ratio 'i value' for different machines, is as under:**

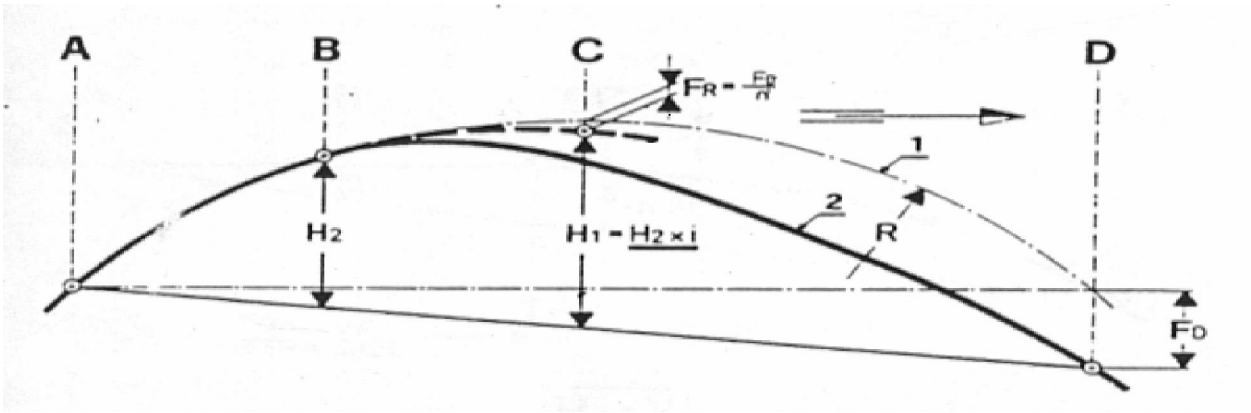
Machine	i Value
• **08-UNO-DUO**	**= 1.33**
• **08-275 UNIMAT**	**= 1.35897**
• **08-275-3S**	**= 1.62241**
• **MP-2000**	**= 1.395122**
• **WST**	**= 1.3292**
• **09-32 CSM**	**= 1.2157**
• **09-3X TAMPING EXPRESS**	**= 1.507**

- The points A & B always remain on the corrected track and the Versine H_2 at Point B represents the measuring base. Point D always remains on the disturbed track. Lining is done at Point C. H_2 and H_1 are separately measured by measuring and lining bogies of the machine, respectively. H_2 is fed in PCB where it is multiplied with constant i and becomes "$H_2 \times i$". Thus $H_2 \times i$ and H_1 are then fed in difference amplifier and if the alignment is OK both will be equal and reading on the dial will indicate zero. If alignment is not OK, the difference of the two will be indicated on the dial as well as the current will flow to lining solenoids, the alignment will be corrected till both $H_2 \times i$ and H_1 are equal or the ratio $H_1 / H_2 = i$, is maintained. **The schematic diagram is as under**:

ERROR = THEORATICAL VERSINE (H_2) ~ EXISTING VERSINE (H_1)

CALCULATED BY PCB MEASURING TRANSDUCER LINING TRANSDUCER

- **ERROR REDUCTION ACCORDING TO THE 4 - POINT LINING SYSTEM:**



Ideal line = 1 **Before lining = 2** **After lining = 3**

- In the above figure, Points A & B are on the already lined track behind the machine. The front end of the chord, Point D is on the disturbed position with lining error $\mathbf{F_D}$, resulting in new Versine H_2. Point C is now lined until H_1 is in the correct ratio to H_2. Depending on the measuring point distances (**Error reduction ratio 'n'**), an error remains at lining Point C, which is called **Left over error or Residual error 'F_R'**.

Error reducing ratio, n		=	**AD x BD / AC x BC**	
Left over error	**F_R**	=	**F_D / n**	
For 08-Machine	**F_R**	=	**F_D / 6**	**n = (20 x 15) / (10 x 5) = 6**

- **n depends on Bogie distances, which is as under for different machines:**

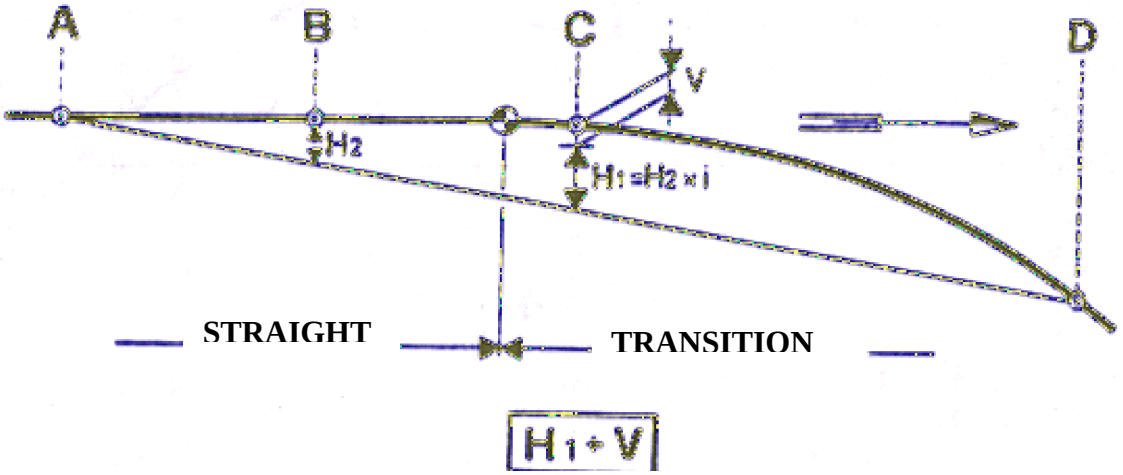
Machine	**n - value**
08-UNO/DUO	**= 6**
08-275 UNIMAT	**= 6.42720**
08-275 UNIMAT	**= 7.61997**
08-32 WST	**= 5.7411**
9-32 CSM	**= 6.27692**
09-3X TAMPING EXPRESS	**= 6.47**

- This error reduction ratio is valid under the presumption that the Points A and B are on the perfect alignment. Proceeding with further lining, points A and B are positioned at the remaining errors and determine therefore a new base for the following measuring and lining operation. These errors are reduced and adapted to another which results in a considerable improvement of the alignment.

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

Lesson-I : Lining **Session-58:**Calculation of V_m value on Transition Curve, Direction of Toggle switch.

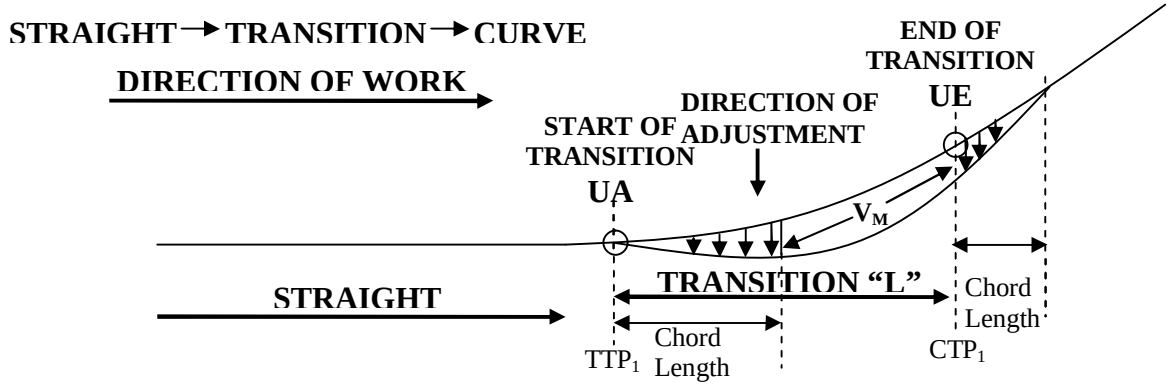
VERSINE COMPENSATION VALUE (V_m) FOR VARIABLE VERSINE: The constant Versine ratio is only valid for tracks with the constant curvature e.g. circular curve, straight. But when there is change in curvature (variable Versine), the Versine ratio is adapted to the curvature by input of correction values called Versine Compensation (V) values. Generally, the V values are fed manually to the Versine Potentiometer in the front tower. With the provision of GVA/ALC, V values are calculated automatically and fed in the Lining system. The cut off zero point of the Versine H_1 is corrected accordingly. As an example, let us



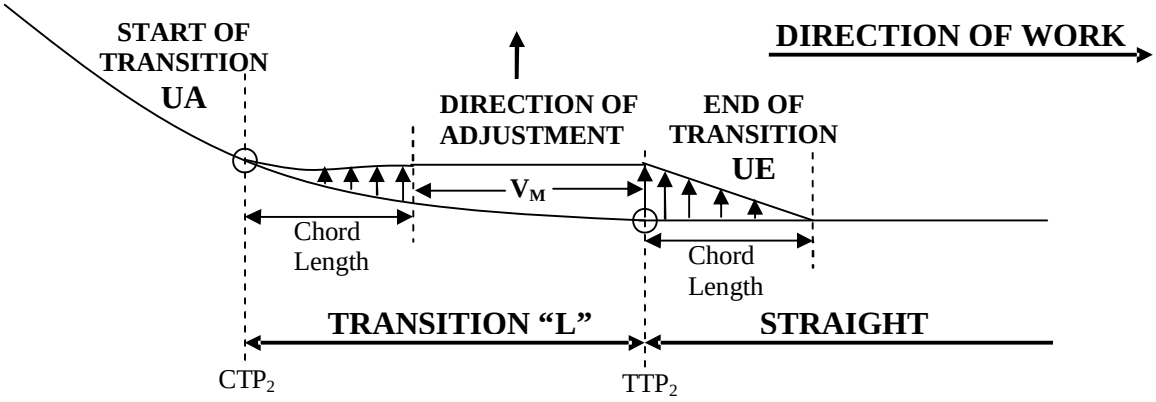
consider a case of the

machine entering from straight to transition.

In the position of the machine shown in the above figure, Machine measures the Versine H2 at the measuring bogie and the Versine H_1 at the lining bogie. Had the machine been on a circular curve the relationship $H_1 = i \times H_2$ would have been true, but because of the changing curvature, we actually have $H_1 = i \times H_2 \pm V$. Therefore, even though the curvature of the transition is true the machine still experiences an error V. Therefore, we have to apply some adjustment at the lining bogie to compensate for V. **The prcedure of applying V values and direction of toggle switch for different situations is given below:**



CURVE → TRANSITION → STRAIGHT



DIRECTION OF TOGGLE SWITCH:

IF MACHINE IS INTERING:

(i) High radius to low radius = outside

(ii) Low radius to high radius = inside

CALCULATION OF V_M VALUE ON REVERSE CURVE:

For the reverse curve or compound curve the value of V is decided as under:
Say R_1 & R_2 are the radius of the two curves and V_1 & V_2 are the corresponding adjustment for the individual curve (page no. 4 & 5)

1. If the R_1 is bigger that R_2, the net adjustment, V_0 will be $V_0 = V_2-V_1$ or $V_{0m} = V_{2m}-V_m$,
2. The applicable of adjustment will start as soon as the front tightening starts entering the transition.

- **Calculation of Vm**
  - Readymade tables are given on each machine.
  - Vm value may be calculated by following formula:

Vm = Constant Value / (Radius x Transition Length)

  - Constant value depends on Machine Chord length as under:

Machine	**Constant value**
08-UNO/DUO	**83000**
CSM	**82485**
UNIMAT 2S	**88333**
UNIMAT 3S	**116603**
WST	**84000**

- **Direction of Compensation**
  - Toggle switch is given in front cabin to decide compensation direction as under:

High radius to low radius = Toggle switch outside +ve
Low radius to high radius = Toggle switch inside –ve

This during coco king 1/6 of the error will be left and therefore it is called smoothening lining of some procedure is available with which it is possible to give exact location of various points like beginning & end of transition and amount of fault at a particular location established with some permanent works these, by shifting front and f the chord by the amount of fault. We can achieve exact alignment.But in the field it is difficult to obtain correct reference marks as such generally smoothing system is adopted which is fairly accurate for smooth running of trains.
If we are tamping constructed line we can always, lay a parallel reference line from which difference can be calculated for feeding into the machine to achieve exact alignment.

NON-SUITABILITY OF 4-POINT LINING ON STRAIGHT:

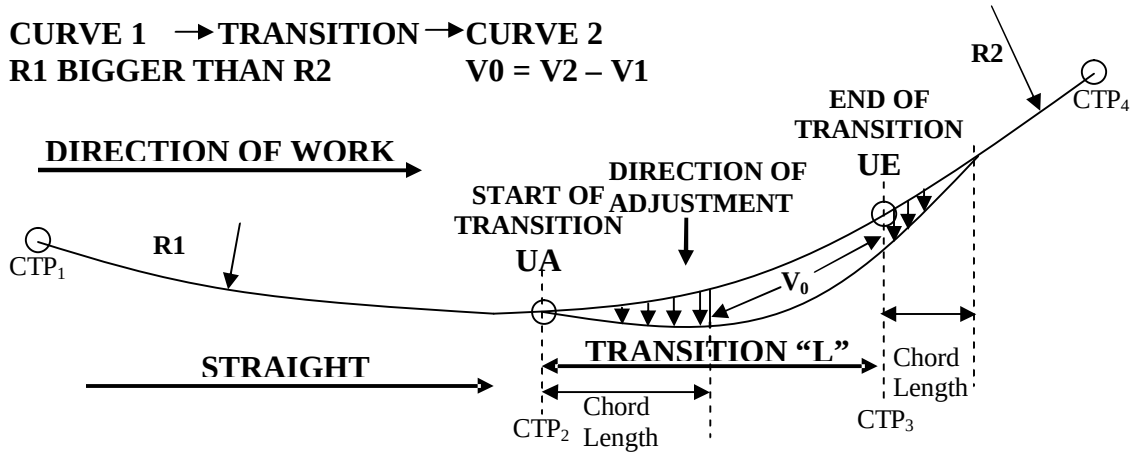
On Straight Track H_2 is zero hence machine corrects versine at C with respect to H2 as
H1 = 1.33 x 0 = 0
If at any point F_D = 12mm
then FR = F_D/6 i.e. 12/6 = 2mm.
On next sleepers H_2 = 2mm
H1 = 1.33 x 2 = 2.66m
again H_2 = 2.66mm\
then H1 = 1.33 x 2.66 = 3.53
As per above calculation if machine is leaving any error that will again accumulates. Hence machine forms a false curve. Therefore 4 point is not suitable for straight track.

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

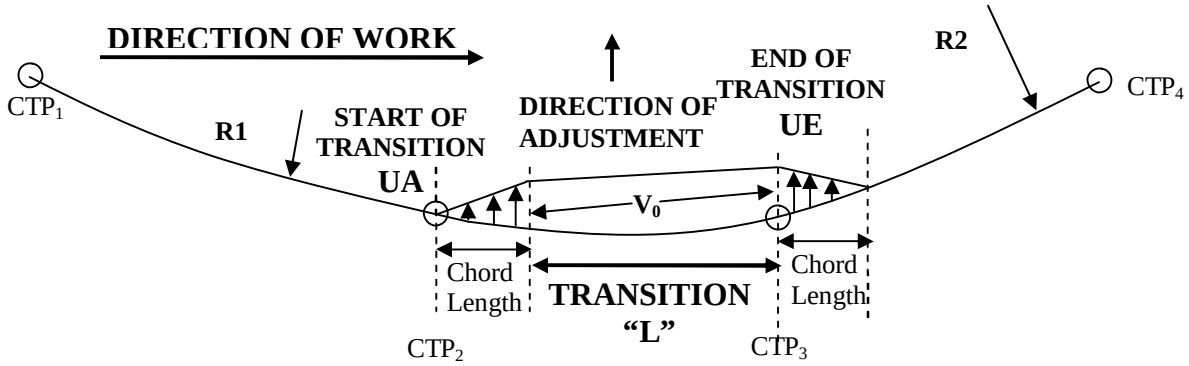
Lesson-I :Lining **Session-60:** Feeding method of Vm value at Reverse and Compound curve.

FEEDING METHOD OF V_M VALUE AT REVERSE AND COMPOUND CURVE:

CURVE 1 → TRANSITION → CURVE 2
R1 BIGGER THAN R2 V0 = V2 – V1

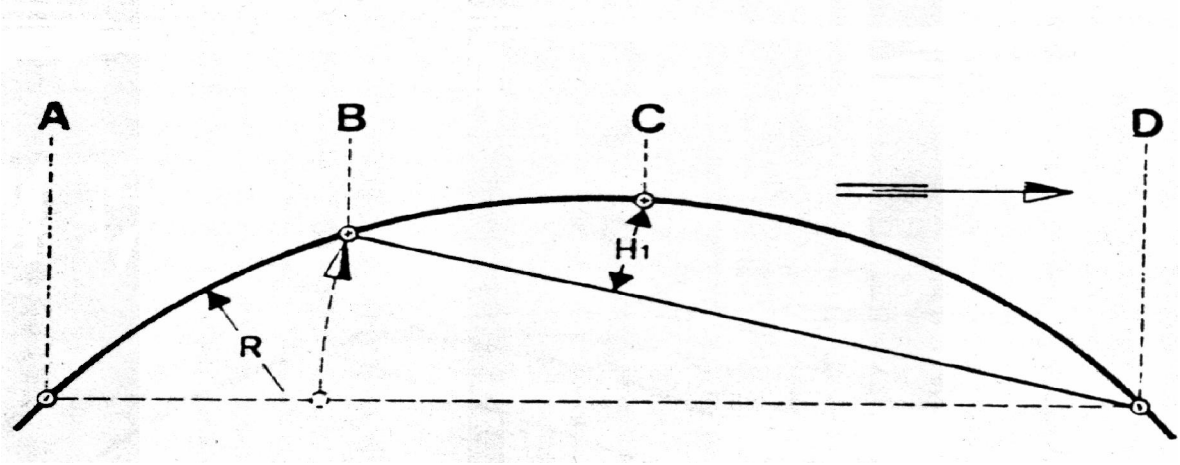


CURVE 1 → TRANSITION → CURVE 2
R1 SMALLER THAN R2 V0 = V1 – V2



THREE POINT LINING SYSTEM:

- **GEOMETRICAL PRINCIPLE OF 3 - POINT LINING SYSTEM:**



H_1 = (BC x CD) / 2R

- The Versine H_2 at Point B is not measured. The track is measured at three points. The lining Versine H_1 at point C is specified according to the curvature. Lining commences until the Theoretical Versine H_1 is achieved. Using the 3-point system, the chord is generally fixed at point B, which results in a reduction of the distance A-B.

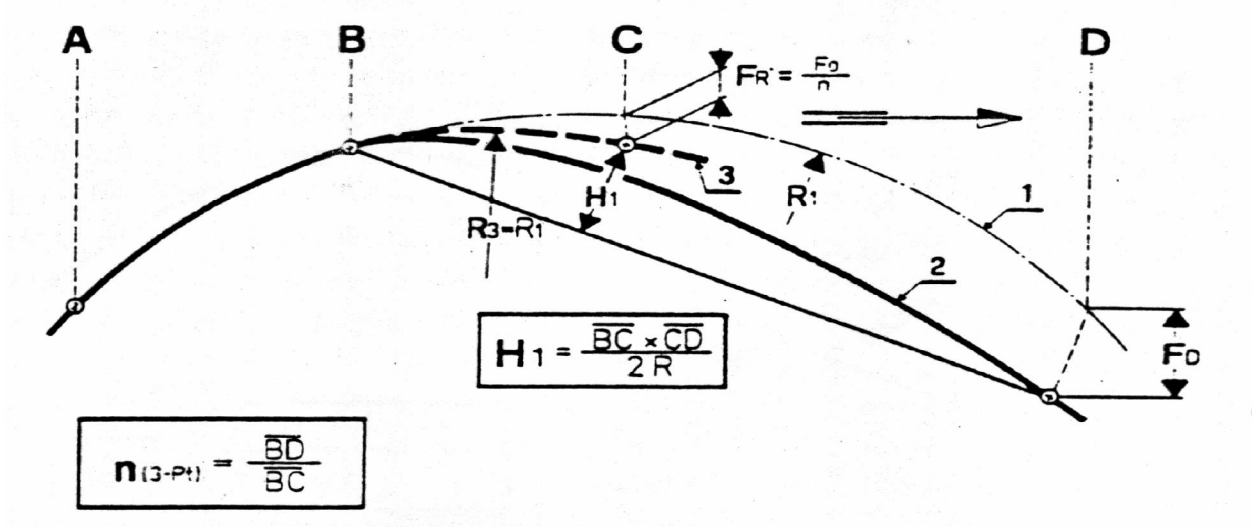
ERROR = THEORETICAL VERSINE – EXISTING VERSINE

CALCULATED BY PCB

FED BY MAN OR COMPUTER

MEASURED BY M/c

- **ERROR REDUCTION ACCORDING TO THE 3 - POINT LINING SYSTEM**



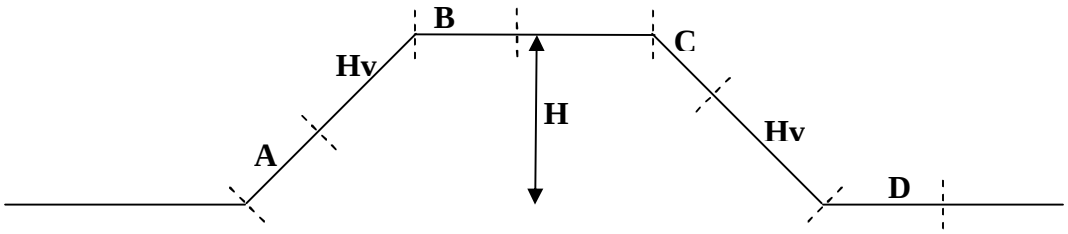
- Point B is on the already lined track behind the machine. The front end of the chord, point D is at the lining error $\mathbf{F_D}$. Point C is lined until $\mathbf{H_1}$ corresponds with the specified Theoretical Versine. Specifying the Theortical Versine, $\mathbf{H_1}$ shifts Point C in a position which corresponds with the required radius R. The remaining error $\mathbf{F_R = F_D / n}$, is a result of the ratio of the measuring point distances. Proceeding with the lining, Point B is at the remaining error and influences therefore the next measurement.
- **$n_{(3- Pt)}$ - value for different machines is as under:**

Machine	**$n_{(3- Pt)}$ - value**
8-UNO/DUO	**= 3**
08-275 UNIMAT	**= 3.12**
08-275 UNIMAT -3S	**= 3.297**
08-32 WST	**= 2.91**
09-32 CSM	**= 3.138**
9-3X TAMPING EXPRESS	**= 3.04**

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

Lesson-I :Lining **Session-62:** Calculation of 'V' value for each machine.

FOR CSM IN 3-POINT LINING VERSINE FOR SECTIONS A, B, C AND D IN TRANSITION CURVES WITH STRAIGHT CURVATURE								HV = 23617 / R X L HV = 23617 / R	
Constant sections A & C	0	425	3399	11417	27191	53107	90534	135455	153120
R = XL =									
Meter after OA/OE	TP/CTP UA/UE	2	4	6	8	10	12	14	14.75
Versine in curve H = BC X CD / 2R									
Versine section A = Constant / R X L									
Versine section C = H - A									
Constant sections B & D	195238	148428	104167	65004	33489	12170	2362	48	0
R = XL =									
Meter after OA/OE	TP/CTP UA/UE	2	4	6	8	10	12	14	14.75
Versine in curve H = BC X CD / 2R									
Versine section A = Constant / R X L									
Versine section C = H - A									



A=B=C=D=14.75 M

Step 1: Calculate the value of H (as above chart).
Step 2: Calculate versine value of sections A, B, C & D (as above chart).
Step 3: For the calculation of 'Hv' value there are two methods:
Method 1: $HV = \frac{\text{CONSTANT}}{R \times L}$ mm/metre
Method 2: $\frac{\text{Versine at starting of B – Versine at the end of A}}{\text{Transition length – machine chord length}}$ mm/metre

Step 4: The calculation of versine is for two metres interval as above. This may be divided for alternate sleeper.

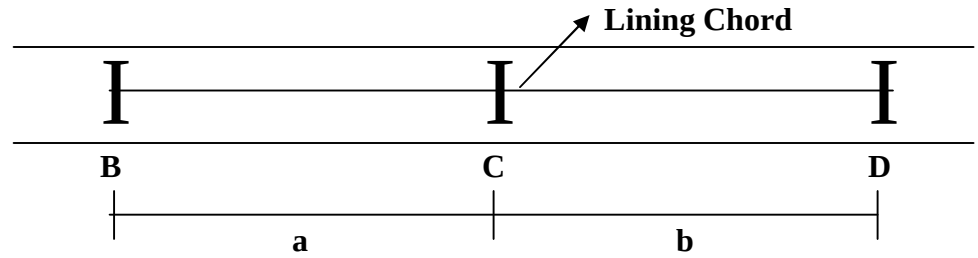
SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

Lesson-I :Lining **Session-64:** Design lining, Laser lining and measuring run method.

- Maintenance of track geometry to desired parameter is very important for the safe and smooth running of trains. Track machines have facilities of measurement and rectification of track defects for achieving design geometry. 5 CSMs & all 3x machines are also equipped with Automatic Guide Computer (ALC) for track geometry measurement and LASER Sighting System (LSS) for lining besides other features for design tamping. However, only few machines are working in design mode mainly due to the inadequate knowledge of field staff. On NCR, there is not much problem of leveling due to stable formation and good initial laying. Hence, this Circular is to enrich knowledge of Design lining among field staff. Smoothening mode lining details are also given in **Annexure-I**.

DESIGN LINING

- Modern Track Machine always corrects Versine during Alignment correction using single chord. Machine measures only one rail i.e. Datum rail and rectify it. Other rail is fixed with the sleeper, hence that is also rectified. Four trolleys are provided for alignment measurement. In design lining, only three trolleys are used. The trolleys are pneumatically pressed against Datum rail and transducer provided on lining trolley measures offset of alignment at C i.e. distance between lining chord and center of lining trolley. After measuring the offset, track is slewed so much that specified Versine is achieved at lining trolley, which is zero for straight track and certain value on curved track.

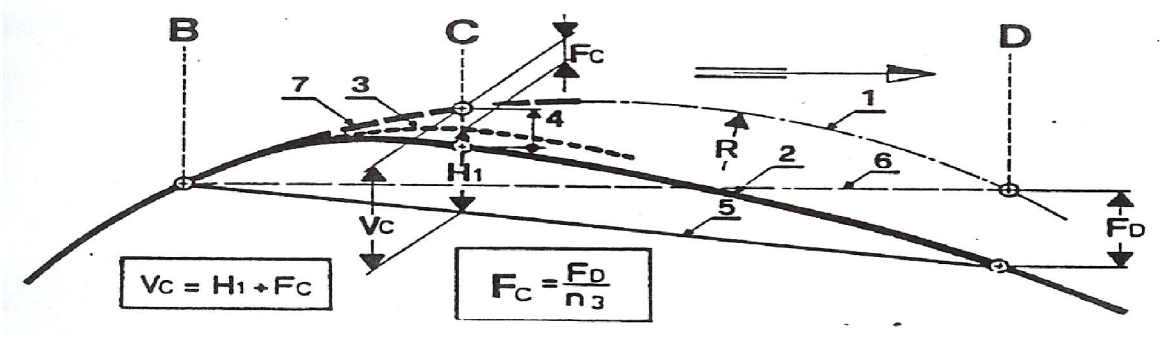


B = Measuring trolley C = Lining trolley D = Front tightening trolley

- In the lining process Front trolley always remains on disturbed track and Measuring trolley always remains on corrected track. Because of misalignment in track at front trolley, front end of the chord will be out of its correct position equal to the alignment defect at that point. Due to incorrect position of the front end proportional alignment error will remain after lining. **Left over error at C, $F_R = F_D/n_{(3\text{-}Pt)}$, where F_D = Lining offset at front trolley and $n_{(3\text{-}Pt)}$ = BD/BC = (a+b)/a**.

- **GEOMETRICAL PRINCIPLE OF 3 - POINT DESIGN LINING SYSTEM:**

  1 = Perfect alignment 2 = Before lining 3 = After lining without error input
  4 = Lining Value 5 = Actual position of the lining chord
  6 = Theoretical position of the lining chord 7 = After lining with error input



- For a perfect alignment of the track according to fixed points, the existing error **F_D**, which is measured at the front end of the chord, is adjusted to the opposite direction, and is automatically and in the right proportion transmitted to the lining Versine by means of the lining control. Thus, the lining error is transmitted, relatively reduced, to the cut off point on the lining trolley C. Therefore radius and angular position are corrected perfectly. In design lining this error is eliminated by shifting front end of the chord equal to alignment defect at that point. In Modern Track Machine, proportional electric signals are relayed through Lining PCB to lining unit and track is lined accordingly.

Slew at C = Specified Theoretical Versine at C ~ (Lining offset measured by transducer at C + Proportional signals corresponding to lining offset at D)

= H ~ (H_1 + F_C) where $F_C = F_D / n_{(3\text{-}Pt)}$ and Left over error F_R = Zero

- **DETERMINATION AND ADJUSTMENT OF LINING ERRORS:**

  - **MANUAL SYSTEM:**

  - **Surveying Design Lining Offset By Long Chord:**

  - In terms of Guidelines on 'Survey for Alignment Correction' as contained in Item No. 6.0 of Ann 5.3 to IRTMM, the lining errors are to be determined by measuring offsets at every 5 m intervals on 40 m chord on straight track and at every 10 m intervals on 20 m chord on curves track and marked on the track. The required slew at every alternate sleeper is worked out by interpolating the offsets, taking note of the obligatory points and ensuring that there are no infringements to moving dimensions. The slews are then marked on alternate sleepers. During the lining operation these values are transmitted to the lining value adjustment. **An example on Field measurement for design lining offset by long chord is given in Annexure-II.**

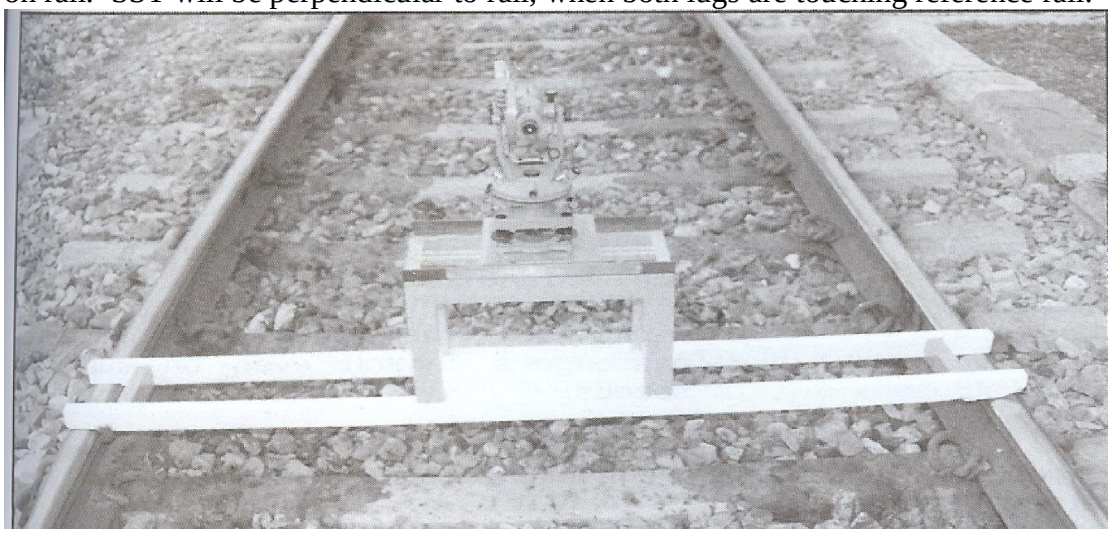
  - **Surveying Design Lining Offset By Theodolite:**

  - The long-wave track geometry faults become significant with the increase in speed of trains. Assuming the typical natural frequency of vehicular oscillation to be 1 Hz, the critical track geometry fault wavelength even in speed range upto 160km/h is upward of 40 m. While working on straight track, the most preferable chord length for alignment correction is in the order of 60 – 80 m.

  - For achieving such chord length, if the Theodolite with the standard tripod stand is used it takes about 10-12 minutes for centering, leveling and measurements. In the saturated high density routes, so much time is not available and whenever a train

approaches, the Theodolite is required to be removed and reset. It is even difficult to ensure verticality of Ranging rod at target.

- **For making it more practicable, fast and efficient, some specially designed gadgets, as given below may be developed, which makes the direct slew measurement with Theodolite quite easy. Using these gadgets, a chord of upto 1 km may be taken between 2 good points, which is the line of collimation of Theodolite at a fixed lateral distance from gauge face of reference rail of existing track and the slew measurements at every 5 m intervals are directly measured on specially designed Satellite with reference to the line of collimation. The equipments and specially designed gadgets used are as under:**
  - **Theodolite:** Normal Theodolite.
  - **Scaled Sliding Table:** It may be made of wood or metal with 1.85 m Length and 0.45 m Height. On upper side, one horizontal graduated table is fixed in which a plate is mounted on which Theodolite slides laterally to keep it at any required lateral distance from the reference rail. A lug is provided similar to that provided in gauge-cum-level. Touching Hook is on left side of the sliding table stand to bypass the burr on rail. SST will be perpendicular to rail, when both lugs are touching reference rail.



  - **Satellite:** It may be prepared from existing gauge-cum-level. In middle portion of the vertical face towards Theodolite, a teethed scale made of luminous red strip is pasted for a length 20 cm either side of zero (centre) point. The height of triangular teeth is 10 mm and distance between the two apexes of teeth is 10mm. This is further divided into 5 equal parts by 4 nos. of black horizontal lines to give a least count of 1 mm. ***Alternatively, the Satellite may be made like the Target described below with a movable vertical arm of length 30 cm and height 45 cm in 'reverse T shape' ⊥, painted white with a black vertical central line pointer towards Theodolite and a Satellite scale (30 cm Steel scale with Least Count – 1mm) on the upper side at either ends starting at 15 cm distance from the centre point on which the vertical arm slides laterally. During survey, this movable vertical arm is sighted and brought in line with the alignment of line of collimation of Theodolite and Target. The shifting of movable vertical arm from centre point is read from Satellite scale and deviation is directly recorded as slew at that point.***
  - **Target:** It may be made of wood. One end of its horizontal board ensures reference rail contact and zero point has a **fixed vertical pointer** of 0.75 m height painted white and has got a red vertical central line passing through zero point towards Theodolite.

- **VHP Sets:** One each at Theodolite, Satellite and Target i.e. total 3 Nos.

- **Method of Working:**

  - **Preliminary Works:**

    - a) Marking of stations at 5 m apart at the centre of track.
    - b) Selecting good point at about ½ to 1 km apart. These good points should have their position in the mean alignment of the existing track.

  - **Slew Recording:**

    - **Step 1 –** Check squaring of SST with reference rail by touching it's both the notches on gauge face.
    - **Step 2 –** Set the Sliding table at zero point, place Theodolite and level it.
    - **Step 3 –** Sight the Target and fix the line of collimation.
    - **Step 4 –** With the alignment of line of collimation, read deviation at Satellite scale by seeing through telescope of Theodolite.
    - **Step 5 –** Take and record deviations of subsequent stations till the readings are visible with the telescope of Theodolite.
    - **Step 6 –** Leaving satellite on last recorded station, SST is shifted on second last recorded station.
    - **Step 7 –** Slide SST as per slew reading of the station on which it is shifted, place Theodolite, level it at site the target again so that initial line of collimation is maintained for further measurement of slews. Repeat the steps till Slews of each stations at 5 m apart are recorded for full length.

  - **An example on Field measurement for design lining offset by Theodolite is given in Annexure-II.**

- **LASER SIGHTING SYSTEM:**

- 5 CSMs and all 3x machines are provided with a LASER Sighting System (LSS) that can be used to extend the measuring system on straight track. LASER lining is used on straight track in 3-point mode to remove long misalignment or false curve. The LASER system consists of LASER gun (transmitter) and LASER receiver. The LASER trolley which consists of laser gun is placed in front of the machine up to 300 m away. The receiver mounted on the front tightening trolley is adjustable so that it follows the

LASER beam and the position is detected by a transducer that provides an input to the lining system equivalent to the offset of the front of the chord. As the machine is working it moves up to the LASER trolley until the distance is a minimum of 20 m away. LASER system operates fully automatically and is able to cope with distances of up to 300 m. But LASER lining is only applicable for straight track. Important details are given below:

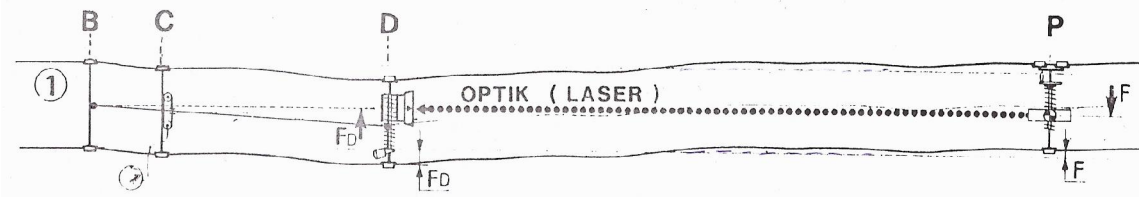
- By means of a special device, the LASER beam is fanned vertically in such a way that, the eventual change in track height has no influence on the system.

- By means of an automatic follow up control, the LASER receiver is always positioned at the centre of the LASER beam and therefore determines the input of the slewing values.

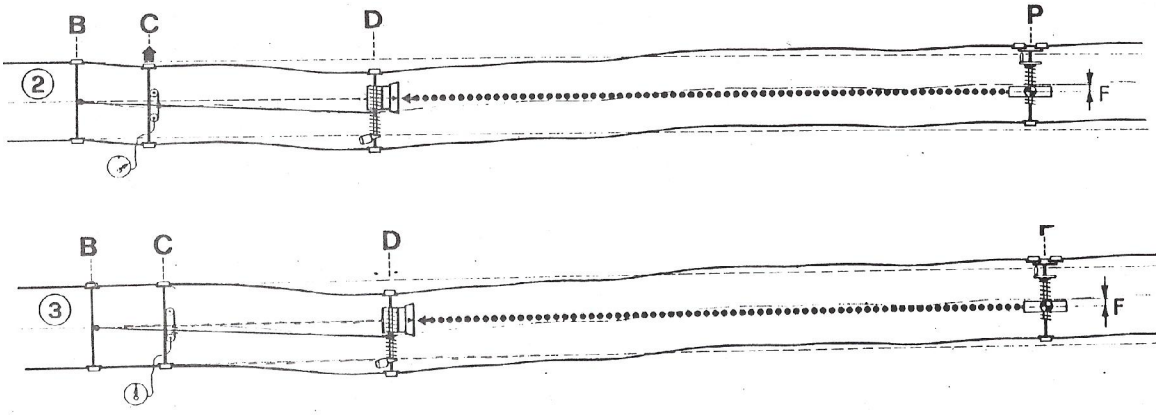
- The distance of the LASER gun from the machine is also dependent on the ambient conditions (rain, snow, fog, high ambient temperature). In good ambient conditions (clear, dry air) the lining distance can be extended considerably.

- **Working Sequence of Design Lining with the Laser Sighting System:**

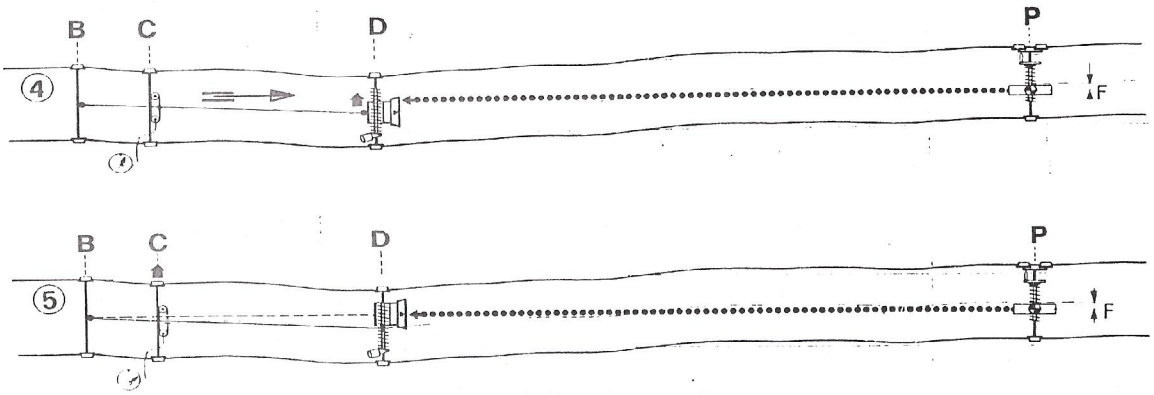
- **Phase 1**: When the design lining commences the front end of the chord with the LASER receiver is shifted by the amount of the error $\mathbf{F_D}$ in the direction of the THEORETICAL alignment, whereby the follow up control is switched off. If the lining errors exceed certain amount, a transition is necessary for the new alignment. LASER transmitter is positioned as far as possible from the machine, adjusted laterally over the amount of the lining error F, aimed at the LASER receiver and fixed in this position.



- **Phase 2 and 3**: The design is set; the follow-up control is switched on. The track is lined at point C and matches exactly with the line of sight.



- **Phase 4 and 5**: The machine drives forward and the front end of the chord is matched up again with the line of sight. The machine is ready for the next lining operation.



ANNEXURE-II

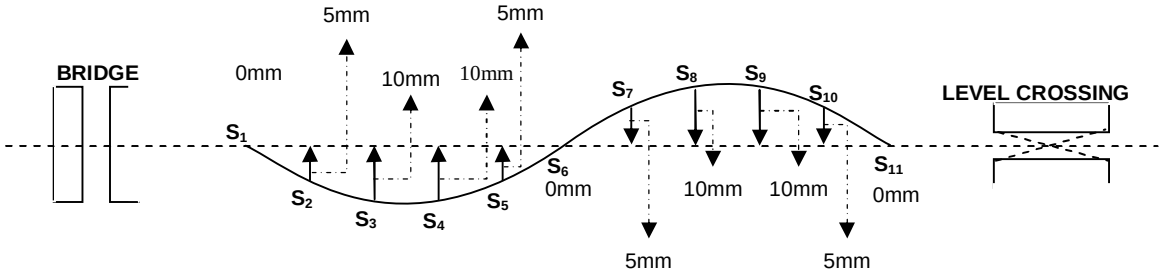
A. FIELD MEASUREMENT FOR DESIGN LINING OFFSET BY LONG CHORD

- **Surveying and Marking of Slews without any Infringement to SOD:**

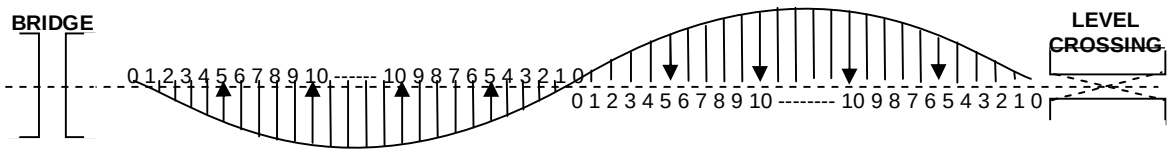
  Ø Surveying should be done between two good points, which may be on well maintained obligatory points i.e. girder bridges, level crossings, points & crossings, permanent structure etc, with the centre line of track on the design or original theoretical position.

  Ø In case of any shift in alignment of the centre line at obligatory points from the design or original position, the centre line must be brought to design or original theoretical position, manually for a minimum track length of 50m before surveying.

  Ø The lining errors are to be determined by measuring offsets at every 5 m intervals on 40 m chord on straight track and at every 10 m intervals on 20 m chord on curves track and marked on the track.

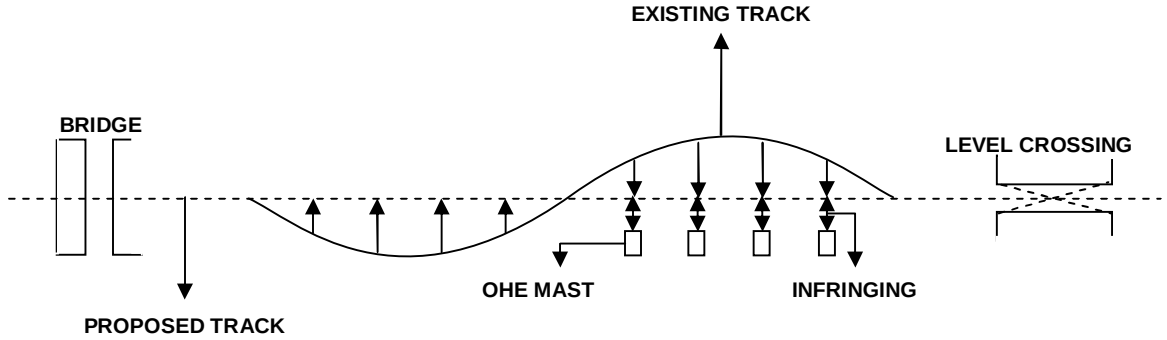


  Ø The required slew at every alternate sleeper is worked out by interpolating the offsets. The slews are then marked on alternate sleepers and Design tamping done by feeding the slew values to Slew Potentiometer in the Front tower.

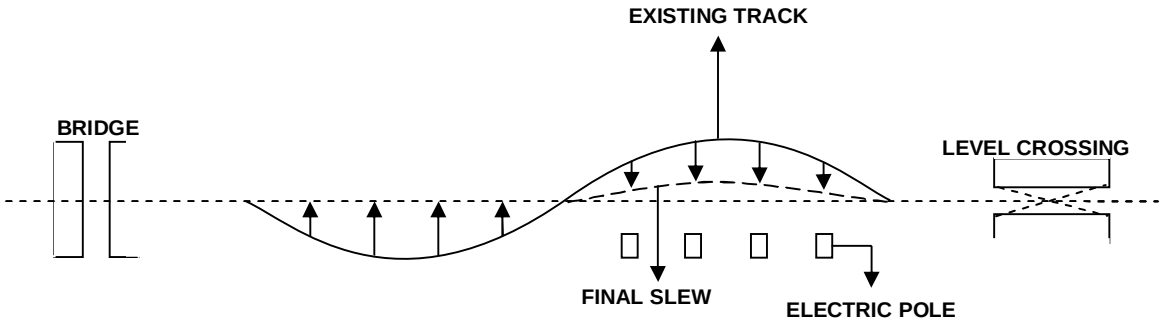


- **Surveying and Marking of Slews in case of Infringement to SOD:**

Ø If the required slew is infringing the SOD viz OHE Mast etc, the slew has to be worked out taking note of the obligatory points and ensuring that there are no infringements to moving dimensions as shown below.



Required Slew Values Infringing SOD



Final Slew Values With No SOD Infringement

Ø The final worked out slews are then marked on alternate sleepers and Design tamping done by feeding the slew values to Slew Potentiometer in the Front tower.

B. FIELD MEASUREMENT FOR DESIGN LINING OFFSET BY THEODOLITE

- **Surveying and Marking of Slews without any Infringement to SOD:**

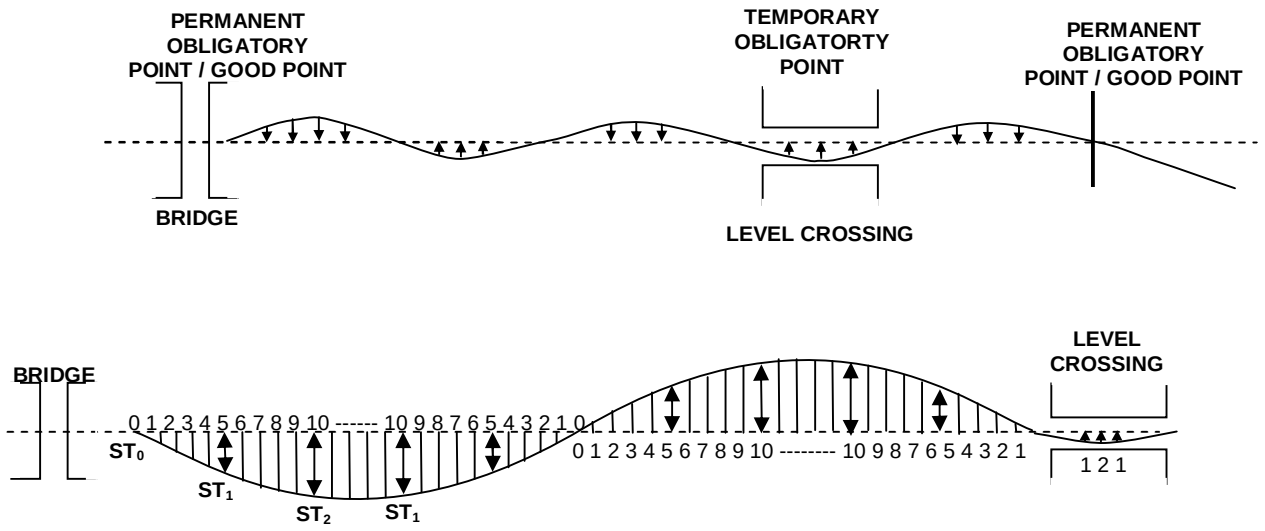
Ø Preliminary Works and Slew Recording Steps are already given in the Circular. However, the following procedure may be followed for Permanent (Girder Bridges, Fixed Structure etc.) and Temporary Obligatory points (Level crossings etc):

Ø In case of any shift in alignment of the centre line at Permanent obligatory points (Girder Bridges, Fixed Structure etc.)from the design or original theoretical position, the centre line must be brought to design or original theoretical position, manually for a minimum track length of 50m before selection of good points.

Ø Either the Permanent obligatory points or any other points at about ½ and 1 km apart having their position in the mean alignment of the existing track are taken as good points. Thereafter, the Working Method as given in the Circular is followed.

Ø Temporary Obligatory points (Level crossings etc) should be opened out and may be shifted to the extent possible after ensuring that there are no infringements to moving dimensions as shown below.

Ø Any shifting of Temporary Obligatory points should be approved by the ADEN.



MEASURING RUN METHOD:

ALC MEASURING METHOD:

The measuring method is used where the track data is not known. The data for the track is obtained via measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radius, etc. After computation by the "ALC" computer the tamper is set to work with the "ALC" automatically entering the computed lift and line data.

SEQUENCE OF OPERATION:

The machien can either measure in the working direction or the reverse. If the track is measured in the working direction, the tamping machine must reverse back to the start of the work site before commencing tamping. There is a "fast measuring drive" key switch on the front and rear driving desks. These enable the machine to use the second gear of the main drive to make the measuring run.

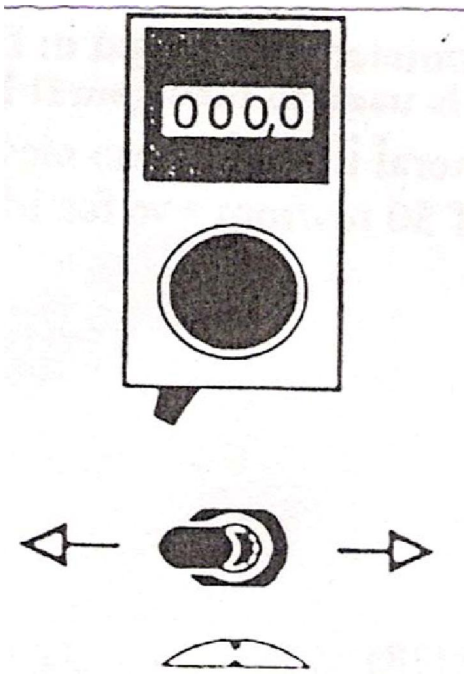
PERFORMING A MEASURING RUN:

Set up the machine for normal working, although there is not necessary to have the tamping banks running. The tamping banks slew switch on the B2 panel should be set to automatic. If it is on manual the fast measuring function will be disabled. It is advisable to drive the machine for a short distance using the normal working drive. Thus checking that the lifting and lining system is in working order before the start of the measuring run by avoiding errors at the start of the measuring run, due to poor bogie alignment or incorrect pre-loading. It is important to select the correct float rail. if the wrong rail is selected, the design for the lift will not be correct. It is also a good idea to mark the position of the machine on the rail before the start of the measuring run, so that the machine can be repositioned accurately at the start position after the measuring run has been completed (Forward measuring run). The lining system has to be set to 3-point. Use the can switch to select the datum rail for the longitudinal height recording. The reference rail for the versine recording is selected by turning on the lining system and selecting the required pre-load.

END OF MEASURING RUN:

At the end of the measuring run return the key switch to the normal position. The computer will automatically produce a "run in from" the old track geometry to the new target geometry at the beginning and end of the measuring run. The measuring run should therefore only cover the length of rail on which the work has to be carried out.

CALIBRATION OF VERSINE POTENTIOMETER(4f1):

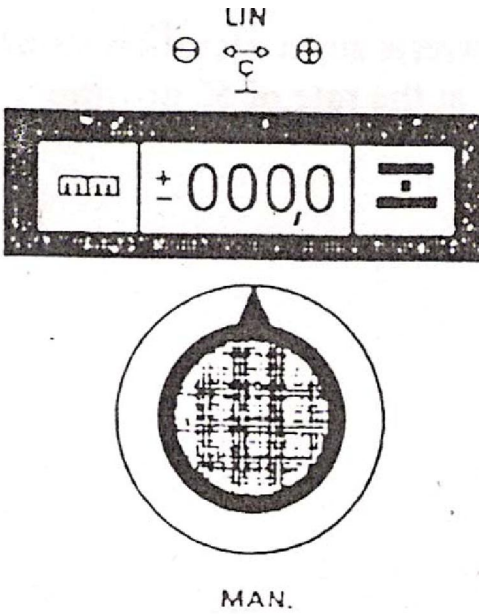


This potentiometer converts versine value to electrical signal at the rate of **50mv/mm +ve for RH side and –ve for LH side.**

For calibration of versine potentiometer select Multicheck address **F00**. Select "0" value in versine potentiometer then output voltage of versine potentiometer should be zero on display. If not , loose the screw of digital counter and take out the counter and now rotate shaft of potentiometer to get zero volt on display. Now set all digits to zero of counter then fit counter on shaft of potentiometer.When voltage of versine potentiometer is checked at multicheck address F00 then polarity will be –ve for RH and +ve for LH side.

Before starting calibration +10V & -10V to this potentiometer should be checked and adjusted by potentiometer P1 & P2 in EK 813SV of front input .

CALIBRATION OF SLEW POTENTIOMETER(4f4):



This potentiometer is provided in front cabin on panel B4.This potentiometer converts slew value to electrical signal at the rate of **50mv/mm** +ve for RH side and –ve for LH side.

For calibration of this potentiometer , keep slew potentiometer at zero position then output voltage should be zero, if not then take out the knob of potentiometer then rotate the shaft of potentiometer to get zero volt. Then by matching the knob at zero position fit on shaft of potentiometer. When voltage of slew potentiometer is checked at multicheck address **F06** then polarity will be –ve for RH and +ve for LH side.

Before starting calibration +10V and –10V should be checked . If there is any variation then adjust by P1 & P2 in EK813SV of front input .

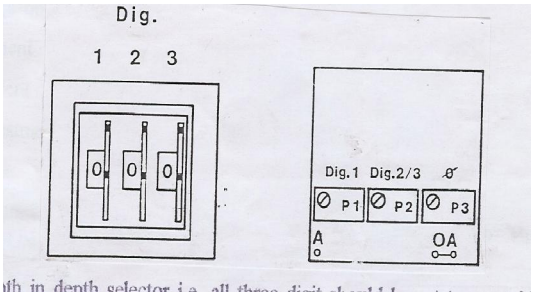
GENERAL LIFT POTENTIOMETER (4f3):

This potentiometer is provided in panel no. B4 in front cabin. This potentiometer converts given general lift value to electrical signal at the rate of 50mv/mm output of this potentiometer can be checked at multicheck address F22.
For calibration of this potentiometer keep general lift potentiometer on zero and check output of this potentiometer with the help of multi meter it should be 0V. If there is some signal on zero position first take out knob of potentiometer now rotate shaft of potentiometer to get zero volt. Now fit knob on shaft by matching zero position.

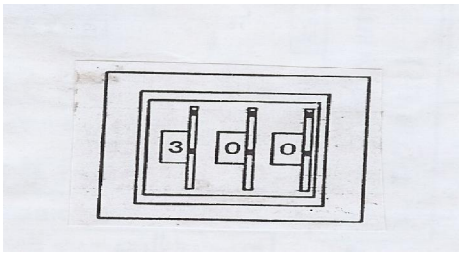
SUPER ELEVATION POTENTIOMETER(2f08):

This potentiometer is provided in B2 panel in working cabin this potentiometer is used do feed super elevation or cant values on curves. This converts cant values to electrical signal at the rate of 50mv/mm.output of this potentiometer can be checked at multicheck address F08.
For calibration of this potentiometer. Set zero value in this potentiometer.. Select multicheck address F08 then check voltage on display. It should be 0V if there is some voltage then remove digital counter set it to zero and also set shaft of potentiometer to get zero volt on display then refit digital counter on shaft.

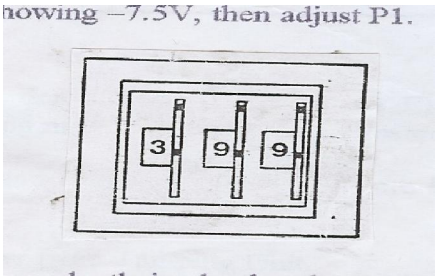
DEPTH SELECTOR CALIBRATION:



(1) Select Zero depth in depth selector i.e. all three digit should be set to zero. Now select multicheck address F13 in multiplex PCB and keep selector switch in 2nd position Now display should read OV. If it is showing some value then adjust potentiometer P3 to get zero volt.



(2) Now select 300 MM depth in depth selector then. Output of selector will be –7.5V if it is not6 showing –7.5V, then adjust P1.

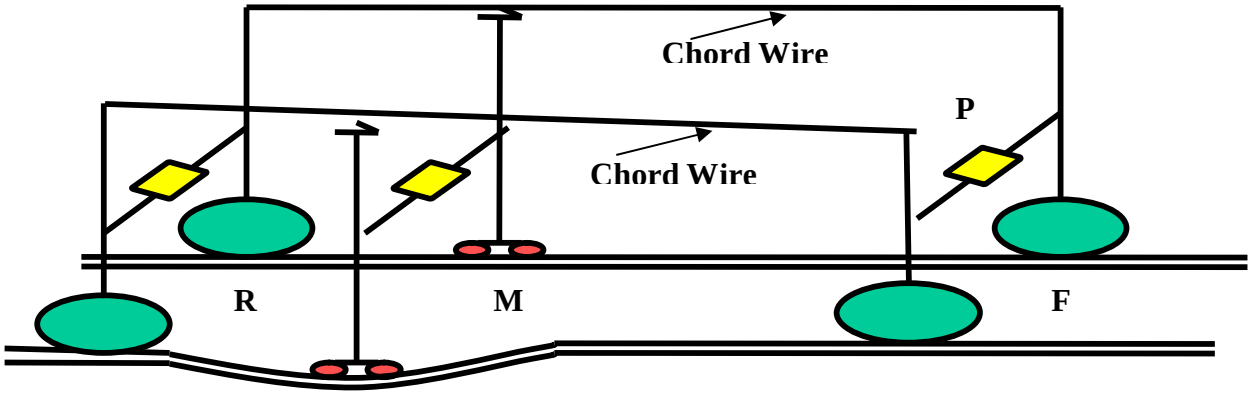


(3) Now select 399m depth in depth selector output of depth selector in display should be –9.975V if it is not, adjust potentiometer P2.

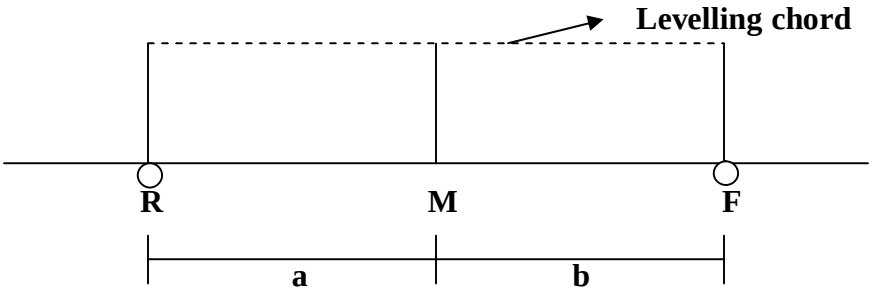
- Tamping Machine corrects the leveling error in the following two modes:

  § **Proportional or Compensation mode**- In this mode, General lift over the Base rail is generally fixed and smoothening action takes place. Longitudinal level and Cross-level are not completely corrected and the Machine leaves some error. Only short wave defects are removed. **Details are given in Annexure-I**.
  § **Design or Precision mode**- In this mode instead of General lift, the target heights are fed over the Base Rail to rectify 100% error. All long wave and short wave defects are fully removed. **This PCE Circular is to enrich knowledge of Design Levelling**.

- **Levelling and Lifting System** consists of two chord wires one for each rail, stretched tightly from Front tower (F) to Rear tower (R). Tamping machines rectify level defects in track by lifting it with reference to these levelling chords. Height Transducers are mounted on Middle feeler rods (M), which rest on track at the place where tamping is actually done and these are also lifted when the track is lifted. Both rails are controlled separately. For Cross-level/Super-elevation correction, Pendulums (P) are provided. Only CSM & 3x are designed for twist correction also. Schematic diagram is given below:



- Height transducers provided on Middle feeler rod measures the gap between its zero level and chord wire. Base rail is lifted to eliminate this gap and other rail is lifted to bring specified cant between two rails, which is kept zero in straight track and a certain value on curved track. Values of unevenness and cant are fed through potentiometers.



R = Rear measuring point M = Measuring & correction point F = Front measuring point

- In levelling process, front tower always remains on unlevelled track and rear tower on levelled track. Because of level defects in track at front trolley, front end of the chord goes out of its correct position equal to level offset at that point. Due to incorrect position of the front end of chord proportional level error remains after levelling.

- Thus, the leveled track at M is having
  Level error = LF*a/(a+b) = LF/r, where **LF = Level offset at front tower &**
  r = Reduction Ratio = (a+b)/a

- **Bogie Distances and Reduction Ratio for different machines are as under:**

Bogie Distance (m)	**UNO/DUO**	**UNI-2S**	**UNI-3S**	**O9-CSM**	**MP-2000**	**09-3X**
RM (a)	4.04	3.32	4.85	3.90	5.10	4.56
MF (b)	9.64	8.89	10.73	8.90	9.05	10.67
RF (a+b)	13.68	12.21	15.58	12.80	14.15	15.23
Reduction Ratio (r)	3.326	3.678	3.212	3.232	2.775	3.333

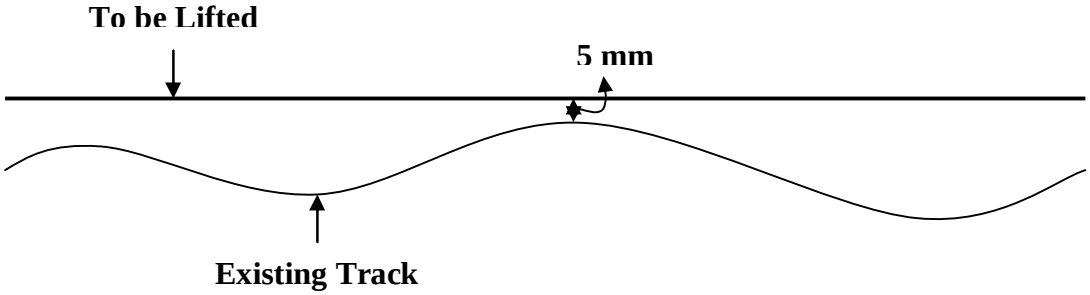
- **In Design levelling, this error is eliminated by raising or lowering front end of the chord equal to level offset at that point. In CSM, UNIMAT and 3x, chord wire is not physically shifted but electronic signals are relayed through microprocessor to leveling unit and track is lifted accordingly.**

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

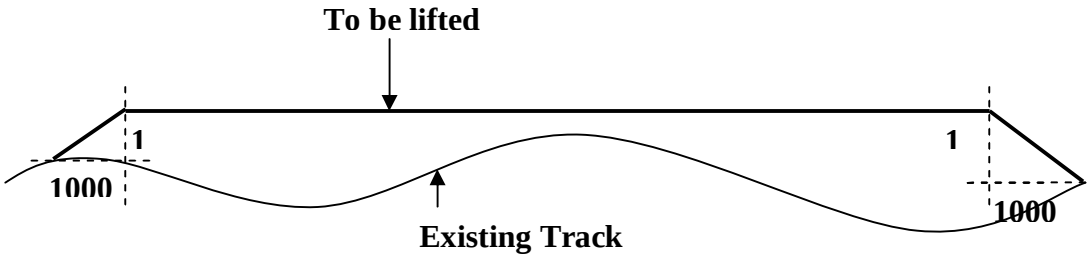
Lesson-II: Leveling **Session-67:** General lift, ramp in & ramp out**.**

General Lift: The amount of lift, which is given to track while tamping to cover all undulations over the Base Rail, is called General Lift. It is decided on the magnitude of the dips/peaks generally available in the track. General Lift should always be more than the largest of dips which shall be ascertained by P.Way supervisor in advance.

§ It is given to the Base Rail. **General Lift is the algebraic difference of higher and lower point of Base rail + 5mm. At one time, General Lift value should not exceed 50 mm. If more than 50 mm lift is required, it can be achieved by lifting two times.**



§ While giving the General Lift, ramp in of 1:1000 and also while closing the work ramp out of 1:1000 should be given to the track for smooth transition.

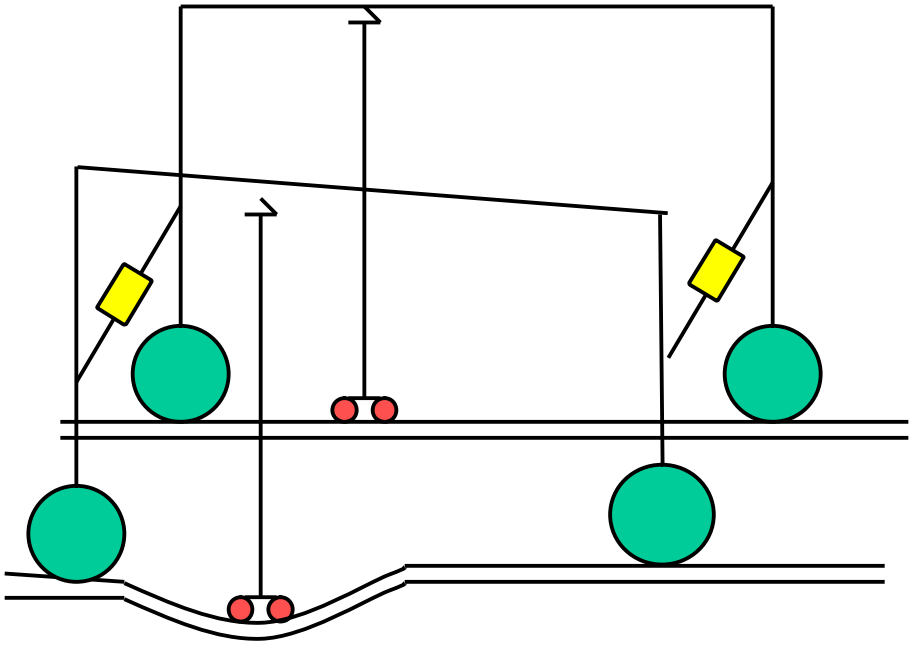


§ For Curves, when the existing Super-elevation (SE) is less than equilibrium SE, General Lift will be equal to track irregularities over the Base Rail (Inner Rail + 5mm) and when the existing SE is more than equilibrium SE, General Lift will be the track irregularities in the Base Rail + max difference between existing and equilibrium SE.

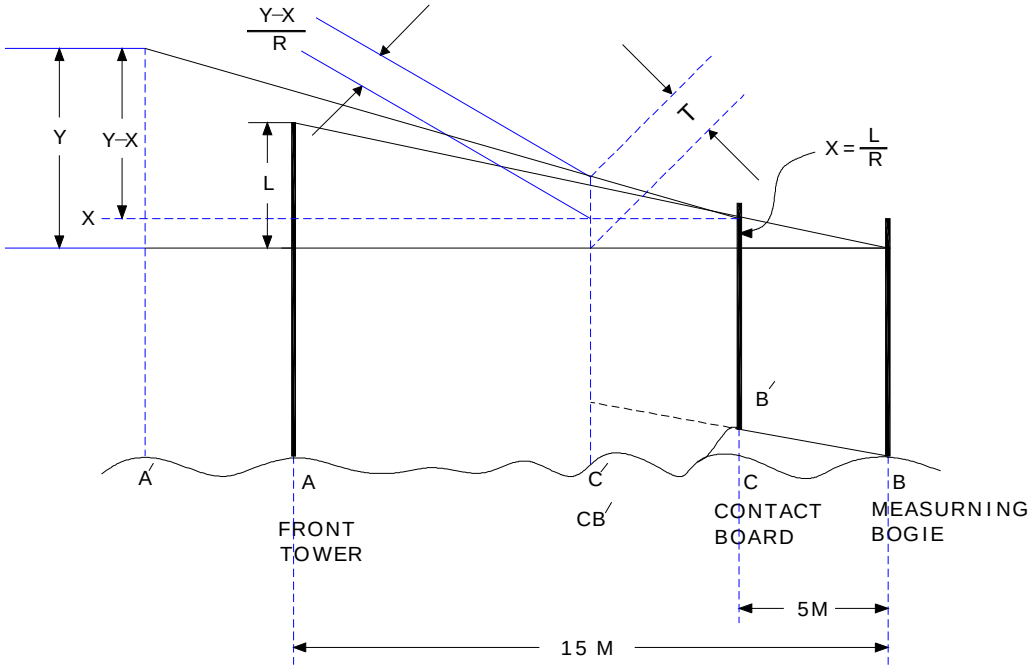
Base Rail: For carrying out attention to longitudinal profile, one rail is kept as Base or Datum Rail. Machine corrects Cross-level w.r.t. Base Rail, which should be selected as under:

- On straight track in single line and middle track in multiple lines, **higher/less disturbed rail** is kept as Base Rail.
- On straight track in double line, **non-cess rail** is kept as Base Rail.
- On curves, **inner-rail** is kept as Base Rail.
- In Plasser Tampers, direction of Cant Selector Switch is to be always kept opposite to the Base Rail.

In Russian Tamper, Base Selector Switch is provided for selecting Base Rail.



RUN IN RAMP



(DIMENSIONS HAVE BEEN ASSUMED IN THIS EXAMPLE)

$$\frac{AB}{CB} = R$$

$$\frac{L}{X} = \frac{AB}{CB} = R$$

$$X = \frac{L}{R}$$

AS THIS MACHINE MAX. AHEAD TO NEXT POSITION
AND SUPPOSE A TOTAL LIFT OF `Y'
HAS BEEN GIVEN ON FRONT TOWER,
TOTAL ACTUAL LIFT AT C.B. OR T.U. CAN BE WRITTEN.

$$T = X + \frac{Y-X}{R}$$

T = TOTAL LIFT AT A PARTICULAR SLEEPER
X = ACTUAL LIFT ACHIVED ON PREVIOUS SLEEPER
Y = LIFT GIVEN TO FRONT TOWER AT THAT POINT
R = RATIO OF DISTANCE

PROPORTIONAL LEVELLING SYSTEM

The tamping machines with non-displaceable front end of the leveling chords are equipped with a proportional levelling and lifting system for measuring and correcting the track geometry.

1. Measuring of the Longitudinal Profile:

1.1 The track is measured at three locations per rail:

- At the front of the machine (location "F") for determination of the actual level and the front measuring reference point.
- In the area of the tamping units (location "M") for the proportional control of the hydraulic track lifting system.
- At the rear of the tamping units (location "R") on the already corrected track for determination of the rear measuring reference point.

1.2 A chord is stretched above each rail between the reference points "F" and "R" which forms two, independent from each other, measuring references for the longitudinal level.

1.3 Measuring transducers are mounted on the feeler rod of the centre measuring device. The control arms of the transducer are connected with the leveling chord. Proportional to the level of the track at point "M" the measuring transducers send electronic signals for the automatic control of the track lifting servo hydraulic system.

2. Measuring of the Cross Level:

At the measuring points "F" and "M" the cross level is measured by means of pendulums.

2.1 The difference between the THEORETICAL and the measured ACTUAL cross level at the front measuring point "F" is automatically transmitted to the lifting adjustment, corresponding to the side.

2.2 During the lifting and tamping operation the cross level is checked at the centre measuring point "M" (in the area of the tamping units).

2.3 The measuring of the cross level at the rear measuring point "R" (optional) serves several functions:

a) Checking the cross level of the track which has been lifted and tamped immediately beforehand.

b) Recording of the cross level by means of an electronic recorder.

3. Input of the Lifting Values: The adjustment of the track lifting takes place at the front reference point "F" and is automatically and in the right proportion transmitted to the cut off points of the measuring transducer mounted on the centre measuring device "M". The leveling system may be used for the following methods:

3.1 **Compensating method:**

Without having the track surveyed, a required lifting value is selected. Existing longitudinal errors are reduced and the cross level errors are eliminated.

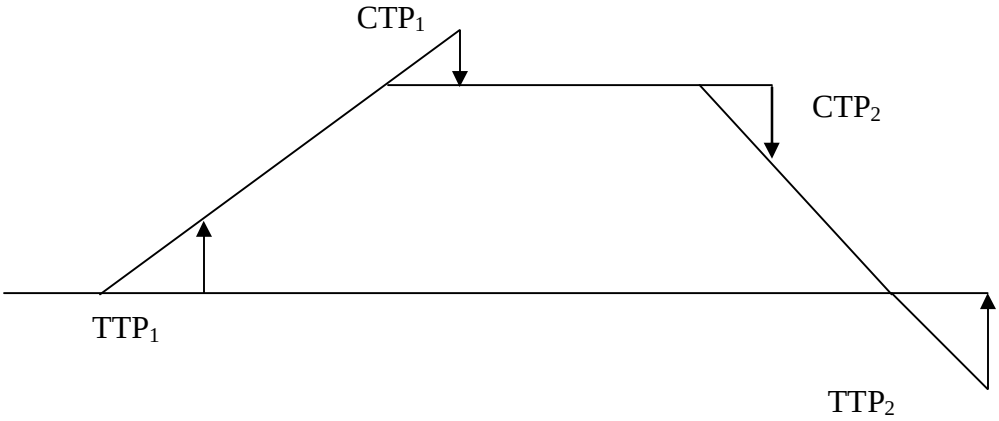
3.2 **Precision method:**

The track has to be surveyed beforehand and the lifting values of one rail are marked on the sleepers. During work the lifting values are set manually.

ERROR REDUCITON:

S. No.	Dist	08 DUO/UNO	08 UNI-2S	08 UNI-3S	O9 CSM	MP-2000
1	Reduction Ratio	3.326	3.678	3.212	3.232	2.775

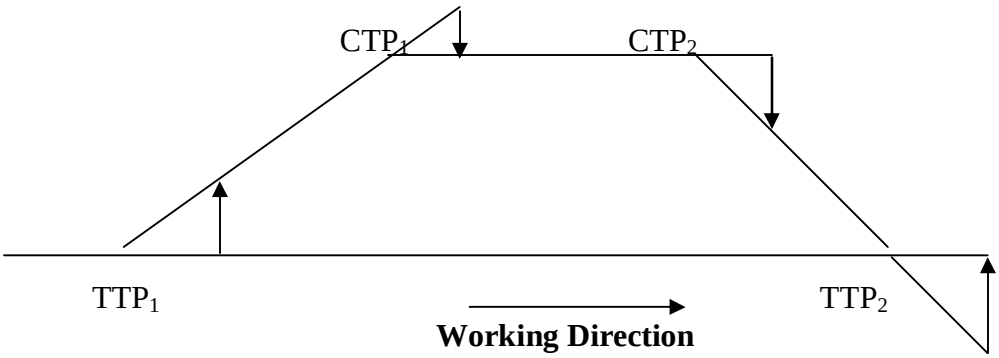
METHOD OF FEEDING OF CANT ON CSM: FEEDING OF CANT. VALUE IN CURVE:



- JE/P.Way will write down cant value of curve on the sleeper near inside rail seat of outer rail.
- Total cant value should be distributed through out the transition length in such a way that it is Zero at TP & Max. at CTP.
- Generally when the tamping machine enters into the transition position, the machine operator start feeding cant value according to the value written on the sleeper.
- In front cabin cant potentiometer is not provided, hence operator will not feed the value.
- Once machine completed entered into transition, the cant value which is written on the sleeper at measuring bogie is feeded.
- Similarly when front cabin reached at CTP1 the remaining bogie is stile in transition portion i.e. working has not reached at full cant value.
- Similarly when machine reached at CTP2 suddenly the cant value will be reduced to the value till TTP2 as per written on the sleeper when the front tower reached at TTP2 then although the reaching of cant value digital reached at zero but reduced it in ergative till measuring bogie reached at TTP2. no raise the cant value equal to zero.

METHOD OF FEEDING OF CANT ON OTHER MACHINES:

Feeding of Cant Value in Curve:



- In all tamping machines, generally there are two digital potentiometers for feeding the Cant value, one at front tower and another at working cabin except CSM in which there is only one potentiometer in working cabin.

- Cant value is written by JE/P.way on the sleeper near inside rail seat of outer rail.

- Total cant value should be distributed through out the transition length in such a way that it is Zero at TTP and Max. at CTP.

- ***There is incorrect practice of feeding of Cant value wrongly in the field i.e. when tamping machine enters into the transition portion, the operator in the front cabin starts feeding cant value according to the value written on the sleeper. As soon as cant value is fed in front cabin when it is at TTP, the lifting starts and cant rail is also lifted. Since, lifting is not required till measuring trolley reaches over TTP, it creates hump.***

- So the operator of front cabin should not feed any cant value till the working cabin reaches over TTP. Thereafter, whatever value is written on the sleeper in front of the front cabin should be fed by the operator in the front cabin.

- When front cabin reaches at CTP_1, the working cabin is still in transition portion i.e. it has not reached at full cant value. The operator in the front cabin should keep on feeding the Cant value at the same rate till the working cabin reaches at CTP_1. Thereafter, the operator in the front cabin should instantaneously reduce the Cant value to Max. Cant written on the sleeper.

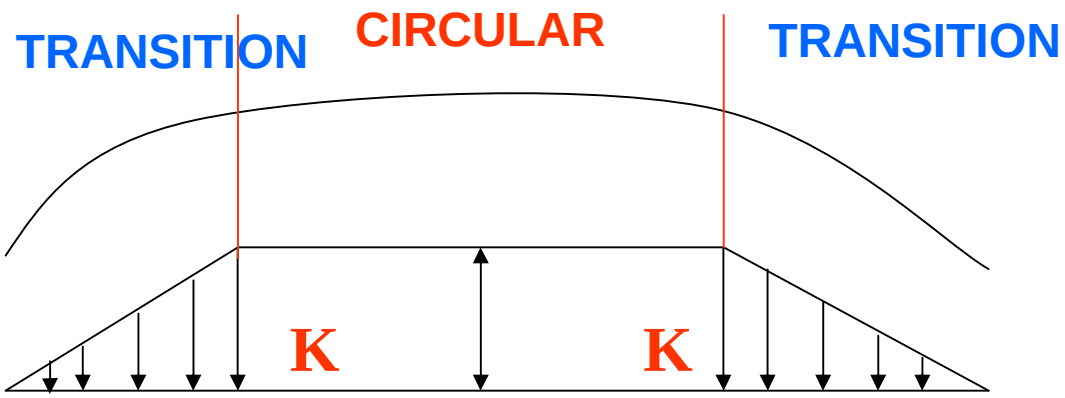
- Similarly when the front cabin reaches at CTP_2, the cant value should be kept as Max. Cant till the working cabin reaches at CTP_2, when suddenly the cant value is reduced to the value as written on the sleeper in front of the front cabin.

- When the front cabin reaches at TTP_2, although the cant value becomes zero at TTP_2, but the cant value should be fed at the same rate by changing the direction of the toggle switch i.e. negative cant value is fed, till working cabin reaches at TTP_2, when suddenly the cant value is brought to zero.

SUB DESCIPLINE – WORKING PRINCIPLE (LESSONS – 02 SESSIONS - 19)

Lesson-II: Leveling **Session-72:** Method of Calculation of Correction value ('K' Value), Function of Pendulum- Front, Middle, Rear Pendulum & Twist correction.

CALCULATION OF CORRECTION VALUE ('K' VALUE):



$$K = 50 \times \frac{SE}{R}$$

FUNCTION OF PENDULUMS:

FRONT PENDULUM: For automatic cross level correction.

MIDDLE PENDULUM: For indication only.

REAR PENDULUM: For twist correction , recording purpose, versine correction and for indication.

TWIST CORRECTION:

Rate of change of level per unit length is called twist. Only CSM machine & 3 X machine is designed for the twist correction.

METHOD OF DATA FEEDING ON TAMPING MACHINES(MANUALLY):

GENERAL LIFT:
The value of general lift is decided by survey i.e. peak value plus 5 mm. This value is fed in general lift potentiometer in one to thousand ratio. In case of design mode target height is feeded in place of general lift.

SUPER ELEVATION:
The value of cant is zero for the straight track. But cant value is feeded in super elevation potentiometer whatever retain on the track on the circular curve this is constant but in case of transition this value varies. The cant value is retain on the sleeper of the track on the outer side.

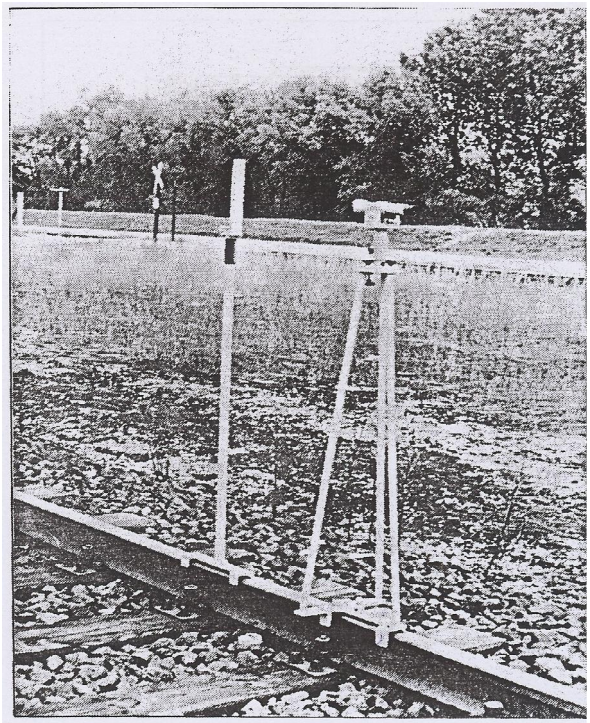
GEOMETRY VALUE ASSESSMENT (GVA):

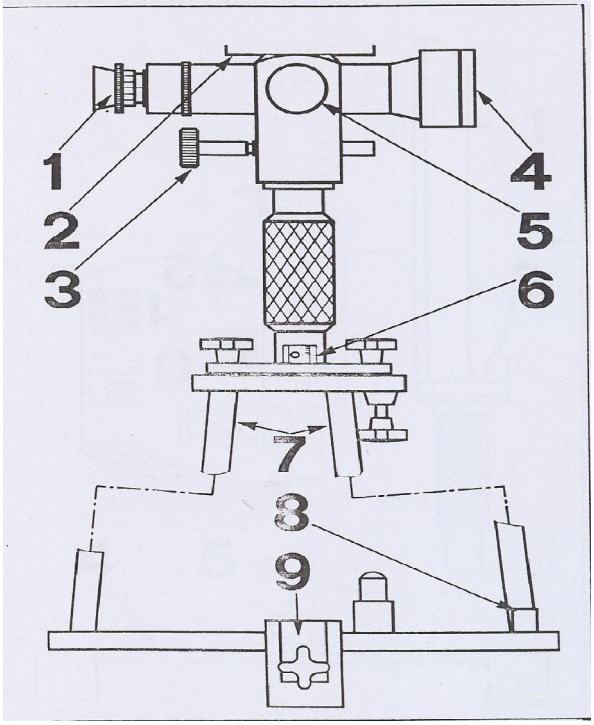
It is a small computer which eliminates the feeding of adjustment values from tables and marking on sleepers. The locations of main points of curve i.e. starting of transition, end of transition, transition length, radius, super elevation and vertical curve data etc are fed into the computer.
The attention of the Operator is not distracted by adjustment operation, mistake in calculation is avoided and therefore, the higher progress is achieved with improved quality.

AUTOMATIC GUIDING COMPUTER (ALC): The system have two modes, (i) geometry mode and (ii) measuring mode
In geometry mode parameter of curve is feed in computer ALC. WinALC software draw the curve as per parameters on screen then curve is corrected accordingly.
In measuring mode the parameters are measured first then mean value of each parameters i.e. versine, longitudinal level are taken and displayed by the computer. The correction is done by the computer as percentage of correction is fed by operator by seeing the position of the track after the correction. This is almost same to the design mode.

DESIGN LEVELING: Longitudinal section: Non-cess rail on straight track in double line section and inner rail on curves.For single and middle line in multiple line sections, any of the two rails which is less disturbed may be selected as datum rail, both for alignment and L-section in straight track.

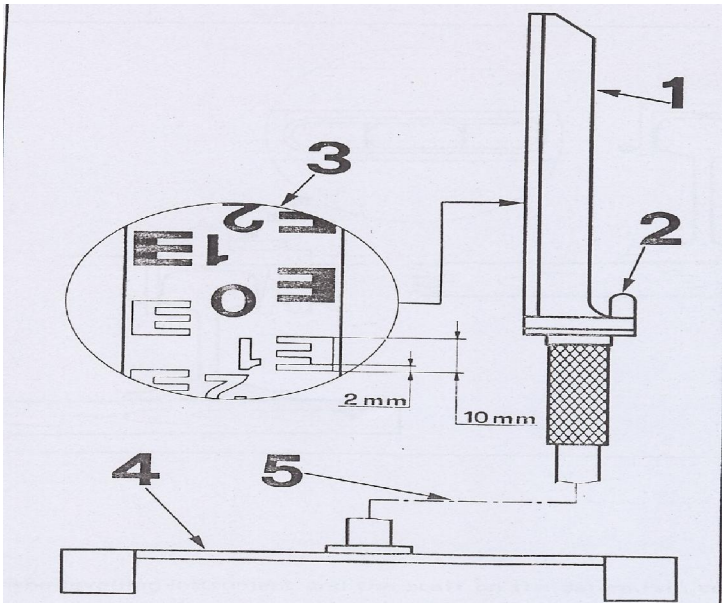
- **DETERMINATION AND ADJUSTMENT OF LEVELLING ERRORS:**Detailed guidelines on '**Survey for Vertical Profile Correction, Plotting of Vertical Profile and Surfacing Operations'** etc. as contained in Para 2.0 to 5.0 of Ann 5.3 to IRTMM at stations marked at 10m interval using conventional level and staff are very time consuming because of repeated setting up (centering & leveling) of dumpy level, change in height of instrument, difficulty in taking precise reading on conventional staff and a lot of calculation work involved for interpolating the data. Hence, it cannot be used at the site immediately after taking data**. In view of the voluminous survey work involved, some specially designed gadgets as given below may be developed, which not only makes the direct measurement of 'Design Level Offset' quite easy with Theodolite kept on rail but it is also more practicable, fast, efficient and accurate.**
  - **Theodolite Stand:** Stand is modified as shown below for easy fixing over rail head with the Theodolite at specified height (line of sight at 1.2m) to have a fixed height of instrument. No centering and levelling of the Theodolite is required for surfacing work in straight horizontal and inclined track as no turning of Theodolite is required. Only correct sighting of Target staff and parallax removal at Intermediate staff needs to be done.



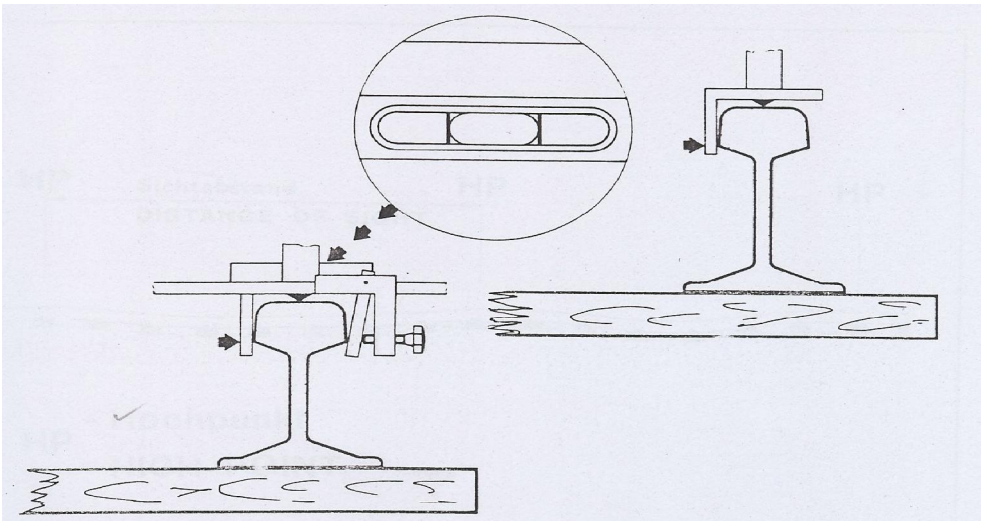


1- Diopter focusing eye-piece 2- Rough Pointer 3- Tilting Screw 4- Telescope 5- Focusing screw 6- mm graduation for height adjustment 7- Tripod 8- Air level 9- Clamping device

- **Target Staff:** Height of target point on target staff is to be kept equal to the height of instrument (1.2m) from the bottom of staff. It is designed using luminous strips for clear visibility and also to ensure verticality without much effort.
- **Graduated Intermediate Staff:** It is designed as shown below to take direct readings of lift required to be given to track, which can be transferred instantaneously. Graduation on Intermediate staff starts from height equal to height of instrument (1.2m) from the bottom of staff. It is designed using luminous strips for clear visibility and Air level is also provided to ensure verticality without much effort. No negative reading is indicated on staff, however, reading up to -25 mm can be incorporated in the staff which may some times be used to reduce general lift at isolated points.

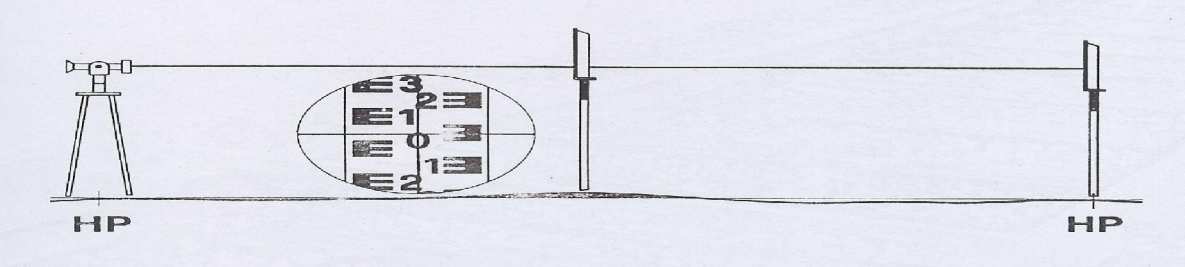


1- Staff 2- Air Level 3- Graduated scale 4- Application-angle 5- Supporting Tube

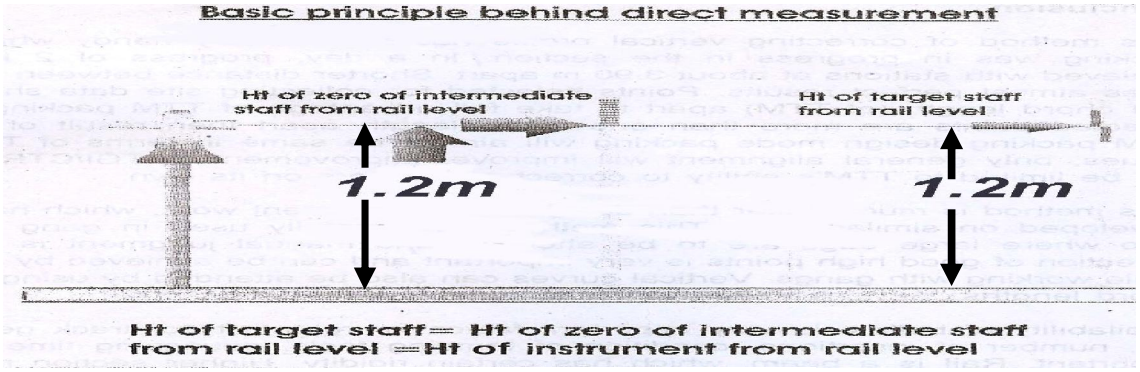


Mono-rail Clamping Arrangement for Theodolite and Levelling Staff

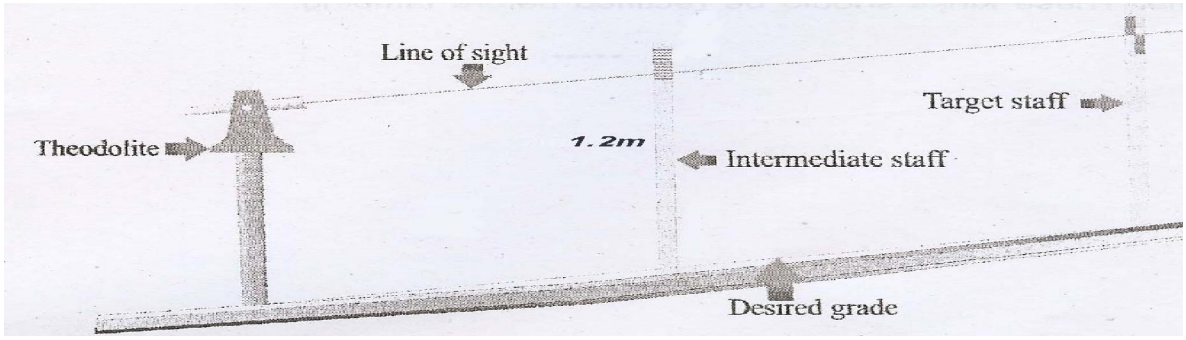
- **Method of Working:**
  - Generally the rail, which is higher and has minimum undulation, is chosen as the Base or Datum rail for leveling. Guidelines for selection of Datum rail is contained in Para 1.0 of Ann 5.3 to IRTMM.
  - Survey is started from obligatory points like bridges, level crossing, points & crossings. When survey is started from other point, a level track of 15 m is prepared and rail top level is transferred on traction mast or rail post as BM for record. Survey of dips is done at Stations marked at 5 m interval on Base rail.
  - Two high point are chosen on Datum rail at required base length (80 to 300m interval within visual range). ***Care should be taken while choosing higher points that no intermediate point is higher than the chosen points. In case negative value appears during leveling, this indicates that the High Point has been badly chosen.***



- Height of instrument (line of sight) is fixed with respect to datum rail level. For this fixed height of instrument the Target is sighted from Theodolite and intersection point of Target staff is fixed with respect to rail level, which is equal to height of line of sight with respect to rail level. Similarly height of zero point is fixed on Intermediate staff equal to height of line of sight with respect to rail level. Once the line of sight is fixed as above, the intermediate staff will read zero value on each point which is on straight line joining base of target staff and base of Theodolite stand. This is true for straight horizontal as well as inclined track. In this way height of instrument is automatically deducted on each reading and readings of sags are achieved without any calculations on site instantly. The required design level offset (lift) at every alternate sleeper is worked out by interpolating the level offsets taken at Stations. In this method neither plotting nor computer calculations are required.



STRAIGHT HORIZONTAL



STRAIGHT INCLINED

SUB: P.WAY, ESTABLISHMENT,ACCOUNTS,STORES &RAJBHASHA

Duration: 74 Sessions = 148 Periods

Sub Discipline -Track Technology (Lessons: 15 Sessions: 47)
Lesson-I: Introduction to Railway Organisation Session-1: History of Railways,Zonal Railways Divisions,Production Units

---

History of Railways and General Features

History of Railways:

The history of railways is closely linked with the growth of civilization of mankind. In 15th century stone slabs or wooden baulks were laid flush with the road surface for carriage of heavy goods loaded on carts and drawn by animal. These were called "Tram ways'. These Tram ways were extensively used in 16th century in mines in central Europe for carriage of coal and other minerals.

The timber bulks were replaced by iron plates to reduce wear and these were called 'Plate ways'. These iron plates were also substituted in course of time by angle irons to give lateral support or better safety. The present railway track is a gradual evolution from these 'Plate ways.'

The first public railway in the world was opened to traffic on 27th September, 1825, when the first train made its maiden journey between Stockton and Darlington in U.K.

The maiden trip on Indian Soil of the first train consisting of one steam engine and 4 coaches was made on 16th April 1853, when it traversed a 21 mile stretch between Bombay and Thana in 1.25 hours time. Starting from this humble beginning, the Indian Railways system has grown up today into a giant net work consisting of 63221 route Kms.

The Indian Railways run about 13.000 trains every day, serving about 7.031 railway stations and carry about 5112 million passengers and about 581 million tonnes of goods traffic in a year. For moving this traffic, the Indian Railways deploy about 1441.000 (14.41lakh) employees and maintain 7,817 locomotives consisting.

.

Railway Board:

The responsibility of the administration and management of the Indian Railways rests with the Railway Board under the overall supervision of the minister for railways. The Railway Board consists of Chairman, financial commissioner for railways and five other functional members.

The other members of the railway Board are separately incharge of matters relating to staff, Civil Engg., Traffic, Mechanical Engg. & Electrical Engg. They function as ex-officio secretaries to the Government of India. The board members are assisted by additional members, executive directors & directors.

Zonal Railways:

The entire railway system has been divided into 16 zones. Zonal headquarters of each railway are given as below:

S. No.	Railway	Zonal Headquarters.
1	Central Railway	Mumbai V.T.
2	Eastern Railway	Colcutta
3	East Central Railway	Hazipur
4	East Coast Railway	Bhubneshwar
5	Northern Railway	New Delhi
6	North Central Railway	Allahabad

7	North Eastern Railway	Gorakhpur
8	North Frontier Railway	Maligaon (Guwahati)
9	North Western Railway	Jaipur
10	Southern Railway	Chennai
11	South Central Railway	Secunderabad
12	South Eastern Railway	Colcutta
13	South East Central Railway	Bilaspur
14	South Western Railway	Banglore (Hubli)
15	Western Railway	Mumbai Churchgate
16	West Central Railway	Jabalpur

Production Units:

Apart from Zonal Railways there are six production units as given below:

S. No.	Name of Unit	Headquarters	Functions
1.	Chittranjan Locomotive Works (CLW)	Chittranjan	Manufacture of Electric Locomotives
2.	Diesel Locomotive Works (DLW)	Varanasi	Manufacture of Diesel Locomotives.
3.	Integral Coach Factory (ICF)	Parambur	Manufacture of Coaches
4	Diesel Component Works (DCW)	Patiala	Manufacture of Diesel components
5	Rail Coach Factory (RCF)	Kapurthala	Manufacture of Coaches
6.	Wheel& Axle Plant (W&AP)	Bangalore	Manufacture of Wheel & Axles

Divisions:

Zonal Railways work on divisional system. Each division has around 800 to 1500kms of track. There are 67 divisions on Indian railways. Each division works under the overall Control of Divisional Railway Manager (DRM) who is assisted by ADRM. In Engineering the division is headed by Sr. Divisional Engineer(C) and he is assisted by Sr.DEN/DENs. Each Sr. DEN/DEN is incharge of around 1100 ITKM & has 2-3 ADENS to assist him in maintenance of P. Way & Works. Zonewise break up of divisions over Indian Railways is listed as below:

S. No.	Railway	Division	S. No.	Railway	Division
1.	Central Railway	Mumbai Bhusaval Nagpur Pune Solapur	2.	Eastern Railway	Howrah Asansol Malda Sealdah
3.	East Central Railway	Danapur Dhanbad Mugalsarai Sanastupur Sonpur	4.	East Coast Railway	Khurda Road Sambalpur Waltair
5.	Northern Railway	Delhi Ferozpur Ambala Moradabad	6	North Central Railway	Allahabad Agra Jhansi

		Lucknow			
7	North Eastern Railway	Izzatnagar Lucknow City Varanasi	8	North Frontier Railway	Alipurdwar Katihar Lumding Rangia Tinsukia
9	North Western Railway	Jaipur Ajmer Bikaner Jodhpur	10	Southern Railway	Chennai Madurai Palghat Truchechirapalli Trivendrum
11	South Central Railway	Secunderabad Hyderabad Guntkal Guntur Nanded Vijayawada	12	South Eastern Railway	Adra Chakradharpur Kharagpur Ranchi
13	South East Central Railway	Bilaspur Nagpur Raipur	14	South Western Railway	Hubli Bangalore Mysore
15	Western Railway	Mumbai Vadodara Ratlam Ahamedabad Rajkot Bhavnagar	16	West Central Railway	Jabalpur Bhopal Kota

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-I: Introduction to Railway Organisation Session-2: TT Organisation on Indian Railways , Organisation at Hd. Qtr. Level and Divisional Level,CPOH and Bridge Workshop

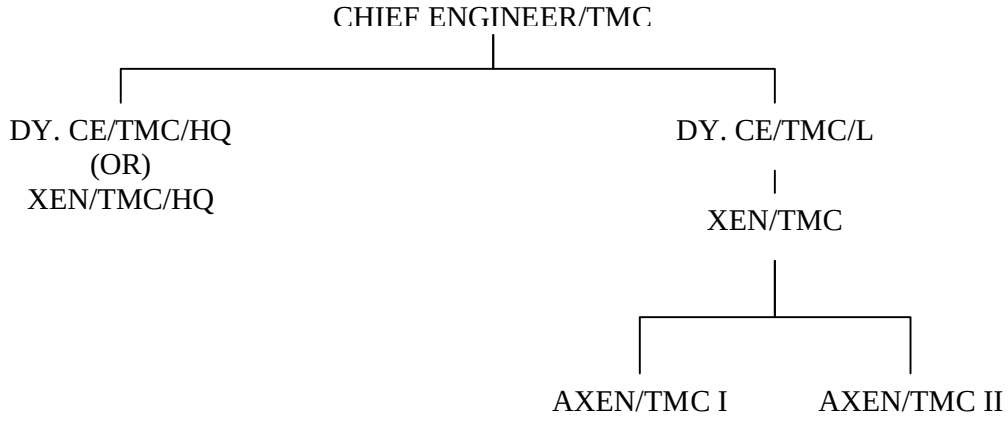
---

TT Organization on Indian Railways

The organization shall be under the overall charge of Chief Track Engineer (Machines) of the Railway who shall be reporting to the Chief Engineer through Chief Track Engineer. The organization shall be responsible for the following functions:

v. Field operation of track machines,
vi. Repair and maintenance of machines,
vii. Supervision and technical services including training, and
viii. Planning and deployment of machines.

To carry out each of the above functions, chief Track Engineer (Machine) shall be assisted by one or more Deputy CE (Machine). As given below:



DUTIES OF AEN:

GENERAL:
The Assistant Engineer is responsible for maintenance and efficient working of all the track machines in his charge.

IMPORTANT DUTIES:

- Ø Inspection and maintenance of all machines.
- Ø Ensure adherence to stipulated maintenance schedules.
- Ø Ensure availability of necessary staff for operation.
- Ø Ensure achievement of stipulated target.
- Ø Ensure adequate availability of consumables and spares.
- Ø Initiate proposals and plans for major schedule of work.
- Ø Ensure co-ordination with other units of engineering department.
- Ø Verification of store.
- Ø Ensure maintenance of various records.
- Ø Ensure availability of tools.

TRAINING OF PROBATIONERS
STAFF MATTERS

All the section engineers and other staff working under him receive proper training in maintenance practice.

SERVICE AND LEAVE RECORDS
WITNESSING PAYMENTS TO STAFFS
KNOWLEDGE OF RULE & REGULATION
INSPECTION BY HIGHER OFFICERS

INSPECTION OF MACHINE BY ASSISTANT ENGINEER

- Ø Inspection of machines by the Assistant Engineer shall be carried out in detail covering necessarily the following aspects and keep in view the Check List Maintenance Schedule issued by RDSO:
- Ø Health of engine.
- Ø Condition of hydraulic, pneumatic, electrical and electronic systems.
- Ø Condition of transmission/brake system.
- Ø Performance of the machine.
- Ø Staff accommodation.
- Ø Availability of the spares with the machine.

EXECUTION OF WORKS

DUTIES OF (SENIOR) SECTION ENGINEER/TMC:

xii. The (Senior) Section Engineer/Track Machines shall be responsible for the satisfactory operation, maintenance and productivity of the machines under his charge and quality of work.

xiii. He shall be well acquainted with the working systems, operating instructions, maintenance schedules, specifications of the oils/lubricants to be used, critical components etc of machines under his charge.

xiv. He shall have thorough knowledge of the rules and regulations and procedures concerning his work and duties as laid down in this Manual, G&S Rules, IRPWM, Engineering Code and other departmental codes, extant orders and circulars issued from time to time.

xv. He shall have in his possession up-to-date copies of the rule books/documents/manuals pertaining to the safe, efficient and trouble-free working of the machines and also other codes and books applicable and needed for the day-to-day working.

xvi. He shall maintain the records pertaining to the machines under his charge and submit the prescribed returns regularly.

xvii. He shall ensure discipline among the staff working under his within the framework of rules and endeavour to keep their moral high and look after their welfare.

xviii. He shall ensure proper handing over/taking over of the charge when transfer/change of portfolio is effected.

xix. He shall plan and ensure timely execution of the maintenance schedules of the machines within the specified time.

xx. He shall keep himself abreast of the various methods and techniques of reconditioning of components and availability status of spares at the Base Depot for efficient recommissioning of the machine during breakdowns.

xxi. He shall investigate major failure of the machine critically for corrective actions/remedial measures and for fixing responsibilities in case of failures occurring due to lapses of staff.

xxii. He shall be conversant with the provisions in various Service Agreement/Contracts and organize the visits of Service Engineers (scheduled or breakdown).

DUTIES OF MACHINE OPERATORS:

Each machine shall be under the direct charge of Section Engineer/Junior Engineer hereinafter called the operator. He shall ensure the following:

viii. Operation and maintenance of the machine.
ix. Carrying out pre-block maintenance and making the machine fit for working.
x. Initial setting out for the block working and closing the work of the machine including ramping in/ramping out of general lift to the track as in case of tie-tamping machine.
xi. Proper functioning of all the systems and components and keeping a watch on the controls/indicators/gauges.
xii. Taking precautions for special Design Mode operations such as curve slewing etc in case of tamping machine.
xiii. Posting of fitters/khalasis at respective places around the machine for monitoring the work of various systems, carrying out during block maintenance (greasing, oiling, tightening of bolts etc.) and also to attract attention of the main cabin Operator and assist him in the event of any problem of malfunctioning of the machine or due to track obstructions.
xiv. He shall ensure safe working of the machine and staff.

When there are more than one Operators on the machine, the senior-most Operator shall be the Machine Incharge. In addition to his normal work as an Operator he shall be responsible for the following functions in which he will be assisted by other Operators/staffs:

vii. Carrying out the prescribed schedule of maintenance and keeping proper records of the same.
viii. Safe custody, accountal and replacement of the spares, Tools & Plants and consumables issued for the machine and returning of released spares to base depot for reclamation/condemnation.
ix. Keeping systems of the machine in working condition and ensuring the target output, duly maintaining quality.
x. Maintaining log books and other records, sending daily and other periodical reports/statements using appropriate fastest mode of communication.
xi. Liaisoning with the Divisional Officials for efficient working of his unit, coordination with the Permanent Way staff and planning daily programme of machine work and interacting with the Permanent Way staff for working in design mode, slewing of curve etc.
xii. Actively associating during visit of firm's Service Engineer, furnishing of such information as may be needed for proper examination of the machine and taking necessary follow up action.

DUTIES OF TECHNICIAN:

The main functions of Track Machine Fitters/Mechanics are:

viii. To attend to the daily and weekly maintenance schedules of machine and record the compliance in log book.
ix. To extend help during other maintenance schedules/service checks by the Service Engineers.
x. To keep in his custody the various tools and equipment necessary to attend repairs and ensure their working condition.
xi. To remain vigilant during movement and working of machine and to inform the operator of any abnormalities.
xii. To guide and supervise the semi-skilled/unskilled staff in attending to the maintenance/repairs.
xiii. To ensure safety of the machine and men from approaching trains on adjacent lines.

Any other work assigned to him by the machine incharge

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-I: Railway Track Session-3: Constituents of Railway Track.
Requirements of Good Railway Track, Classification of Routes. Different Gauges

1. TRACK:

It is also called permanent way. It basically consists of two parallel rails having specified distance in between them and fastened to sleepers which are embedded in the layer of ballast, which is spread over formation.

Rail are joined to each other longitudinally by fish plates and fastened to sleeper by various fittings. Sleepers are placed at a specified distance and are held in position by embedding in the ballast.

Gauge:

The perpendicular distance between inner faces of rail is called gauge. It Is measured 13mm below from rail top.The Indian Railways operate in three different gauges mainly Broad Gauge (1676mm), Metre Gauge (1000mm), Narrow Gauge (762mm & 610mm) wide. The broad gauge accounts for nearly 50% followed by metre gauge 43% of the total route length. The gauge of track in India is measured as the minimum horizontal distance between the running or gauge faces of two rails 14mm below from top of rail.The standard gauge is 1435mm

DIFFERENT GAUGES ON INDIAN RAILWAY:

(i) B.G. (broad gauges) : - 1676 mm
(ii) M.G.(Meter gauges) :- 1000 mm
(iii) N.G. (Narrow gauges):- 762 mm
(iv) Specific Narrow Gauge:-610 mm
(v) Standard Gauge :- 1435 mm (Foreign Railways)

2. COMPONENTS OF TRACK:

Following are the main components of the track:-

(1) Rails
(2) Sleepers
(3) Fitting & Fastenings
(4) Ballast
(5) Formation

In earlier days, temporary track used to be laid for carrying earth and other building material for construction of railway line, which used to be removed subsequently. Permanent way is called to distinguish the final track constructed for movement of trains from the temporary track constructed to carry building materials etc.

3. REQUIREMENT OF GOOD TRACK:

A permanent way or track should give comfortable & safe ride at maximum permissible speed with minimum cost. For achieving the above objectives a good permanent way should have the following characteristics:-

(i) The gauge should be correct and uniform.

(ii) The rail should have perfect cross-level.
(iii) The alignment should be straight and free of kinks.
(iv) The gradient should be uniform and as gentle as possible.
(v) The track should be resilient and elastics in order to absorb shocks and vibrations of running trains.
(vi) The track should have good drainage so that the stability of the track is not affected due to water logging.
(vii) The track should have good lateral strength, so that it can maintain its stability due to variation of temperature and other factors.
(viii) There should be provision for easy replacement and renewals of various track components.

CLASSIFICATION OF ROUTES:

Broad Gauge Routes:

All the B.G. routes of Indian Railways have been classified based on speed criteria as given below:

(A) Group 'A' Lines:

These are meant for a sanctioned speed of 160 KMPH. In this category the following lines falls:

1. New Delhi – Howrah – by Rajdhani Exp. Route.
2. New Delhi – Bombay – By Frontier Main or Rajdhani Route.
3. New Delhi – Chennai Central – By Grant Trunk Route.
4. Howrah – Mumbai VT - via Nagpur.

(B) Group 'B' Lines:

These are meant for a sanctioned speed of 130 KMPH .

(C) Group 'C' Liens:

These include suburban section of Mumbai, Delhi ,Chennai and Kolkota

(D) Group 'D' special:

Section where traffic density is very high or likely to grow substantially in future and sanctioned speed is 100 Kmph at present.

Group 'D' Lines:

Sections where Max^{m} speed is100 Kmph.

(E) Group 'E' Special:

Sections where traffic density is very high or likely to grow substantially in future and at present the max^{m}. Sanction speed isles than 100 Kmph.

Group 'E' Lines:

These includes other sections and Branch line.

Classfication of M.G. Routes

Depending upon the importance of route, traffic carried and Max^{m} permissible speed. M.G. routes are classified in three categories as Q.R. and S. routes.

(1) 'Q' Routes:

These routes consists of routes where the max^{m} permissible speed will be more than 75 Kmph. And the traffic density will be more than 2.5 GMT. Max^{m} speed do not exceeds 100 Kpmh. As Bangalore-Miraz route.

(2) 'R' Routes:

These routes will have a speed potential of 75 Kmph. and the traffic density will be more than 1.5 GMT. Routes have further been sub-divided into 3 category depending upon the volume of traffic as follows:

(a) R_1: Where the traffic density will be more than 5 GMT.

(b) R_2: In between 2.5 GMT to 5 GMT

(c) R_3: 1.5 GMT – 2.5 GMT

(3) 'S' Routes:

These routes will be the routes where speed potential will be less than75 Kmph and where the traffic density is less than 1.5 GMT. These will consists of other routes which are not covered in 'Q', 'R_1', 'R_2' and 'R_3' routes.

'S' Routes have been further subdivided into 3 routes as S_1, S_2 and S_3 etc.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-3: Formation Session-4: Formations in Embankment and Cutting.

Formation:

Formation is the prepared flat earth surface on which track ballast is laid. Formation may be with or without sub-ballast. Top of formation is provided with a cross slope of 1 N 40 to drain off the water quickly.

Sub Grade: A formation without sub-ballast is called as sub-grade.

Types of Formation:

Formation may be of following types-

Formation in embankment: Formation prepared by depositing the soil over ground level is called formation in embankment.

Formation in cutting: Formation prepared by excavating the soil below ground level is called formation in cutting.

Zero fill formation: Formation where the track is laid on ground level is called zero fill formation.

Function of Formation:

(i) To provide a smooth & uniform bed for laying of track.
(ii) To bear the static and dynamic loads transmitted to it through ballast section.
(iii) To facilitate drainage
(iv) To provide stability to the track.

Width of Formation:

Width of formation depends on the number of tracks to be laid and the gauge.

The minimum width of formation required to be provided on straight track for single line/double line, embankment/cutting for BG as well as MG, on new construction and gauge conversion shall be as under-

Straight Track:

Gauge	Formation	Single Line (m)	Double Line (m)	
			Existing Line	New Construction
BG	Embankment	6.85	11.58	12.155
	Cutting	6.25	10.98	11.555
MG	Embankment	5.85	9.81	-
	Cutting	5.25	9.21	-
NG	Embankment	3.70	7.32	-
	Cutting	7.01	7.01	-

Note: (i) The above formation width in cutting does not include the requirement for drain and width of berm.

(ii) These widths are for sections where concrete sleepers have been provided or proposed to be provided.

Width of formation on curved track:

On curves, the actual formation width on single/double lines and track centres to be adopted on double lines should be decided by the Chief Administrative Officer (Const.) after giving due consideration to the following-

(i) Width of ballast shoulder

In case of LWR/CWR track the width of ballast shoulder on outside of curve shall be 500mm in place of 350mm, extra width of formation shall be taken into account for single line and 300mm for double line.

(ii) Due to extra clearances on double line: On account of the effect of super elevation, increase in track centres on curves with corresponding increase in formation width shall also be taken into account

Formation profiles – The recommended track centre distance shall be as under:

(i) **On BG**

(a) For existing track – 4.725m

(b) For new constructions and gauge conversion, doublings – 5.305

(ii) **On MG** – 3.96m

Cess: The width of formation beyond toe of the ballast to the end of formation is called cess. This additional width beyond ballast toe provides stability to formation. The level of cess is measured with respect to top of rail and should be ensured in accordance with ballast profile for different types of sleepers.

Height of Formation and side Slopes:

The height of formation depends upon the ground contours and gradients. Side slopes of the formation is dependent on the shearing strength of soil and its angle of repose. In case of clayey & sandy soil normally the side slope is 2:1 (Horizontal: Vertical) for the formation in embankment and a slope of 1:1 in cutting or even sleeper in case of rock.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-4: Rails Session-5: Functions, Types & Standard Rail Section

(1) RAILS:

Rails are similar to steel girder placed end to end at gauge distance to provide continuous of leveled surface for train move.

(2) FUNCTIONS OF RAILS:

Following are the main functions:-

(i) Rails provides continuous and leveled surface for movement of trains.
(ii) It provides a path way which is smooth and has very less friction like $1/5^{th}$ of road.
(iii) The rails serves as a lateral guide for running of wheels.
(iv) The rail wear various types of stresses such as vertical load, braking forces, and thermal stresses due to temperature etc.
(v) Rails carry out the functions of transmitting load to a large surface area of formation through sleeper and ballast.

(3) TYPES OF RAIL:

Various types of rails are:-

(1) Double Headed Rail (D.H. Rails):

Originally these rails were used having identical heads on both the sides, so that these may be used on both the sides.

(2) Bull Headed Rail (B.H .Rails):

The shape of these rails is similar to D.H.R. and only difference is that its head has more metal to allow wear & tear, so that it may run for long life.

(3) Flat Footed Rails (F.F.Rails):

These rails are having inverted 'T' cross-section and can be directly fixed to the sleeper with the help of spikes. These rail have been standardized for use in Indian Railways. These rails have more economical design giving greater strength & Lateral stability.

Sub Discipline-Track Technology (Lessons: 15 Sessions: 47)
Lesson-I: Rails Session-6: Standard length, Rolling marks & UTS

Standard Length of Rail:

Theoretically longer the rail, lesser are the number of joints and fittings and lesser should be the cost of construction and its maintenance. Longer rails are not only economical but give smoother and comfortable riding of trains. The length of rails is however, restricted due to the following factors.

(i) Lack of facilities for transport of longer rails particularly on curves.
(ii) Difficulties in handling of long rails.
(iii) Uneconomical in manufacturing very long rail.
(iv) Difficulties in having a bigger expansion joint for long rails.
(v) Heavy internal thermal stresses in long rails.

Taking the above factors limit consideration. Indian Railways have standardized 13 metres rail length previously (42 ft. for Broad Gauge and 12 meters previously 39 fit) for MG and NG track. Indian Railways are also planning to use 26 meters long and even longer rails on its system.

Every rail rolled has a brand on its web, which is repeated at interval such:
IR – 90R-TISCO-II 1985-Basic BASSEMER
The abbreviations used indicates

(i) IR	:	Indian Railways
(ii) 90R	:	Weight and type of section; 90 ibs/yard rails as per revised British specifications.
(iii) TISCO	:	Tata iron and Steel Company
(iv) If 1985	:	Month and year of manufacture; Feb. 1985

As per IRS/T-18-88, the brand marks are being revised and these will be as follows:
IRS-52kg-710-TISCO-11 1991 → OB
The explanation for various new abbreviations is as given below:

(i)	IRSE-52-kg	:	Number of IRS rail section i.e. 52 kg or any other section.
(ii)	710	:	Grade of rail section i.e. 710 or 880.
(iii)	TISCO	:	Manufacturer's name i.e. Tata Iron & Steel Co. or any other firm.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-V: Sleepers Session-7: Functions, Types & Sleeper Density

---

SLEEPERS

Sleepers are transverse ties on which rails are laid:

1. Functions of Sleeper:-

(1) Holds rails to correct gauge and alignment.
(2) Give a firm and even supports to rails.
(3) Transfer the load evenly from rails to the wide area of ballast.
(4) Act as an elastic medium between rail and ballast to absorb shocks and vibrations of moving loads.
(5) It provides longitudinal and lateral stability to permanent way.

2. Types of Sleepers:

i) Wooden sleeper
ii) Steel sleeper
    (a) Cast iron steel sleeper

(b) Steel trough sleeper

iii) Concrete Sleepers

(a) Mono block concrete sleeper

(b) Twin block

3. Sleeper Density: It is the no .of sleepers used per rail length.
Length of each rail = 13m (B.G.), 12m (M.G.)

Sleeper density is expressed as M + X or N + Y

Where M or N is the length of rails in meters or Yards respectively and X and Y is the variable no. For example:

In B.G. the no. of sleeper per rail length for a sleeper density M + 7 will be 20 or 1540 sleepers per kilometer of rail.

Sleeper density	No. of sleeper per kilometer	Exact c/c spacing required as per calculation	C/c spacing to be provided in the filed	
			L.W.R.	S.W.R.
M + 8	1660/Km.	60.24 cm	60	-
M + 7	1540/Km.	64.93 cm	65	66
M + 4	1310/Km.	76.33 cm	-	78

4. REQUIREMENTS OF AN IDEAL SLEEPERS:

The ideal sleeper should normally fulfill the following requirements:

i) The initial cost as well as maintenance cost should be minimum.
ii) The weight of sleeper should be moderate, so that it is possible to handle it easily.
iii) The design of sleeper and fastenings should be such that it is possible to fix and remove the rails easily.
iv) The material of sleeper and its design should be such that the sleepers do not break or get damaged while packing below the sleepers.
v) The sleeper should be such that it is possible to maintain and adjust gauge properly.
vi) The sleeper should have sufficient bearing area.
vii) The design of sleeper should be such that it is possible to have track circuiting.
viii) The sleeper should have anti-sabotage and Anti-theft quality.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-V: Sleepers Session-8: Requirements of PRC sleepers- their advantages and disadvantages

---

CONCRETE SLEEPER

The use of concrete sleepers on Indian Railways becomes necessary due to following reasons.

i) Scarcity of good quality of timber.
ii) High cost of maintenance in wooden and steel sleepers.
iii) Introduction of high speed and heavier axle loads.

ADVANTAGES OF CONCRETE SLEEPERS:

(i) Concrete sleepers being heavy, gives greater strength and stability to track and are suitable specially for LWR/CWR due to great resistant to buckling .

(ii) Concrete sleepers with elastic fastening provide a track which can maintain better gauge ,cross level and alignment and retains packing well.

(iii) Concrete sleepers have flat bottom therefore they are best suited for modern method of maintenance.

(iv) These can be used in track circuited areas or track circuited section.

(v) These have longer service life approx 50 years.

(vi) It has anti-sabotage and anti-theft quality.

(vii) Not susceptible to fire hazard.

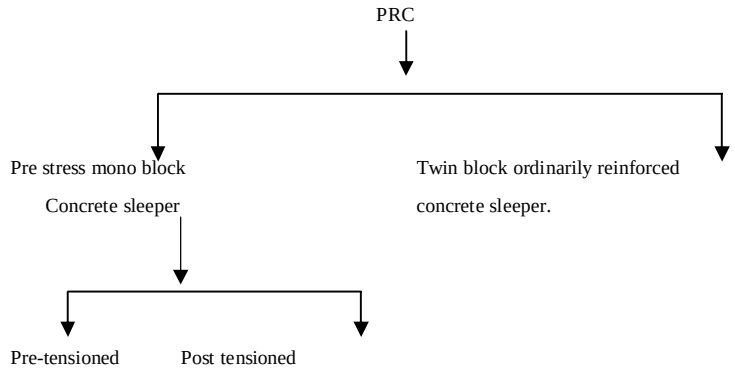
Disadvantages:

1. Being heavy, their handling and maintenance is difficult and mechanical means have to be adopted for this.

2. They get heavily damaged in the case of derailment as they are brittle and hard.

3. Nil scrap value.

TYPES OF CONCRETE SLEEPER:



SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-VI: Fastenings Session-9: Rail to Rail fastenings

Track fittings are of two types:-

(1) Rail to rail fittings

(2) Rail to sleeper fittings.

RAIL TO RAIL FITTINGS:

These fittings are used for tieing one rail to another longitudinally in same horizontal and vertical plane. One of the main fittings of such types of rail is fishplate. Fishplate is called, so as its section looks like a fish.

TYPE OF FISHPLATE:

Fishplates are of following two types:

i) Ordinary fishplate

ii) Combination fishplate.

(i) Ordinary Fishplate:

These plates are having I-section. These are used to connect similar line section together, such as 90R rail to 90R rail and 60 Kg rail to60 Kg rail.

(ii) Combination Fishplate:

These are used for connecting the rail length of two different rail sections. Such as 90R rail to 52 Kg rail, 52 Kg rail to 60 Kg rail. The combination fishplates are designed so as to suit the two rail sections.

No expansion gap is kept at such joints so as to give more strength. A common top table and gauge face of the two rail section is available with the help of the Junction fish plates or combination fish plates in-spite of varying depth & thickness of the section.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-VI: Fastenings Session-10: Rail to Sleeper fastenings

ELASTIC FASTENING:

Fastenings are subjected not only to severe vertical, longitudinal and lateral forces also to heavy vibrations. With increasing load and speed, their effect become more and more severe, with the result that the conventional rigid fastenings are not able to withstand these and start working loose.

Therefore some such fastenings are to be adopted which are able to withstand shocks and vibrations. Elastic fastenings possess all these qualities.

i) E.R.C. (Elastic Rail Clip or Pendrol):

It is made out of a round steel spring bar 20.6 mm of dia and has a typical shape. It exerts toe load on the foot of the rail, of around 710 Kg to 1100 Kg, when fitted with proper rubber pad and liner.

ii) Rubber Pad:

It is an integral part of an elastic fastenings. It is provided between rail and sleeper to absorb or dampers the vibrations and shocks and provides a cushioning effect between the bottom of rail and sleeper. It is made of special quality of rubber and has longitudinal groove in both sides.

iii) Liner:

These are used with concrete sleepers and are provided between the toe of the pendrol clip and rail foot. These are of two types:

(a) Steel Liner: It is used on non circuited track areas.

(b) Insulating Liner: These are used on track Circuited areas/sections.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-VII: Ballast Session-11: Functions & Specifications

Ballast is the layer of broken stone placed and packed below and around sleepers.

Broken Stone – grit:

Functions of Ballast:

1. To transfer and distribute the load from sleeper to a large area of formation.
2. To provide elasticity and resilience to track for getting proper riding comfort.
3. To provide necessary resistance to track for longitudinal and lateral stability.
4. To provide effective drainage to track.
5. To provide effective means of maintenance.

BALLAST SPECIFICATIONS:

Ballast should be hard, tough, angular, durable, non porous and non water absorbent. It should resist attrition. It should be machine-crushed. It should be cheap and economical. Ballast should not be flaky ( )

SIZE OF BALLAST AND ITS GRADATION:

(a) Retained on 65mm square mesh sieve-NIL

(b) Retained on 40mm square mesh sieve-40-60%

(c) Retained on 20mm square mesh sieve7,98% machine crushed and 7,95% hand crushed size of sieve – 100cm x 70cm x 10cm.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-VIII: Points & Session-12: Functions & Important terminology.

POINTS & CORSSINGS

Functions:-

Points and X-ing are provided to transfer a vehicle from one track to other. The points which consist of a pair of switches gives the facility of diverting and X-ing provides gap in the rails to be crossed by flanged wheel. A complete set of point and X-ing along with lead rails is called turnout. It is designated or called as R.H. and L.H. turnout depending upon direction of traffic diverted by it.

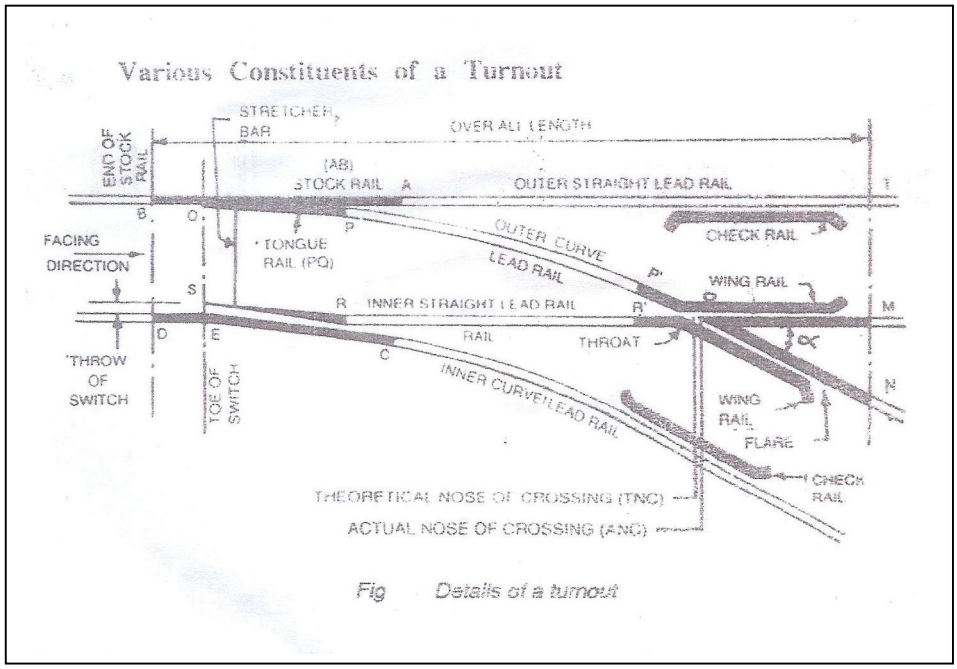


Fig Details of a turnout

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-VIII: Points & Session-13: Constituents of Turnout.

CONSTITUENTS OF POINTS AND CORSSING:

1. **Tongue Rail**:

It is the tapered moveable rail made up of high carbon and manganese steel to withstand wear. It is connected to lead rail at its thicker end.

2. Stock Rail:

It is the running rail against which the tounge rail operates.

3. Switch:

A pair of tounge rail and stock rail with necessary connections and fittings form a switch.

4. Points:

A pair of tounge rails along with their stock rails are termed as points.

5. Turn Out:

It is an arrangement of point and X-ing with lead rails by means of which rolling stock (Vehicles) may be diverted from one track to another track.

6. X-ING:

X-ING is introduced at the junction where two rails X-each other. It permits the wheel flange of railway vehicle to pass from one track to another track.

SWITCHES:

There are two types of switches:

1. STUB SWITCH:

In this type of switch no separate tounge rail is provided and some portion of the track is moved from one side to another side. These are obsolete now.

2. SPLITS WITCHES:

It has a pair of stock rail and a pair of tounge rail split switches are of two types:

(a) Loose Heel Type:

In this type, the switch rail or toung rail finishes at the heel of the switch. In order to enable the free end of the toung rail to be moved, two bolts of the heel block are kept loose.

(b) Fixed Heel Type:

In this type of switch, toung rail does not end at heel of the switch, but it extends further. The movement of the toung rail is made on account of the flexibility of toung rail by increasing its length.

TOE OF SWITCHES:

Depending upon the mode of machining of toe of switches, they may be of the following type.

(1) UNDER CUT SWITCH:

This is the type of switch the foot of the stock rail is machined to accomodate toung rail.

(2) OVER RIDING SWITCH:

In this type of switch the stock rail has the full section and the toung rail is planned to 6mm thick edge which over rides the foot of the stock rail.

1. Switch Angle:

It is the angle between the gauge faces of stock rail and tounge rail at theoretical toe of switch (TTS). This angle depends upon heel divergence and length of tounge.

2. Flange Way Clearance:

It is the distance between adjoining faces of running rail and wing rail/check rail near the x-ing. It is meant for providing clearance for the passage of wheel flange. Limiting value are:

	Max^m	Min^m
B.G	48	44
M.G.	44	41
At L /X-ING	51	57 mm

3. Heel Divergence:

It is the distance between gauge faces of stock rail and tongue rail at heel joint.

4. Throw of switch:

It is the distance through which the tongue rail moves laterally at the toe of the switch for movement of trains limiting value are:

	Max^m	Min^m
B.G.	115	95
M.G.	100	89

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-VIII: Points & Crossings Session-16: Types of Crossings, Crossing number & Main constituents of Built-up Crossing

---

TYPES OF CROSSING:

A. ON THE BASISOF CROSSING ANGLE CROSSINGS MAY BE DIVIDED INTO:

(i) Acute Angle Crossing:

An acute angle crossing or V-crossing is in which the intersection of two gauge faces form an acute angle.

(ii) Obtuse Angle Crossing:

In this crossings gauge faces form on obtuse angle at the point of intersection.

(iii) Square Crossing:

In this case two gauge faces intersect each other at 90.

B. FROM THE MANUFACTURING POINT OF VIEW CROSSINGS CAN BE TWO TYPES:

(i) Built up Crossing:

In this crossing two wing rails and nose are assembled together with the help of bolts and distance blocks. These are being used broadly on Indian Railways.

(ii) Cast Manganese Steel Crossing:

In this crossing no bolts are there. This piece is one piece cast crossing which needs very little maintenance.

CROSSING NUMBER

Number and angle of crossing:

A crossing is designated either by the angle the gauge faces make with each other or more commonly by the number of crossing represented by 'N'. There are three methods of measuring the number of crossing and the value of 'N' depends upon the method adopted. The methods.

Right angle method:

This is the method used on Indian Railways. In this method, the measurement of N is taken along the base of a right angled triangle. This method is called 'Coles 'method.

$$\text{Cot } a = \frac{N}{1}$$

or $N = \text{Cot } a$

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-VIII: Points & Crossings Session-17: Standard Turnouts & permissible speed

---

Speed on the Turnouts:

The design of the turnouts and permissible speeds are closely linked with each other as the forces coming on the turnout are dependent on the speed. The turnouts on IR are curved without the superelevation and transition hence the speed on the turnouts is restricted due to comfort, safety and the maintainability criteria.

Upgradation of speeds on Turnouts and loops upto 30 kmph:

Speed in excess of 15 kmph shall be permitted on turnouts laid with ST or PRC sleepers only. All turnouts on running loops shall be laid with curved switches. With minimum rail section being 52 kg. All rail joints on these turnouts shall be welded to the extent possibly. Permissible speeds on curved switches ten sw1 shall be as under:

1.	1 in 8½ sw	1.5 kmph.
2.	1 in 8½ symmetrical split with curved switch.	30 kmph
3.	1 in curved switch	30 kmph

Position of sleepers at Points & Crossing:

The sleepers are normally kept perpendicular to track. At points and crossings a situation arises when sleepers have to cater for the main line as well as for turn out portion. Longer sleepers are used for some length of the track for this purpose.

WELDING OF RAIL

NECESSITY OF WELDING:

The rail joint is the weakest link in a railway track and therefore causes certain maintenance problem.

Following are the evil effects of rail joint:

i) Due to moving load's in pact on the joint ballast under the joint sleeper get loosed.
ii) The life of rail, sleepers and fastenings gets effected adversely. The rail ends particularly get battered and hogged and chances of rail failure at joint increases.
iii) Lot of noise pollution is created due to rail joint, making the rail travel uncomfortable.
iv) Due to a rail joint, there is a danger of removal of fish plates and rails by the miscreants and chances of subotage increases.
v) Due to rail joint, there is excessive wear and tear of track components and rolling stock.
vi) Pressure of rail joints, results in increased fuel consumption.
vii) 25% extra labour is required for maintenance of joints.

Due to these evil effects of rail joints we go for welding of rail joints.

The various types of rail welding techniques are as follows:

(1) OXY – acetylene welding

(2) Electric arc welding.

(3) Electric are welding

(4) Flash butt welding

(5) Alumino -thermit welding

(1) Oxy Acetylene or Gas Pressure Welding:

In this type of welding necessarily heat is produced by a combination of oxygen and Acetylene gas. The rail ends to be welded are brought together and heat is applied through a burner. Temperature upto 1200^0C to1400^0C is achieved, so that the metal of the rail ends get melted and fusion takes place ,welding the rail ends together.

(2) Electric Arc Welding:

In this method the heat is created by the passage of electric current across a gap between two conductors. About 3500^0c temperature is achieved, causing the two rail ends weld together.

(3) FLASH BUT WELDING:

In this method heat is generated by electric resistance. The two rail ends are brought together, so that they almost touch each other. The electric energy is switched on, thereby allowing an electric current of about 5 volt and 35000 ampere to pass between faces of two rails; lot of flashing takes place and considerable heat is generated rising the temperature from 1000^0c-1500^0c. At this time the rail ends are pressed together causing welding of the rails.

(4) ALUMINO – THERMIT WELDING:

This is the only form of site welding. Its principle is that when a mixture of finely divided aluminium and iron oxide called thermit mixture is ignited a chemical reaction takes place with evaluation of heat, producing iron and Aluminium oxide. The iron released from the reaction is in molten condition (2450^0c), which is poured in the gap between the two rails, welding the rail ends together. The equation which follows is:

$$2Al + Fe_2O_3 \cdots\cdots> Al_2O_3 + 2Fe + heat$$

Development of Welded Rails:

Indian Railways keeping in pace with the advanced Railways of the world, have made phenomenal progress in welding of rails in the last few decades. The development of welded rails has been necessitated due to economic considerations coupled with the technical advantages that a welded track possesses over the fish plated track. Rails were initially welded into panels of rails, 5 rails and 10 rails. The development of these rail panels, called short welded panels (S.W.P.) or short welded rails (S.W.R.) was the first stage of development in the country. In course of time, the track technology got considerably advanced and a new concept of **'locking up of stresses'** in the rail, thereby resisting its longitudinal movement was developed. Accordingly, long welded rails of varying lengths were laid to eliminate rail joints and to get more advantages of welding. A time has now come when the concept of **'continuous welded rails'** is getting fast developed and welded rails are being laid continuously so as to get full advantages of joint less track.

As per present practice, the rules are welded for the block section from station to station to get maximum advantages of a welded track and also to minimize the use of switch expansion joint.

IMPORTANT DEFINITIONS:

1. L.W.R. (Long Welded Rail):

It is a welded rail, central part of which does not have any longitudinal movement due to temperature variation. Length of rail more than 250 meter in B.G. and 500 m. in M.G. should function as L.W.R.

2. S.W.R. (Short Welded Rail):

It is a welded rail, which contracts and expands throughout its length. It is generally three rail length long.

3. Breathing Length:

It is the length at each end of L.W.R. or C.W.R. which is subjected to contraction or expansion on account of variation in temperature.

4. S.E.J. (Switch Expansion Joint):

It is an expansion joint installed at each end of L.W.R.. to permit expansion or contraction of the adjoining breathing length due to temperature variation.

5. Anchor Length:

It is the length of the track required to resist the pull exerted on rail by rail tensor during distressing.

For B.G., Anchor length = La = 2.5 ($to^oc - tp^oc$) in meter.

For M.G., La = 4.5 ($to^oc - t^opc$) in meter

Where, to = stress free temperature.

o = Prevailing rail temperature.

6. Destressing:

The operation under taken with or without rail tensor to secure stress free condition in L.W.R. at a specified rail temperature is called destressing.

7. RAIL TEMPERATURE:

It is the temp. of rail as recorded by an approval type of rail thermometer at site.

8. MEAN RAIL TEMPERATURE :

Mean rail temperature of section is the average of maximum and minimum rail temperature recorded for that section for last five years.

$$\text{Mean rail temperature } t_m = \frac{\text{Max}^m \text{ Rail temp.} + \text{Min}^m \text{ R.T.}}{2}$$

RANGE OF TEMPERATURE:

= Max^m. Rail temp. – Min^m. Rail temp.

Ex. = $60^oC - (-10^oC)$

= 70^oC

Temperature map of Indian Railway shows the range of temperature and mean rail temperature of different places in India.

Ex. – Bombay 60^oC (20^oC)

Ze. Range of temperature = 60^oC

Mean Rail temperature= 20^oC

9. Prevailing Temperature:

It is the rail temperature prevailing at the time when any operation connected with de-stressing is carried out, denoted by to.

10. Stress Free Temperature (t_o):

It is the rail temperature at which the rail is free of all thermal stresses . At this temperature, there is no thermal stresses in the rail panel.

11. DESTRESSING TEMPERATURE (t_d):

It is the average rail temperature during the period of fastenings of rails to sleepers after de-stressing the L.W.R. without using tensor. If rail tensor are used, for all practical purpose, t_d can be taken as t_o. De-stresing temperature ranges are as follows.

Rail section	De-stressing temperature range (t_d-range)			
52 Kg & higher section	-	tm + 5	to	tm +10
other section	-	tm	to	tm +5

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-IX : Welding of Rails Session-24: Theory of Welded rails.

THEORYOF L.W.R.:

The theory of expension and contraction of metals with the increase or decrease of temperature is well known.

A rail also expands and contracts depending upon the variation in temperature. The expansion of the rail is the function of:

1.Co-efficient of linear expansion of rail material (x), $x = 1.152 \times 10^{-5}/^{o}C$

2.Length of the rail (L)

3.The variation in rail temp. (ΔT)

Normally a free rail would have experienced longitudinal movement corresponding to the variation in the rail temperature but rails are fastened to sleepers, which are embedded in the ballast, these expansion and contraction due to temperature change are restricted because of the restrain offered by the above factors. The restrain in the longitudinal movement of the rail gives-rise to the internal stress in the metal called locked-up stresses

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-IX : Welding of Rails Session-25: Thermal forces in LWR.

The resulting force known as thermal force given by

$$P = E.A.X.T$$

Where, E = Modules of elasticity of rail/metal

= 2.15×10^6 t Kg/cm^2

A = Cross-section of rail section in cm^2

X = Co-efficient of linear expansion

T = Temperature variation in ^oC.

For 52 kg rail.

Area of cross section = 66.15 cm^2

P = EAXT

i.e. P = E A X T

= $2.15 \times 10^6 \times 66.15 \times 1152 \times 10^{-5} \times 1^0$

= 1.638 tonnes

S = Wt. of rail = A x l x f

A = $\frac{S}{f}$, where l = 1 meter

f = density

P = $E \times \frac{S}{f} \times \propto \times t$

$$\boxed{P = 31.5 \times S \times T \text{ in Kg.}}$$

When t = 1^oC.

P = 31.5 x 52 x 1

1638 Kg

1.638 tonnes.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-IX : Welding of Rails Session-26: Permitted locations of LWR/CWR.

Permitted Locations for LWR/CWR:

General:

i) Complete track renewals (Primary) shall provide for LWR/CWR. Existing rails laid on permitted locations may also be converted into LWR/CWR provided they meet the requirements of welding.

ii) New constructions/doublings/gauge conversions, permanent diversions shall be opened with LWR/CWR.

iii) In goods running lines, goods yards, classification, reception yards rail joints may be welded if the condition of all the track component is sound.

LWR/CWR shall not be permitted on locations where:

i) Rails are subjected to heavy wear, corrosion, corrugation needing frequent renewals.

ii) Formation is weak and track deformations are large likely leading to buckling.

iii) Formation soil is susceptible to pumping failure causing excessive migration of soil into the ballast cushion needing frequent opening & screening.

iv) Track is vulnerable to frequent flooding, subsidence and breaches.

Alignment:

i) LWR/CWR shall not be laid on curves sharper than 440m radius both for BG & MG. However in temp. zone 1.LWR/CWR may be laid on curves upto 360m radius (5^0) on BG with following additional precautions:

- Min. track structure should be 52 kg rail laid on PSC sleepers with M 7 sleeper density and 300 mm clean ballast cushion.
- Shoulder ballast for curves sharper than 440 m should be increased 600 mm on outside of curve over a length of 100 m on either side of common tangent point.
- Reference marks should be provided at every 50m interval to record deep if any.
- Each curve of length 250m should preferably be provided with SE on either side which should be located in straight track at 100 m away from the tangent point.

ii) LWR/CWR may be continued through reverse curves not sharper than 875m radius. For reverse curves sharper than 1500 m radius shoulder ballast of 600 mm over a length of 100 m on either side common tangent point shall be provided on out side of curve.

Gradients:

The steepest permitted grade shall be 1 in 100.

Vertical curve:

A vertical curve shall be provided at the junction of grade when the algebric difference between two grades is either equal to or more than 4 mm per meter or 0.4%. The min. radius of the vertical curve shall be kept as under:

BG	MG

Route	**Min. Radius**	**Routs**	**Min. Radius**
A B C,D&E	4000m 3000m 2500m	All routes	2500m

Any deviation from above shall require the approval of territorial Chief Engineer.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-IX : Welding of Rails Session-27: Different Temperature Zones.

DIFFERENT TEMP. ZONES

TEMPERATURE ZONES**:**

Indian Railway is divided into four temperature joins.

South

Zone	Range of Temperature in 'C'
I	40 – 50
II	51 – 60
III	61 – 70
IV	71 - 76

North India

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-IX : Welding of Rails Session-28: De-stressing

DESTRESSING OF L.W.R.

Whenever these is abnormal behaviour of L.W.R. indicated below, the distressing should be done:

1. Gap in S.E.J: Whenever the gap differs beyond limit specified.

2. After special maintenance operation: Such as deep screening, lifting, lowering, sleepers renewal.

3. Unusual occurrence: Such as rail fracture derailment, accident and breach.

4. After every three years as a maintenance operation

5. When breathing length is found to be excessive in spite of fastenings being tight & the packing in sound condition or when any appreciable movement is observed in non-breathing portion of track.

6. Initial de-stressing after laying must be done after passage of 10 GMT or one year. Which ever is later at the discretion of Chief Engineer.

TRACK RENEWALS:

Permanent Way Renewals:

Classification of Renewals –

(**1**) All track renewals can be classified generally into one of the following categories:

(1) Complete Track Renewal (Primary) abbreviated as C.T.R. (P)
(2) Complete Track Renewal (Secondary) abbreviated as C.T.R. (S)
(3) Through Rail Renewal(Primary) abbreviated as T.R.R. (P)
(4) Through Rail Renewal (Secondary) abbreviated as T.T.R. (S)
(5) Through Sleeper Renewal (Primary) abbreviated as T.S.R. (P)
(6) Through Sleeper Renewal (Secondary) abbreviated as T.S.R. (S)
(7) Casual Renewals.
(8) Through Turn-out renewal (TTR)
(9) Through Fitting renewal (TER)
(10) Through Weld renewal (TWR)
(11) Through Bridge timber renewal (TBTR)
(12) Scattered renewal

(2) Primary renewals are those where only new materials are used and secondary renewals are those where released serviceable materials are used.

(1) Scattered Renewal- In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage track components. These are carried out in isolated locations and not more than 10 rails and/or 250 sleepers in a gang beat in a year. Such renewals are a part of normal maintenance operations.

(2) Casual renewal – In this case, unserviceable rails, sleepers and fastenings are replaced by identical sections of serviceable and nearly the same vintage or new track components. These are carried out in isolated locations of continuous but small stretches. Such renewals are not a part of normal maintenance operations and cannot be covered under scattered renewals.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-X: Track Renewals Session-31: Factors governing Track Renewal

Factors Governing Permanent Way Renewal:

(1) Criteria for Rail Renewal – The following are to be considered in connection with the criteria of rail renewals:

- Incidence of rail fractures/failures.
- Wear on rails.
- Maintainability of track to prescribed standards.
- Expected service life in terms of Gross million tonnes carried.
- Plan based renewals.

(a) **Incidence of Rail Fractures/Failures –** A spate of rail fractures on a particular sections having 5 withdrawals of rails per 10km. in a year due to fracture and/or rail flaws detected ultrasonically failing in the category of IMR & REM will have priority while deciding rail renewals. In case the rail failures at fishplate/welded joints are pre-dominant, end cropping with or without welding could be considered.

(b) **Wear on Rails – (i) Limiting Loss of Section-** The limiting loss in rail section, as a criterion for recommending rail renewals shall be as under:

Guage	Rail Section	Loss in section in percentage
B.G.	52 kg./metre	6
	90 R	5
M.G.	75 R	4.2
	60 R	3.25

Rail wear may be determined by actual weighment, taking rail profiles at ends after unfishing joints and taking rail profiles with special profile measuring gadgets.

(ii) **Wear due to corrosion –** Corrosion beyond 1.5mm in the web and foot may be taken as the criterion for wear due to corrosion. Existence of the localised corrosion such as corrosion pits, specially on the underside of the foot, acting as stress raisers from the origin of fatigue cracks and would necessitate renewals.

(iii) **Vertical Wear –** When the reduction of the depth c^f the rail head reaches a point beyond which there is a risk of wheel flanges grazing the fish-plates, such rails should be renewed. The limits of vertical wear at which renewals are to be planned are given as below.

Vertical Wear

Gauge	**Rail Section**	**Vertical Wear**
B.G.	60 Kg/metre	13.00 mm
	52 Kg/metre	8.00 mm
	90 R	5.00 mm
M.G.	90 R	4.50 mm
	60 R	3.00 mm

Lateral wear is to be measured at 13 to 15 mm, below the rail top table. Worn rail profile should be recorded and superimposed over new rail profile to find out the lateral wear.

(b) Maintainability of track to prescribed standards-

(i) There may be cases, where renewals may be necessary on the following considerations viz.

(1) Poor running quality of track in spite of extra maintenance labour engaged for maintaining the same,

(2) Disproportionate cost of maintaining the portion of track in safe condition.

(ii) The condition of rails with regard to hogging/battering, scabbing and wheel burns and other conditions such as excessive corrugation of rail as can be ascertained by visual inspections, with affects the running quality of track, and make the track maintenance difficult and uneconomical, should be taken into account while proposing renewals.

(iii) Renewals of rail due to hogged and battered rails ends should be considered only if other remedies have not been found to be effective.

(c) Renewals on consideration of service the life in terms of total G.M.T. of traffic carried – The rail shall be planned for through renewal after it has carried the minimum total traffic as shown below-

Gauge	**Rail Section**	**Total G.M.T. carried for T.12 Med. Manganese Rails**	**Total GMT carried for 90 UTS rails.**
B.G.	60 Kg/m	550	800
	52 Kg/m	350	525
	90 R	250	375
M.G.	75 R	150	-
	60 R	125	-

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XI: Maintenance of Track Session-32:General Instructions as contained in IRPWM

System of Track Maintenance:

1. **System to be adopted –** The track should be maintained either by conventional system of track maintenance or by 3-tier system of track maintenance.

2. Details of Maintenance Works –

(a) In both the systems, track requires to be overhauled periodically with the object of restoring it to best possible condition, consistent with its maintainability. Periodicity of overhauling depends on several factors, such as type of track structure, its age, volume of traffic, rate of track deterioration, maximum permissible speed, system of traction, condition of formation etc. Irrespective of the system of track maintenance adopted, it is obligatory to overhaul specified lengths of gang beat annually. The length of the section to be overhauled shall be such that complete overhauling of track will be accomplished within a specific period (normally 3 to 5 years).

(b) Immediately after cessation of mansoon, the run down lengths should be quickly attended to, to restore the section to good shape. After this is done overhauling/through packing of track should be taken in hand. After completion of one cycle of systematic through maintenance, track should be attended to wherever required.

(c) In any system of maintenance it is necessary to allot certain number of days in a week for 'picking up slacks' to ensure that whole gang length is in safe condition for passage of trains.

Through Packing:

Conventional Maintenance By Beater Packing – General: Through packing shall consist of the following operations in sequence. The length of track opened out on any one day shall not be more than that can be efficiently tackled before the end of the day:

(a) Opening of the road.
(b) Examination of rails, sleepers and fastenings.
(c) Squaring of sleepers.
(d) Slewing of track to correct alignment.
(e) Gauging.
(f) Packing of Sleepers.
(g) Repacking of joint sleepers.
(h) Boxing of ballast section and tidying.

Through packing is best done continuously from one end of a gang length towards the other.

Track Maintenance by Machines:

General – Mechanical maintenance of track involving use of "on track machines" should be planned, on long continuous lengths.

Systematic Overhauling:

(1) Sequence of Operations – Overhauling should consist of the following operations in sequence:

(b) Shallow screening and making up of ballast.
(c) All items attended to, while doing through packing.
(d) Making up the cess.

(2) Shallow Screening and making up of Ballast.

(a) For good drainage periodical screening of ballast is essential.
(b) In the case of manual maintenance, the crib ballast between sleepers is opened out to a depth of 50 to 75mm. below the bottom of sleepers, sloping from the centre towards sleeper end. For machine maintained section, the crib ballast in the shoulders should be opened out to a depth of 75 to 100mm. below the bottom of sleepers, sloping from the centre towards sleeper end. The ballast in the shoulders opposite to the crib as well as the sleepers is removed to the full depth. A slope is given at the bottom sloping away from the sleeper end. The ballast is then screened and put back. Care should be

taken to see that the packing under the sleepers is not disturbed and the muck removed is not allowed to raise the cess above the correct level.

(c) Two contiguous spaces between sleepers should not be worked at the same time.

(d) Screening should be progressed in alternate panels of one rail length. In no circumstances should several rail lengths of track be stripped of ballast.

(e) Where drains across the track exist, they should be cleaned and filled with boulders or ballast to prevent packing from working out and forming slacks.

(f) After screening, full ballast section should be provided, extra ballast being run put previously for the purpose. Work should be commenced after making sure that the ballast will not be seriously deficient. Deficiency, if any, should be shown in the central portion of sleeper and this also should be made up soon.

(3) Through packing of track – The detailed operations are described in Para 224. Through packing may be done either by conventional beater packing, or by using machines.

(4) Making up of Cess – Cess when high should be cut alongwith overhauling and when low should be made up. A template should be used for this purpose.

(5) General – Overhauling should be completed before the end of March. In the case of L.W.R. territory, the provisions in L.W.R. Manual should be followed.

(6) Screening in Welded area – In the case of S.W.R. area screening may be carried out at rail temperatures and conditions.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XI: Maintenance of Track Session-34: Provisions on Works incidental to Regular Track Maintenance with thrust on Deep Screening.

3-tier System of Track Maintenance:

3-tier System of track maintenance shall be adopted on sections nominated for mechanized maintenance. This shall consist of the following 3 tiers of track maintenance.

(i) On-track machines (OMU)
(j) Mobile Maintenance Units (MMU)
(k) Sectional Gangs.

Picking up Slacks – Slacks usually occur on stretches of yielding formation on high banks and cuttings, on approaches of bridges, on badly aligned curves, where ballast is poor in quality or quantity or where drainage is defective. Attention to slacks should be need based, need for the same being determined by inspections and results of track recording. Picking up slacks shall be done where the alignment is kinky or top level is uneven and the track has to be restored to normal condition quickly. The quantum of work turned out by a gang during the day will depend on the extent of slacks. In all cases sighting is done, the defects assessed and marks made on sleepers to be dealt with in chalk. The marked sleepers should then be dealt with as in through packing care being taken to see that the packing of adjacent sleepers does not get disturbed. In case a large percentage of sleepers needs attention in a rail length, the entire rail length should be attended to. The marking of defects shall be as indicated below:

Defects	Symbol	Place of indication
Cross levels	C-2	On the sleeper inside gauge face.
Loose packing	H or P	On the sleeper outside the gauge face
Gauge	O ±	On the sleeper inside the gauge face.
Unevenness	→ ←	On the rail web on gauge face side.
Alignment	↓	On the foot of rail inside the gauge face.
	→	

It is imperative that when joints are picked up, at least three sleepers on either side of the joints are packed. Picking up slacks may be done, by conventional method or by off-track tampers. In the case of a low joint, the fishplates should be slightly loosened and the joint tapped, so that the rail ends are, rendered free and are capable of being lifted. After the joint is thoroughly packed the fishplates should be tightened again.

Works Incidental to Regular Track Maintenance:

Deep Screening of Ballast:

General –

(a) It is essential that track is well drained for which screening of ballast should be carried out periodically. Due to presence of bad formation, ballast attrition, excessive rain fall and dropping of ashes and ore, ballast gets chocked up and track drainage is impaired. In such situations, it becomes necessary to screen the entire ballast right up to the formation level/sub-ballast level. Further through screening restores the resiliency and elasticity of the ballast bed, resulting in improved running quality of track. Such screening is called "Deep screening", as distinguished from the shallow screening, which is done, during overhauling.

(b) Deep screening should be carried out in the following situations by providing full ballast cushion:
   (1) Prior to complete track renewal.
   (2) Prior to through sleeper renewal.
   (3) Where the caking of ballast has resulted in unsatisfactory riding.
   (4) Before converting existing track, fish plated or SWR into LWR or CWR; or before introduction of machine maintenance, unless the ballast was screened in recent past.
   (5) The entire track must be deep screened atleast once in ten years.

(c) The need for intermediate screening between track renewals may be decided by the Chief Engineer depending on the local conditions.

(d) At the time of deep screening, formation treatment should be carried out along with the deep screening.

(e) In case of the bad formation, formation treatment should be carried out along with the deep screening.

(f) The work of deep screening should be carried out continuously from one end of the section to the other.

With Manual Packing: The details of the work to be carried out in stages on various days, after the starting of the screening operation and the speed restriction recommended to be imposed are shown in Table.
According to the above schedule normal Sectional speed can be resorted on the 21st day.

Table-I Proposed Schedules for Deep Screening (Manual Packing)

Details of Work	**Day of Work**	**Speed Restrictions and their length**	
		Broad Gauge	**Metre Gauge**
Deep Screening and Initial packing First through packing Second through packing	1 2 3	20 Km. p.h.	20 Km. p.h.
Picking up slacks as required	4 5 6 7 8	45 Km. p.h.	30 Km. p.h.

Third through packing	9 10		
Picking up slacks as required Third through packing	11 12 13 14 15 16 17 18 19 20	75 Km. p.h.	60 Km. p.h.
	21 onwards	**Normal Sectional Speed**	**Normal Sectional speed**

With Machine Packing: The details of the work to be carried out in stages on various days, after the start of the screening operations and the speed restriction recommended to be imposed are indicated in the schematic representation in Table II.
According to this schedule, normal sectional speed can be resumed on the tenth.

Table – II Proposed Schedules for Deep Screening (Machine Packing/B.G.)

Details of Work	Day of Work	Speed Restrictions and their length
Deep Screening with Initial packing First machine packing	1 2	20 Km. p.h.
Picking up slacks as required Second machine packing	3 4 5 6	45 Km. p.h.
Picking up slacks as required Third through packing	7 8 9	75 Km. p.h.
	10 onwards	**Normal Sectional Speed**

The period mentioned in the schedules shown above is the minimum and can be suitably increased to suit local condition of the track consolidation.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XI: Maintenance of Track Session-35: Provisions on Maintenance of Track in Track Circuited Areas as contained in IRPWM

Maintenance of Track in Track Circuited Areas:

Track Circuit:

Is an electrical circuit formed along running rails. It's function is to indicate presence or absence of a train on a portion of track. When track is not occupied track relay is energized & in case of occupation, track relay is de-energized. The following precautions shall be taken while working in track circuited areas-

- Incharge Sectional P. Way Engineer shall instruct the staff not to place across or touching two rails in the track, any tool or metal object which may cause short circuiting.
- All gauges, levels, trolleys and lorries used on the track circuited length shall be insulated.
- Steel or C. 1 pipes used for carrying water gas under the track shall be placed sufficiently below the rails to prevent any short circuiting.
- While carrying out track maintenance, care shall be taken to ensure that no damage of track circuit fittings like bond wires bootlegs, jumped wires etc. tales [;ace/
- Use of steel tape should be avoided.
- Pulling back of rails in track circuited areas shall be done in the presence of S&T staff.
- Proper drainage shall be ensured in yard to avoid flooding of track during rains., where watering of coaches is done. It would be desirable to provide washable concrete aprons on platform lines.
- Ballast shall be kept clean through out the track circuited length and care shall be taken to ensure that ballast is kept clear of rails i.e. 50mm from under side the foot of rail.
- Min. ballast resistance per Km. of track < 20 ohms in the station yards and < 4 ohms in block sections.

General Instructions to staff:

(1) General Knowledge of Engineering Staff –

(a) Every engineering official working in electrical traction area shall be in possession of a copy of rules framed for the purpose of the operation of the Traction Power Distribution system pertaining to Engineering department and ensure that staff working under him are also acquainted with the rules. He will ensure that rules pertaining to carrying out engineering works are strictly observed.

(b) All electrical equipment, every power line or cable shall be regarded as being 'live' at all times. No work shall be commenced adjacent to any electrical equipment except on authority issued in writing by a competent official of the Electrical Department to the effect that the equipment has been made dead and earthed.

(2) Defects in a Overhead Equipment: Defects or break-downs in the overhead equipment including track and structure bonds noticed by the Engineering staff shall be reported immediately to the Traction Power Controller. When defects in the overhead equipment that are likely to cause damage to pantographs or trains, are noticed and it is not possible to convey information to Station Masters or signalmen to enable them to issue caution orders, the line shall be protected by the staff noticing such defects according to General Rule 3.62.

(3) Traction Bonds – In electrified area the return current fully or partially flows through the rail. To ensure a reliable electrical circuit continuity and also to ensure proper earthing in case of leakage of current, various types of traction bonds as described below are provided at suitable places and maintained by the Electrical Traction Department-

(b) Longitudinal Rail Bonds – In the case of D.C. traction system, practically the whole return current flow through the rail. Therefore, two flexible copper bonds offering minimum resistance to the flow of current are provided at each rail joint under the fish-plates. Two solid lugs at the two ends of the copper bonds are inserted in holes

drilled at the two rail ends between the fish bolt holes and are pressed by using a bend press to rivet them firmly to the rail. On points and crossings and at junction fish-plates where continuity bonds of the above type can not be provided due to space constraint, continuity of return current path is achieved by using mild steel straps or G.I. wire ropes.

Absence of such bonds may cause unsafe working condition and in extreme cases may damage the rail ends.

(c) Cross Bonds (D.C): Cross bonds are provided between adjacent tracks at regular intervals to reduce resistance of the current to the minimum. Such cross bonds are also known as transverse bonds.

(d) Structure Bonds: All Structures supporting overhead equipment either in A.C. or D.C. track circuited areas are connected to the running rails for ensuring good earthing. Failure of insulator or leakage of current switches off the supply from the sub-station so that men coming in contact with supporting structure etc. do not get electric shock. Removal or tampering of such bonds can, therefore, result in unsafe conditions. Since the structures are grouted in concrete, they are likely to become charged in case such bonds are kept disconnected. Similarly other steel structures such as foot-over bridges, sheds, etc., in the vicinity of O.H.E. lines are also connected to rails through similar structure bonds.

Special Instructions to Staff Working in Traction Area:

(1) Need for Precautions – Precautions are required to be taken on account of following:-

(d) **Proximity of a Live Conductor –** The risk of direct contact with live O.H.E. is ever present while working in electrified sections such as for painting of steel work of through spans of bridges and platform cover.

(e) **Build up of potential due to return current in rail. –** The return current in the rails may cause a potential difference-

(i) Between rail and the surrounding mass of earth.
(ii) Between two ends of a fractured rail.
(iii) Between the two rails at an insulated joint.
(iv) Between earth and any other metallic mass.

(2) The following precautions should, therefore, be taken while working in traction areas:-

(a) No work shall be done within a distance of two metres from the live parts of the O.H.E. without a 'permit-to-work'.

(b) For work adjacent to overhead equipment the Engineering Inspector shall apply to the proper authority sufficiently in advance for sanctioning the traffic and power block required.

The Traction Power Controller through Traction Foreman will arrange to isolate and earth the section concerned on the date and at the time specified in consultation with the Traffic Controller. He shall then issue 'permit-to-work' to the Engineering Inspector.

On completion of the work the 'Permit-to-work' should be cancelled and Traction Power Controller advised, who will then arrange to remove the earth and restore power supply.

(c) "No part of the tree shall be nearer than 4 mts from the nearest live conductor. Any tree or branches likely to fall on the live conductor should be cut or trimmed periodically to maintain the safety clearances. The responsibility for wholesale

cutting of the trees, i.e. cutting of tree trunks, will rest with the Engineering Department. In the electrified territories, however, the cutting of the trees shall be done by the Engineering Department in the presence of authorized TRD staff to ensure safety and satisfactory completion of the work. The day-to-day trimming of the tree branches, wherever required, to maintain the 4m safety clearances from OHE shall be done by the authorized TRD staff and Supervisors.

In case of dispute, the decision whether to cut or trim a tree, shall be taken through a joint inspection of Engineering and Electrical officials.

The modalities to be adopted for cutting/trimming of the trees i.e. contractually or departmentally, may be decided by the respective departments based on local conditions. Accountal and disposal of trees cut wholesale will be done by the Engineering Department. While the disposal of the trimmed tree branches will be the responsibility of the TRD Department. The expenditure for cutting/trimming of trees to maintain safe clearance of OHE, shall be debited to revenue grant of TRD Department."

(d) No fallen wire or wires shall be touched unless power is switched off and the wire or wires suitably earthed. In case the wires drop at a level crossing, the Gatekeeper shall immediately make arrangements to stop all road traffic.

(e) Work on Station roofs and Signal Gantries- Staff working on station roofs and signal gantries and similar structures adjacent to Live Overhead Equipment shall not use any measuring tapes, tools and materials when there is a possibility of their being dropped or carried by wind on to the live overhead equipment.

(f) Earth Work – For excavation work adjacent to tracks, the following action is taken:-

(i) In D.C. traction areas, intimation should be given in writing sufficiently in advance to the concerned Traction Distribution Officer to enable him to depute the Traction staff to be present in order to prevent possible damage to the traction underground feeder cables witch are always located near the running lines.

(ii) In A.C. traction area, intimation should be given to the concerned officers of the Electrical General services and also S & T Department, since all the S & T and Electrical lines are cabled of account of Electrical Induction.

In all A.C. and D.C. traction area, cable markers showing location of cables are provided by the Traction Department. In addition, the cables are protected by tiles and bricks, and during excavation if workmen come across such tiles or bricks in an arranged manner, they should at once report the matter to the higher officials. Any further excavation should be carried out only in the presence of the authorized staff of Electrical Traction and or S & T Department as the case may be.

(g) **Alteration to Tracks –** The relative alignments of the centerline of the track with respect to the alignment of the contact wire must be maintained within the specified tolerances. This applies to both horizontal and vertical clearances. Slewing or lifting of track must nt be done outside the agreed maintenance limits, unless the position of the contact wire is altered at the same time. Adjustment of cant has a magnified effect of the horizontal displacement of the centerline of the track with respect to the alignment of the contact wire.

Horizontal clearances to structures within the limits laid down in the Schedule of Dimensions must be maintained. For Slewing or alternations to track involving adjustment of contact wire (outside the agreed maintenance limits) sufficient notice should be given to the traction staff so that they arrange to adjust the overhead equipment.

(h) **Alterations to Track bonding:** All bonds removed by the staff of the Engineering Department shall be replaced by the staff of the Engineering Department and all such removals and replacements shall be reported to the Assistant Electrical Engineer, Traction Distribution in-charge, concerned without delay.

(i) **Working of Cranes:** No crane shall be worked except on the authorized 'permit-to-work'. In every case of working a crane, arrangement should be made for the presence of authorized overhead equipment staff to ensure that all safety precautions are taken.

(j) **Inspection of Tunnels:** For inspection of roofs and sides of a tunnel, the overhead equipment shall be rendered 'dead'. Special insulated apparatus shall be rendered 'dead'. Special insulated apparatus should be used if sounding the unlined portions to locate loose rock in the roof and sides, is required to be carried out, when the overhead equipment is 'live'.

(k) As far as possible closed wagons shall be used for material trains. In case open or hopper wagons are used, loading and unloading of such wagons in electrified tracks shall be done under the supervision of an Engineering Official not below the rank of a Permanent Way Mistry, who shall personally ensure that no tool or any part of body of the workers comes within the 'danger zone' i.e., within 2m. of O.H.E.

(l) Steel tapes or metallic tapes with woven metal reinforcement should not be used in electrified tracks. Linen tapes are safer and, therefore, should be sued even though they are not accurate.

(m) The top foundation blocks in electrified structures should be kept clear of all materials.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-XII: Engineering Restrictions & Indicators

Session-37:Categorioes of Engineering Works, Engineering Fixed Signals/Indicators: Temporary and Permanent

---

Engineering Indicators:

Engineering Indicators may be classified in two categories as below:

Temporary Engineering Indicators:

These indicators are used in connection with execution of some engineering work and removed as soon as the work is over. These indicators are flood lit at night. Retro-reflective indicators need not to lit at night. Significance of each indicator is given as below:

(i) Caution Indicator – This cautions the driver to get ready to reduce the speed. Caution indicator shall be provided at 800m in rear of the speed indicator and at 1200m where the trains are required to stop dead as in this case more braking distance is required by driver. This shall consist of 1400mm long, 400mm wide. Fish tailed at one end and pointed at the other having 130mm dia holes 2 nos. for showing yellow lights at night . The board shall be painted yellow & black. Height of the board (bottom of the board) shall be 2.0M from rail level post will have 300mm high bends of white & black. Indicator shall be used in case of permanent as well as temporary restrictions. Temp. Engg. Indicator shall display at night 2 yellow lights to approaching trains or provided with fluorescent tape luminous paint or retro-reflective indicators (need not to lit at night.

(ii) Speed Indicator – It indicates to the driver to reduce the speed as indicated. This shall be provided 30M in rear from the point of commencement of speed restriction. Indicator shall consist of an equilateral triangular board with 1 meter

sides having yellow base, 300mm high and 40 mm thick figures in black indicating the speed at which the train may proceed. The board shall be provided on a 2.0m high post (from the rail level to bottom of the board) painted with 300mm high white and black bands Indicator shall be illuminated at night by fixing a hand signal lamp in front of it or provided with luminators.

(iii) Stop Indicator – It indicates to the driver to stop the train short of indicator. Indicator shall be provided 30m m in rear of the commencement of stop dead restriction. This shall consist of a rectangular board 1400mm x 400 mm in size having 130mm dia holes 2 Nos. for showing red lights at night painted with red and white vertical strips or provided with fluorescent tape luminous paint or retro reflective indicator. The board shall be fixed 2.0 meter high from rail level to the bottom of the board) painted with 300 mm high bands of white & black.

(iv) Termination Indicator – The indicates that the driver to resume normal; speed and last vehicle has cleared the restricted zone. This indicator shall be fixed at a distance equal to the longest length of passenger/goods train running in the section beyond the restricted zone.

The indicator shall be in accordance with the diagram &shall consist of one meter dia disc painted yellow bearing 250mm high and 40mm thick letter T P and T.G. in black. The board shall be painted with 25mm thick black band at the circumference. It shall be fixed on a post 1650mm high (from rail level to the bottom of the disc) and shall be painted with 300mm high bands of black & white. The indicator shall be lighted at night by a fixed hand signal lamp or provided with fluorescent tape luminous paint or retro reflective indicator.

Permanent Speed Restriction Indicators:

(i) These indicators are same as mentioned above but used at the locations requiring permanent speed restriction (less than maximum sanctioned speed) such as weak bridge, sharp curve, weak formation turn out etc. As these restrictions last beyond the currency of the working time table hence mention of such restrictions are made in the working time table. Indicators provided are not lit at night.

(ii) Siding Boards – Siding boards indicating speed restriction are provided at facing of an outlying siding letter 'S' is painted in 300 mm height with black paint on 1 metre dia circular board having yellow base. These boards are provided in addition to caution & speed indicator where maximum sanctioned speed of the section does not exceed 59 kmph.

Indicators (General):

These indicators are provided either to give audible warning by the driver to ensure safety or shunting operation.

Whistle Indicator (W):

Whistle Indicators shall be provided at 600 m in rear of the places where the view of driver is obstructed by cutting or tunnel or curves and where it is necessary to give audible warning at the approach of a train to those working on the track.

Whistle Indicators for Level Crossing (W/L):

These indicators shall be provided at the approaches of all unmanned 'C' class level crossing or manned level crossing where the view is not clear on either side for a distance of 600 metres and those which have normal position open to road traffic. Bilingual whistle boards shall be provided at 600 m distance along the track from the level crossing to give audible warning by the drivers of approaching trains to the road users.

Shunting Limit Boards:

Board shall be 600 x 1000 mm in size painted yellow with a black cross on top and shunting limit written in black below it.

Works at Times of Poor Visibility:

No work which may cause obstruction to the passage of train shall be undertaken during foggy or tempestuous weather impairing visibility except in case of emergency. When such works are undertaken 2 detonators, 10 m apart shall be fixed 270 m in rear of caution indicator and caution hand signal exhibited to approaching trains.

Speed Restriction:

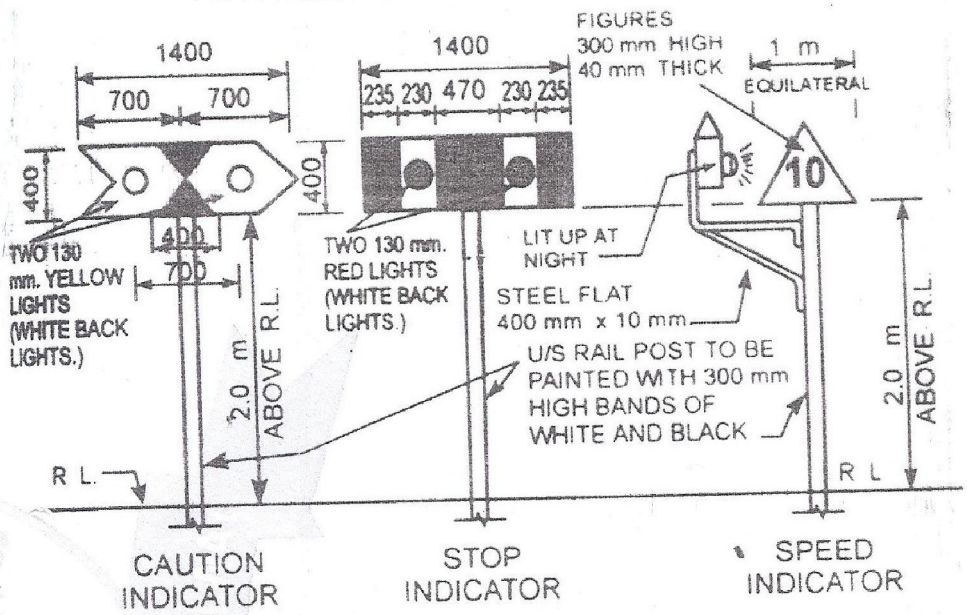
In case where the trains are required to pass with restricted speed from site of work, the following temporary Engineering Indicators shall be exhibited.

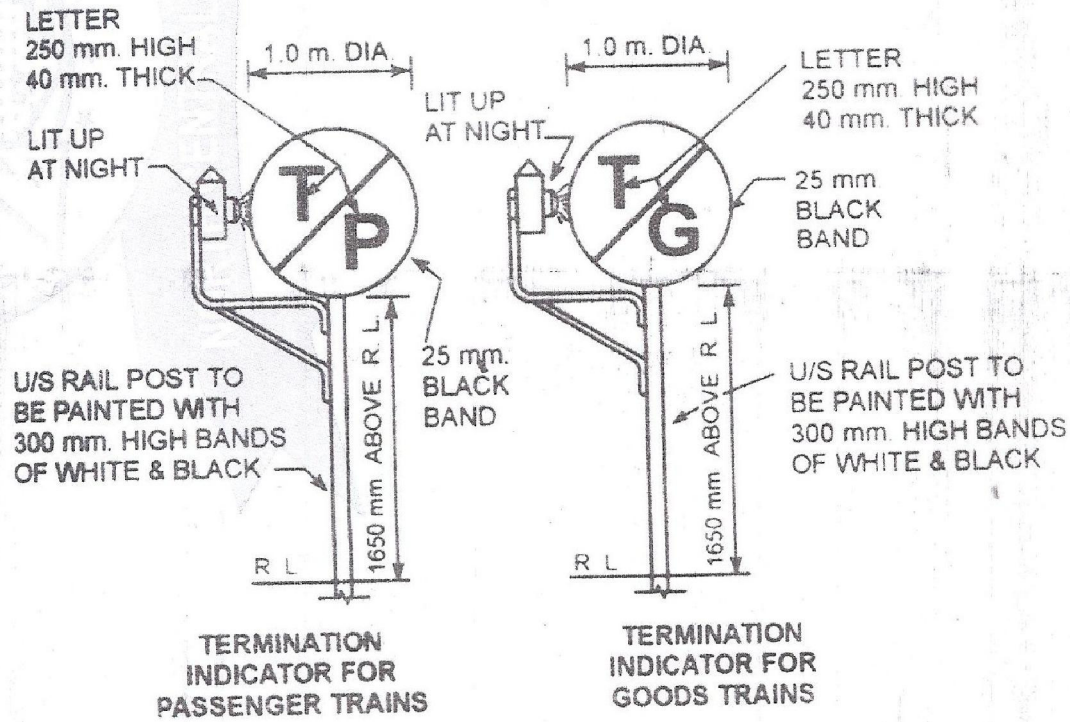
(i) Caution Indicator – At 800m in rear of the obstruction.

(ii) Speed Indicator – At 30m in rear of the obstruction.

(iii) Termination Indicators for passenger & goods train – At a place from where the driver may resume normal speed, which is the length of longest passenger/goods train running in the section.

ENGINEERING INDICATORS FOR TEMPORARY RESTRICTIONS





SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-XII: Engineering Restrictions & Indicators

Session-38: Emergency Protection of track: Single Line & Double Line, Detonators & Flare Signals.

Whenever in consequence of an obstruction to line or any other cause it becomes necessary to stop approaching train by railway official, he shall plant a danger signal in rear of the spot and proceed with all haste in the direction of an approaching train on double line or likely to approach first on single line showing danger hand signal (red flag by day and red light by night) to a point 600m on BG and 400 m on MG/NG from the obstruction. He shall fix one detonator over the rail. (Preferably supported by the sleeper underneath), after which he shall proceed further to a point not less than 1200m on B.G. and 800 m on MG/NG from the obstruction and fix 3 detonators 10 m apart. He shall take stand at a place not less than 45 m away from the last detonator from where he can obtain a good view of the approaching train. In case if no train is visible then he shall fix. 3 detonators on line and pick up intermediate detonator (provided at 600 m) continuing to show the danger hand signal and reach to the site of obstruction. In case of single line the track will be protected from other side in the similar manner.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-XIII: Curves Session-39: Necessity of curves: their types, TTP, CTP & Transition lengths.

Necessity of curves

Curves are provided to bypass obstacles, to have longer and easier gradients or to route the line to obligating or desirable locations.

CLASSIFICATION OF CURVES:

1. Simple Curve:

In this curve radius is uniform through out its length.

2. Compound Curve:

This type of curve is made of two or more curves with different radii but same flexure.

3. Reverse Curve:

This type of curve is made of two curves having opposite flexure with no straight in between or straight not less than 50m.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XIII: Curves Session-40: Radius, Degree, Versine & Field Measurement.

RELATION BETWEEN DEGREE AND RADIUS OF CURVE:

A curve is designed either by its radius or by its degree. The degree of a curve 'D' is the angle subtended at its center by a chord of 30.5.m or 100 ft.

2π R distance 360^0

1 distance $\frac{360}{2\pi R}$

30.5 distance $\frac{360}{2\pi R} \times 30.5$

$$D = \frac{1748}{R} = \frac{1750}{R}$$

$D = 1750/R$ or $RD = 1750$

VERSINE:

If a chord is stretched between two points on a curve, the perpendicular distance at any point between the chord and curve is called versine at that point.

PWI uses 20m chord. Stations are 10m apart. At every station STN No. (station Number), SE(Super-elevation) and V(versine) is written on sleeper.

Ex. SYN No. – 10

SE - 15mm

V - 9mm

RELATION BETWEEN VERSINEAND CHORD LENGTH:

Here

C- Chord length

V- Versine

2R- Dia of circle.

From theorem we know that

$$\frac{C}{2} \times \frac{C}{2} = \frac{V(2R-V)}{}$$

$$\text{or, } \frac{C^2}{4} = 2VR - V^2$$

V being very small V^2 is negligible.

$$\frac{C^2}{4} = 2VR$$

$$V = \frac{C^2}{8R}$$

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XIII: Curves Session-41: Super-elevation: Cant deficiency, Cant excess, Cant gradient, Equilibrium cant.

SOME DEFINITIONS:

Super-elevation or Cant (C_a):

Super-elevation or cant is the difference in height between the outer rail and inner rail on a curve. It is provided by gradually lifting the outer rail above the level of inner rail. The inner rail is considered as the reference rail and is normally maintained as its normal level.

Functions of super-elevation are:

(1) To have a better distribution of load on both the rails.

(2) To reduce the wear and tear of rails and rolling stock.
(3) To neutralize the effects of lateral forces.
(4) To provide comfort to passengers.

NOTE: In transition portion super-elevation increases, versine increases. In circular portion, both become constant.

RELATION BETWEEN SUPER-ELEVATION, SPEED AND RADIUS ON A CURVE:

EQUILIBRIUM SUPER ELEVATION:

Let Radius of the curve = R

Velocity on curve = V

Super-elevation = C

Mass = $m = \frac{W}{G}$

Now,

Centrifugal force on the rolling stock

$$F = \frac{MV^2}{R} = \frac{WV^2}{gR}$$

In ΔCAB, $\tan Q = \frac{AB}{AC} = \frac{F}{W} = \frac{V^2}{gR}$ - (1)

Again in $\Delta C'A'B'$ $\tan Q = \frac{A'B'}{AC} = \frac{C}{G}$ - (ii)

Where G = Dynamic gauge = Perpendicular Distance between centers of two rails.

= 1750 (BG)

= 1058 (MG)

From equation (i) & (ii)

$$\frac{C}{G} = \frac{V^2}{gR}$$

Or $C = \frac{GV^2}{GR}$

Or $C = \frac{GV^2}{127R} = mm$

NOTE: Super-elevation is provided in formation.

Max^m permissible cant – 165mm (BG) By the order of C.E. in station area for nominated stock max^m cant = 185mm.

Cant may be given by three methods.

1. Inner rail base rail.
2. Outer rail base rail
3. Outer rail is lifted equal to ½ cant and inner rail is downed equal to ½ cant.

EQUILIBRIUM SPEED:

It is the speed at which the effect of centrifugal force is exactly balanced by the cant provided.

Maximum Permissible Speed:

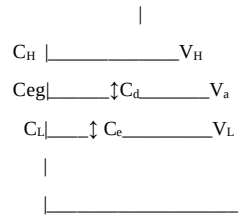
This is the highest speed which may be permitted on a curve taking into consideration the radius of curvature, actual cant, cant deficiency, cant excess and length of transition. When the max^m. permissible speed of the curve is less the max^m. Sectional speed of the section of a line, permanent speed restriction becomes necessary on such curves.

Cant Deficiency (C_d):

Cant deficiency occurs when a train travels around a curve at a speed higher than the equilibrium speed. It is the difference between the theoretical cant required for such higher speed and the actual cant provided.

Cant Excess (C_c):

Cant excess occurs when a train travels around a curve at a speed lower than equilibrium speed. It is the difference between the actual cant provided and the theoretical cant required for such lower speed.



CANT GRADIENT AND CANT DEFICIENCY GRADIENT:

These indicate the amount by which cant or deficiency of cant is increased or reduced in a given length of transition.

For ex: A gradient of 1 in 1000 means that cant or deficiency of cant of 1mm is attained or lost in every`1000mm of transition length.

Cant deficiency gradient

= 50mm: 100m

= 50mm: 100 x 1000mm

= 1: 2000mm.

RATE OF CHANGE OF CANT OR CANT DEFICIENCY:

This is the rate at which cant or cant deficiency is increased while passing over the transition curve.

For example: 35 mm/sec. Means that a vehicle when traveling at a maximum permitted speed, willl experience a change in cant or deficiency of cant of 35mm in each second of travel over the transition.

NOTE: Sectional speed is determined by commissioner Railway Safety (CRS)

Gauge	**Max^{m}. Degree**	**Radius**
B.G.	10^{0}	175m
M.G.	16^{0}	109m
N.G.	40^{0}	44m

LIMITED PARAMETERS CONCERNING CURVES:

S. No.	ITEM	B.G.	M.G.	N.G.
1.	Maximum cant.	'A', 'B' 'C' route –165mm "D' & 'E' - 140mm	90mm(100 with permission of C.E.)	
2.	Max^{m} cant deficiency	75mm (In spl. Cases 100mm with nominated rolling stock and permission of C.E.)	50mm	40mm
3.	Cant Excess	75mm	65mm	-
4.	Max^{m} cant gradient	In 720 (1 in 360 in exceptional cases with permission of C.E.)	1:720	-
5.	Rate of change of cant	Desirable 35mm/sec. Max^{m} 55mm/sec.	35mm/sec.	

TRANSITION CURVE:

A transition curve is an easement curve on which the change in degree of curvature and gain of super-elevation are uniform throughout its length, starting from zero at the tangent point to the specified value at the circular curve.

$Y = \frac{X^3}{6RL}$

Indian railways mostly use cubic parabola for transition curve.

R→ Radius in meter

L → Length of transition curve in meter

OBJECTIVES OF TRANSITION CURVE:

1. To decrease the radius of curvature gradually in a planned way from infinity at straight to that of the circular curve to help the vehicle to negotiate a curve smoothly.

2. To enable the vehicles to negotiate a curve smoothly ensuring a gradual increase or decrease of centrifugal forces.

3. To enable the vehicles to negotiate a curve smoothly ensuring a gradual increase or decrease of centrifugal forces.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XIII: Curves Session-42: Negative Super-elevation, Gauge widening.

GAUGE WIDENING AT CURVES:

For smooth running of a vehicle with rigid wheel base on sharp curves it is necessary for the rear axle to come in line of radius. A constant out ward thrust acts on the front axle, till the rear axle does not come in the line of radius due to which a vehicle tries to widen the gauge which is not safe. Therefore for such a curve it is necessary to widen the gauge.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XIII: Curves Session-43: Safe Speed on Curves.

SAFE SPEED ON CURVES

MAX^{m} PERMISSIBLE SPEEDON FULLY TRANSITIONED CURVE:

(1) V_m = $0.27 (C_a + C_d) R$ - B.G.

(3) V_m = $0.347 (C_a + C_d) R$ - M.G.

(3) V_m = $3.65 (R-6)$ - N.G.

But not more than 50 KMPH.

LENGTH OF TRANSITION:

It is maximum of the following:

(1) L = $0.008 C_a \times V_m$ (Based on rate of change of cant)

(2) L = $0.008 C_d \times V_m$ (Based on rate of change of cant deficiency)

(3) L = $0.72 C_a$ (Based on cant gradient)

Where $C_a \rightarrow$ cant actual

$C_d \rightarrow$ cant deficiency

$V_m \rightarrow$ Max^{m} permissible speed on a curve.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)
Lesson-XIV: Track Tolerances Session-45: Different Track Parameters and their service tolerances

---

TRACK TOLERANCES:

Safety in train operation and desired level of riding comfort to passengers is primarily based on track geometry and its standard of maintenance. Maintenance of high standard of tolerances in track is influenced by various factors of track design, manufacture laying and maintenance. In addition to if stable formation suitability and adequacy of ballast, good fastenings, and effective condition of other track components also pay a big role. Loss of track geometry in directly proportional to loss in track foundation. Therefore in actual practice it is not possible to obtain a flawless and perfect track parameters governing the track geometry. The limits by which the track parameters vary may be defined as the track tolerances.

Track Parameters:

The tolerances are generally laid down for the following track parameters-

(i) **Unevenness -** Difference in the longitudinal levels over a fixed base is called unevenness and is generally measured over a base of 3.6m for left & right rail separately.

(ii) **Gauge Variation –** This is measured as the deviation from the nominal gauge which is 1676 mm for BG & 1000 mm for MG Gauge is the minimum horizontal distance between running faces of two rails.

(iii) **Cross Level Difference –** This is measured in terms of relative difference in the level of two rail tops measured at the same point.

(iv) **Twist –** It is the rate of change of cross level per unit length. Twist is determined by measuring the cross level at two points over a fixed base say 3.6 m and divide the cross level difference by the base length. Normally it is denoted in mm/mtre.

(v) **Alignment Variation –** This is measured in terms of variation in versines taken on successive chords of fixed length of 7.2 in with overlaps of ½ chord on left & right rail separately.

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XIV: Track Tolerances Session-46: Different Track Parameters and their service tolerances

---

Tolerances Under Loaded or Floating Condition:

As regards unevenness, cross level and twist these parameters differ appreciably in loaded condition vis-a-vis in floating condition. Where as gauge & alignment almost remain unaffected.

Important of Tight Tolerances:

Keeping day by day increase in traffic density and higher speeds in view track must be maintained to close tolerances. It will be more economical to control and reduce the ill-effects of badly maintained track by enforcing tight tolerance in the track which can be obtained by machine maintenance than by providing a heavier track structure to increase its strength large tolerances in track cause heavy oscillations in the vehicles and these are retransmitted to the track causing progressive deterioration.

Types of Track Tolerances:

The purpose of controlling track irregularities is to keep the track in safe and smooth running conditions. With increase in track irregularities vibration of vehicles exceed. Efforts to keep track irregularities within close tolerances lead to high maintenance cost. Therefore it is beneficial for the Railways Administration to lay down track tolerances which give most cost-effective solutions, depending upon their purpose, track tolerances are classified as below:

New Track Tolerances:

These tolerances are prescribed for laying new track and also meant for testing the quality of newly laid track. Since the material is new and track laying is done independent of traffic blocks, the tolerances prescribed for new track are the closest.

The following limits of track geometry should be observed as a desirable initial standard for track laying with new materials.

(a) **As recorded by track recording car –** The track parameters should generally conform to category 'A' values.

(b) **As recorded by portable acceler –** meter/OMS-2000 – Vertical or lateral acceleration value should be within 0.15 g.

(c) As measured in floating condition – The track parameters should conform to the following standards-

S. No.	Parameter	Particulars	Value
1	Gauge	Sleeper to Sleeper variation	2mm
2	Expansion gap.	Average gap worked out by recording 20 successive gaps.	± 2mm
3	Joints	i) Low joints ii) High joints iii) Squareness of joints on Straight	Not permitted. Not more than 2 mm ± 10mm
4	Spacing of sleeper	With respect to theoretical spacing	± 20mm
5	Cross level	To be recorded on every 4^{th} sleepers	± 3mm
6	Alignment	On straight on 10M chord On Curves Radius≥ 600m on 20M chord (Variation over theoretical versine) Radius < 600mm on 20M chord (Variation over theoretical versine)	5mm 10mm
7	Longitudinal level	Variation with reference to approved longitudinal level	± 50mm

Maintenance Tolerances:

These are the tolerances which are set for bringing back the track geometry to the desired standards after every maintenance operation cycle. The tolerances depend not only upon the track structure but also on the tools/equipments used, method of maintenance adopted, supervision of maintenance adopted, supervision available and such other factors. These tolerances are set arbitrarily to assess the results of maintenance.

Northern Railway has however laid down the following tolerances for maintaining the track with tie tamping machines-

Unevenness	3mm over a base of 3.6m
Alignment	2mm over a base of 7.2m
Cross level	2mm.

In case of manual maintenance also the above tolerances can be obtained.

Index Tolerances:

S. No.	Parameter	Index Tolerance
1	Cross Level	3mm
2	Alignment on 7.2m chord	3mm
3	Sleeper to sleeper variation in gauge	2mm

SUB DISCIPLINE-TRACK TECHNOLOGY (LESSONS: 15 SESSIONS: 47)

Lesson-XV: Schedule of Dimensions Session-47: Different Schedules, Standard Dimensions, Loading Gauge, ODC.

Schedule of Dimensions:

Present Schedule of Dimensions:

The present SOD revised in the year 2004 consist all the dimensions in metric units. All the dimensions in FPS units have been deleted. The following modifications have been done in the SOD of 1973:

Schedules:

Revised SOD of year 2004 contains only two schedule i.e. **Schedule-1 & Schedule-II.**

Schedule-I: Consists of those items which are mandatory and have to be observed on all 1676mm gauge on Railways in India. This also contains certain selected items of schedule-II of 1973 version of SOD. In this schedule, dimensions have been classified under two heads namely for "Existing works" i.e. the works existing before the issue of new SOD year 2004 and for "New works" which would include new constructions, additions of new lines/structure, gauge conversion and doubling except the alterations to points & crossing siding, building etc. Any deviations to the dimension of new works will require prior sanction of CCRS/CRS.

Schedule-II: Consists of items included in Schedule-III of 1973 version of SOD.

In addition to above the appendix dealing with extra clearances required on curves have been modified to suit maximum speed of 160 Kmph and maximum SE of 165mm as per high speed, Rajdhani and Shatabdi routes with other parameters kept as earlier. Correction slips issued from time to time to SOD of 1973 have been incorporated in revised SOD of year 2004.

Chapter Wise Details of Contents in Schedule of Dimensions:

	Chapter	Schedule	Details of Contents
I	General	1	Spacing of tracks curves bridge, rails, building and structures, interlocking and signal gears tunnels, through semi through girder bridges and safety refuges formation width gauge on straight and curves.
II	Station Yards	1	Spacing of tracks, platforms, buildings & structures,

			points and crossings, length of sidings.
III	Workshop & Station machinery	1	Water tanks and Water Cranes, workshops and running sheds.
IV(A)	Rolling stock (C&W)	1	Wheel and axles, height of floors, buffers & couplings wheel base & axles base and length of vehicles, max moving dimensions, loading gauge for goods
IV(B)	Rolling stock (3660mm wide stock)	1	Maximum future moving dimensions, loading gauge for goods.
IV(C)	Rolling Stock (Locomotives)	1	Wheels and axles, buffer & couplings, max. moving dimensions, max. moving dimension for Locomotives.
V	Electric traction (DC)		
V(A)	Electric traction 25KV AC 50 Cycles		Electrical Clearances
	AC 50 Cycles Schedule	II	Existing infringements of schedule 1 which may be permitted to continue on 167mm gauge railways.

Loading Gauge:

Loading gauge represents the maximum width and height to which a rolling stock viz, Locomotive, Coach or Wagon may be built or loaded.

On Indian Railways maximum height and width of rolling stock prescribed as per loading gauge is as follows-

Maximum Height	4565mm
Maximum Width	3250mm

Construction gauge is decided by adding necessary clearance to the loading gauge so that vehicles can move safely at prescribed speed without any infringements. Various fixed structures on the railways like bridges; tunnel and platform sheds etc. are built as per construction gauge so that the sides and top remain clear of the loading gauge.

Standard Moving Dimensions:

Construction of rolling stock (Loco, carriage and wagon) and movement of conventional rolling stock is based on certain standard moving dimensions provided in the SOD. Sometimes very large consignments which when loaded on ordinary or special wagons exceed the standard moving dimensions, their transportation development of industries in a region etc.

Indian Railways have evolved a standard procedure to enable quick movement of such consignments with certain restrictions regarding day or night movement, speeds loading, lashing & packing conditions depending upon the minimum clearance available to fixed structures on the routes required to be traversed. Such consignments are called “Out of Gauge” or Over Dimension Consignments.

Over Dimensioned Consignment (ODC):

When a consignment whose length, width and height is such that one or more of them infringe the standard moving dimension at any point during the run, then the consignment is called as Over Dimensioned Consignment (ODC). The movement of ODC has been standardized on Indian Railways and each zonal railway keeps the upto date list of infringements.

In case of loaded consignment extra clearance of 75mm for bounce in the vertical direction on a straight track shall be accounted for between consignment & fixed

structure. But in case of curved track the following additional factors shall be taken into account.

1. Horizontal Clearance	Allowance for lean due to super elevation and overhead due to curvatures additional lurch on curves.
2. Vertical Clearance	Vertical tilt to be added to the height of consignment.

Classification of ODCs:

Taking into account of extra clearance as indicated above, oversized consignments are classified into following three classes –

(i) Class 'A' – Permitted out of gauge loads or O.D.C.
These loads which exceed the maximum moving dimensions but do not ingringe any fixed structure on the route by a net cerance of 150mm and above and gross clearance of 225mm and above.

(ii) Class 'B' – Exceptional out of gauge loads or ODC.
Where the net clearance ranges from 75mm to less than 150mm and grss clearance of 225mm.

(iii) Class 'C' – Extra-orinary out of gauge loads or ODC
Where the net clearances are less than 75 mm and gross clearance less than 150mm.

SUB: P.WAY, ESTABLISHMENT,ACCOUNTS,STORES &RAJBHASHA

Duration: 74 Sessions = 148 Periods

Sub Discipline - Establishment

(Lessons: 13 Sessions:14)

Lesson-XVI: Leave Rules Session-48:Various types of Leaves, Eligibility etc.

Various types of Leaves

Q. By which Leave rules Rly. Employees are governed ?

Ans. Rly. employees are governed by "Liberalized Leave Rules" (LLR) also know as CPC (Central Pay Commission) Leave Rules.

Q. When these rules came into existence ?

Ans. Since 1st February, 1949.

Q. What kind of Leave are admissible ?

Ans. The following kinds of Leave are admissible:-

I. LAP (Leave on Average pay)
II. LHAP (Leave on Half Average pay)
III. Commuted Leave
IV. C.L. (Casual Leave)
V. S.C.L. (Special Casual Leave)
VI. Compensatory Casual Leave
VII. Extra ordinary Leave
VIII. Leave not due
IX. Maternity Leave
X. Hospital Leave
XI. Special Disability Leave
XII. Study Leave

I. LAP (LEAVE ON AVERAGE PAY)

Q How much LAP is admissible in a Calendar year ?

Ans. 30 days to all Railway servants except employees serving in a Railway School.

Q. Whether L.A.P. is credited in advance ?

Ans. Yes.

Q. How L.A.P. is credited to leave A/c ?

Ans. In two installments in a calendar year, on 1st day of January and on 1st day of July @ of 15 days each.

Q. How many L.A.P.',s are credited in the half year of appointment, retirement, removal and dismissed or death in service ?

Ans. At the rate of 2.1/2 days per month.

Q. Upto what extant L.A.P. can be accumulated ?

Ans. Upto 300 days, thereafter it will Lapse.

Q. Whether L.A.P. can be prefixed or suffixed to holidays ?

Ans. Yes.

II. LAP (LEAVE ON HALD AVERAGE PAY)

Q. How much L.H.A.P. is admissible in each completed year of service ?

Ans. 20 days.

Q. How L.H.A.P. is credited ?

Ans. In two installment of 10 days each on 1st Jan. and 1st July every year.

Q. How much L.H.A.P. can be granted in the half year of appointment, retirement, removal, dismissal or death ?

Ans. At the rate of 5/3 days for each completed month of service.

III. COMMUTED LEAVE

Q. What is Commuted leave ?

Ans. Commuted leave is a leave granted on Medical Certificate not exceeding half the amount of leave on half average pay.

IV. CASUAL LEAVE (C.L.)

Q. What is Casual leave ?

Ans. Casual leave is a leave admissible to Railway Servants in all groups (i.e. A.B.C.&D) and is granted to enable them to attend to sudden/unforeseen needs/requirements.

Q. Whether it is a recorded Leave ?

Ans. No

Q. Whether C.L. may be prefixed or suffixed ?

Ans. Yes

Q. Whether Sundays, Holidays, Closed days and Weekly offs falling within C.L., will count as C.L. ?

Ans. No

Q. Whether C.L. can be combined with any other leave ?

Ans. No except Compensatory C.L. to Group 'C' & 'D' Staff.

Q. Whether C.L. can be granted for half day ?

Ans. Yes.

V. SPECIAL CASUAL LEAVE (S.C.L.)

Q. For what purposes Special Casual leave is Granted ?

Ans. Special Casual leave is Granted for the following purposes:-

(i) For participation in sports events/Tournaments of National and International importance.
(ii) For Scouting work.
(iii) For participation in Cultural activities like Dramas & Music Competitions.
(iv) For attending meeting of Unions/Federations.
(v) Fir attending meetings if Technical/Scientific Institutions.
(vi) Fir attending meetings/conferences of medical institutions by Doctors.
(vii) For attending Republic Day parade.
(viii) For attending Courts as Jurors or Assessors.
(ix) For attend to work connected with running/administration of Rly. men's co-operative Societies.
(x) For attending to work connected with running/administration of Rly. men's co-operative Societies
.For attending Annual Training Camp of Territorial Army.
(xi) For appearing as Defence Helper in departmental enquiries.
(xii) For casting vote in elections of Lok Sabha or Assemblies to employees residing at a place where the date of polling is different from that at the place working.
(xiii) For voluntary donation of blood.
(xiv) For promoting small family norms under the Family Welfare programme
(xv) For unavoidable absence due to Bandhs, Curfew, dis-location of train services or other disturbances.

Q. Upto what extent Special Casual leave can be granted ?

Ans. It may be sanctioned to the extent of actual time Spent in the events subject to a maximum of 30 days in a calendar year to be extended upto 90 days by G.M. in case of participation in sports events of national and international importance.

VI. COMPENSATORY CASUAL LEAVE (C.C.L.)

Q. What is C.C.L.?

Ans. C.C.L. is a Leave granted to the Ministerial Staff and Group 'D' Staff in offices, excepting supervisors for attending office on Sundays, Closed days, Weekly offs and holidays.

Q. Whether C.C.L. can be prefixed or suffixed with C.L., Sundays and holidays?

Ans. During which period C.C.L. can be availed?

Q. How many C.C.L.'s can be availed at one time?

Ans. Three

VII. EXTRA ORDINARY LEAVE (E.O.L.)

Q. Under what circumstance. E.O. is granted?

Ans. E.O.L is granted under the following special circumstances:-
(i) When no other leave is admissible.
(ii) When other leave is admissible, but the employee applies in writing for the grant of such Leave.

Q. To what extant E.O.L. is granted to Permanent or Temporary Employees?

Ans. (i) To Permanent employees — Upto a maximum of 5 years in one spell together with all kinds of leave

(ii) To Temporary employees — Upto 3 months without Medical Certificate upto 6 months with medical Certificate. Upto 18 months for treatment of cancer, Mental illness, T.B. Leprosy.

Q. Whether E.O.L. can be combined with any other leave.

Ans. Yes, except C.L.

Q. Whether Leave salary is admissible during E.O.L.?

Ans. No

VIII. LEAVE NOT DUE

Q. What is leave not due ?

Ans. It is leave on half average pay granted in advance of earning on medical Certificate with prospect to returning on duty after availing leave.

Q. To whom is granted ?

Ans. To both permanent & Temporary employees, except teaching staff.

Q. What is the Quantum of Leave ?

Ans. 360 days maximum to Permanent employees during entire service and 360 days to Temporary Railway employees suffering from T.B., Cancer, Mental ailment and Leprosy.

IX. MATERNITY LEAVE

Q. Who are eligible for grant of Maternity Leave ?

Ans. Female Railway employees, including apprentices with less than two surviving Children.

Q. What is the Quantum of leave ?

Ans. (i) 135 days from the date of commencement.

(ii) 6 weeks in case of mis-carriage including abortion. Total period restricted to 45 days in the entire service.

(iii) In further continuation, leave may also be granted (including commuted leave upto 60 days and leave not due) upto a maximum of 1 year, if applied for without production of medical certificate.

(iv) In further continuation also, Leave may be granted for illness of female employee and also in case of illness of newly born child beyond one year.

(v) A male Railway Servants (includings an apprentice) with less than two surviving children is also eligible for Maternity Leave for a period of 15 days during the confinement of his wife.

Q. Whether Maternity Leave is a recorded Leave?

Ans. No

Q. Whether it may be combined with any other leave?

Ans. Yes.

Q. Whether it is granted to Female Casual labour with temporary status?

Ans. Yes.

X. PATERNITY LEAVE

Q. Who are eligible for grant of Paternity Leave ?

Ans. A male Railway Servants (includings an apprentice) with less than two surviving children is eligible for Paternity Leave for a period of 15 days during the confinement of his wife.

Q. Whether Paternity Leave is a recorded Leave?

Ans. No

Q. Whether it may be combined with any other leave?

Ans. Yes.

Q. Whether it is granted to Male Casual labour with temporary status?

Ans. Yes.

XI. HOSPITAL LEAVE

Q. Under what circumstances Hospital Leave is granted?

Ans. It is admissible to the Group 'C' or 'D' employees while under treatment for illness or injuries met directly due to risks incurred in the course of official duties even if injuries incurred due to carelessness of employee.

Q. Upto what extent leave is admissible?

Ans. May be granted for such period, as the authority granting if considers necessary and certified by the authorized medical attendant.

Q. Whether there is any maximum limit?

Ans. No, the amount of leave granted by G.M. is un-limited.

Q. Whether it may be combined with any other leave?

Ans. Yes, provided on combination, the total period of Leave does not exceed 28 months.

Q. What leave salary is payable during leave?

Ans. Equal to leave salary on Average pay for the first 120 days and equal to leave salary o Half Average pay for remaining period.

XI. SPECIAL DIS-ABILITY LEAVE

Q. What is special dis-ability leave?

Ans. The leave is granted when an employee is disabled by injury inflicted internationally in consequence of due performance of his official duly or official position.

Q. To whom admissible?

Ans. Both to permanent and temporary employees.

Q. What is Quantum of Leave?

Ans. As certified by authorized Medical Attendant.

Q. Whether there is any maximum limit?

Ans. Yes, Shall in no case exceed 24 months in respect of one dis-ability.

Q. Whether this Leave may be combined with any other leave?

Ans. Yes.

Q. What Leave salary is granted during Leave?

Ans. For the first 120 days, equal to leave salary on Average Pay-for the remaining period equal to leave salary on Half Average Pay.

Q. Whether in the case of employees governed by W.C. Act, the amount of leave salary shall be reduced by the amount of compensation payable?

Ans. Yes.

XII. STUDY LEAVE

Q. Under what circumstances study Leave is Granted?

Ans. This may be granted for study in following cases:-

(i) To under go a special course of study consisting of higher studies of Technical subject having a direct and close connection with the sphere of his/her duty in or outside India.

(ii) For a course of training or study tour certified to be of definite advantage to Govt. and related ti sphere of duty.

(iii) For study, not closely or directly connected with the work of railway employee but which is capable of widening his/her mind and improve his/her abilities as civil servant.

(iv) For pursuing a course of Post Graduate study in Medical Science in India by Medical Officers if it shall be valuable in increasing efficiency of medical officer in performance of his/her duties.

(v) For post Graduate study in Medical Science outside India if Director General Railway Board certifies such study will be valuable in increasing the efficiency of such Medical Officer in performance of his/her duty.

XIII. EX-INDIA LEAVE

Q. What is Ex-India Leave?

Ans. Ex-India leave is an authorized leave which can be availed out of India.

Absence beyond 5 years

Q. How is the period of absence beyond 5 years to be regularized?

Ans. In case a Railway Employee remain away from work beyond 5 years it becomes an unauthorized absence, since rules permit authorized absence upto 5 years. Regularization of period of absence beyond 5 years has to be regularized by Railway Board. Every Railway Employee become liable for action under D&AR for any unauthorized absence.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)

Lesson-XVII: Pass Rules Session-49: Various types of passes, Eligibility etc.

Pass Rules

Eligibility for Various Type of Passes:

(1) Group A&B(Gazzated) First Class A

(2) Group B(Non Gazzated) &Group C

(a) Those appointed prior to 01-08-69

(i) Employees drawing Pay of Rs 5000/-or more in the scales the maximum of which is 6000/- **First Class**

(ii) All other employees **Second/sleeper class**

(b) Those appointed from to 01-08-69 to 31-03-87

(i) Employees drawing Pay of Rs 5375/-or more in the scales the maximum of which is 7000/-or more First Class

(ii) All other employees **Second/sleeper class**

Eligibility for Various Type of Passes:

(c) Those appointed from 01-04-87 to 01-02-99

(i) Employees drawing Pay of Rs 7250/-or more First Class

(ii) The employees in the scales, the Minimum of which is 6500/- **First Class**

(iii) All other employees **Second/sleeper class**

(d) Those appointed after 01-02-99

(i) Employees in the scales the minimum of which is 6500/- **First class**

(ii) Employees drawing Pay of Rs 7600/-& above First Class

(iii) In the Scales of 5000-8000/5500-9000,Pay>7250<7600/ **Second Class A**

(iv) All other employees **Second/sleeper class**

(3) All Group D Employees: **Second/Sleeper class**

Note: The second class A pass holders can travel by 3rd AC.

Definition of the Family:

As per the pass rules, the family consists of the following members.

(1) Husband/wife of the employee.

(2) Son below 21 years of age &fully dependent on the employee.

(3) Son above 21 years of age if he is studying in a recognized institute or he is doing research without Scholarship or he is working as a trainee under a chartered accountant or he is disabled as per the medical certificate given by the doctor.

(4) Unmarried daughter of any age

(5) Widow daughter if dependent on the employee

(6) Divorce daughter if dependent on the employee.

Definition of dependents

As per the pass rules the dependent members are.

If father of the employee is not alive:

(1) Mother including divorce mother

(2) Unmarried/widow sister

(3) Brother/step brother below 21 years of age if he is living with the employee &dependant on the employee.

(4) Disabled brother of any age.

(5) Brother studying in the recognized Institute.

(6) Divorce daughter if dependent on the employee.

Note: A person will be treated as dependent if his total earnings from all the sources are less than 15% of the emoluments of the employee.

Definition of the attendant:

Any person who is in personal service of the employee.

Some of the serving &Retired employees have a misconception that they can take any known person/relative as an attendant. This has been clarified by the Board.

The attendant can travel in second class along with the employee. In case the attendant can not travel in the same train such as Rajdhani/ shatabdi,then separate pass in second class can be issued to the attendant.

Definition of the guardian:

The meaning of the guardian should not be taken in legal terms.

Any adult family member/relative/paid nurse/ governance/attendant can be guardian of a child to accompany him. If no body from the above is available then the pass of the guardian can be issued to any other person with the approval of G M.

Type of passes:

(1) Duty pass

(2) Privilege pass

(3) School pass

(4) Post retirement Pass

(5) Residential card pass

(6) Special pass

Duty Passes:

These passes are issued to the Railway servants to travel on duty. These can be in the form of

(1) Metal pass

(2) card pass

(3) check pass

Card pass:

It is given to the employees who are required to travel frequently. It is issued for travel over a certain period of time say 01 year. It can be renewed every year if required. Its availability should be limited to that area in which the frequent travel is required. Photograph should be pasted on the card pass.

Check duty pass:

It is given to the employees for general travel on duty. The availability of check pass should be enough to cover the duty period.

Transfer & Kit pass:

Check pass is given to the employees & his family for travel on transfer to new place of posting. Separate passes can be issued for the employee & his family if the family travel afterwards. The transfer pass is given of the same class as the privilege pass.

Kit pass is given for carrying house holds/car e. t. c.

Privilege pass:

(A) Gazatted officers: 6 sets of passes in a year.

Staff: 1 set of pass up to 5 years service &3sets of pass after 5 years service.

P T Os:

(A) 4 sets of P T Os in a year to all the employees.

School pass:

School pass is issued to the children of the employee studying at some other station. These are issued on the basis of the certificate issued by recognized schools. In a year,6 one sided passes can be issued for the student. These are issued if there is a leave of at least 03 days in the school or school is suddenly closed due to other reasons.

The school pass is issued from the station where the school is situated to the HQ of the employee

or from the school to that station other than the HQ of the employee where any one of the parent stays due to some reasons or from the school to some other station provided the distance of that station is less than the residence of father/mother & it is beneficial to employee.

Post retirement passes:

Residential card passes:

This pass is issued to the employees who live away from their work place. These are issued for those sections where this facility was provided prior to 14-01-1953.

Special passes:

(1) For medical treatment: If the medical facilities are not available at the station where the staff is posted, then a pass shall be issued to him for a station where the medical facilities are available.

(2) For Taking Part in the sports: These passes are issued to the players for taking part in the sporting events organized by Railway Board & other recognized sporting events.

(3) For the scouting activities: These passes are issued to the staff who are office bearers of scouting association or rovers or rangers or cubs or bulbuls or scout or guide for taking part in the camps etc.

(4) Settlement pass: On retirement the employee issued a pass for journey from the station of his retirement to the station where the employee has settled. In case of death of the employee, this pass is given to the widow.

(5) For attending the courts as a witness the passes are given to the employees.

(6) Passes to suspended employees: If the suspended employee has been given permission to leave the H Q then passes can be issued as follows

(a) Group A &B officers: 3 sets of his privilege passes, if the officer has already taken 3 sets then –NIL.

(b) Group C &D staff: 1 set of his privilege passes, if the staff has only one set in his account then-NIL.

(7) P T Os to the suspended employees:3 sets to all category of the employees. the PTOs already availed to be deducted from these 3 sets.

(8) Powers to issue passes to the suspended employees

(a) Group A &B officers: General Manager

(a) Group C &D staff: DRM or Dy HOD

(9) School passes are not affected by suspension.

(10) Passes to the physically challenged employees: The pass is issued along with an attendant.

Punishment for misuse of Pass/PTO:

Misuse of pass: The misuse of pass/p t o is a severe offence. Necessary charge sheet shall be issued & action shall be initiated against the employee for imposing a suitable punishment commensurate with the offence.

Punishment for loss of Pass/PTO:

(1) For Railway employees:

(a) Duty/residential card pass

First class/first class A/white pass	Rs 35/-
Second class	Rs12.50/-
Trolley pass	Rs 50/-

(b) Duty check pass/privilege pass

First class/first class A/white pass	Rs 10/-
Second class:	Rs 5/-

Punishment for loss of Pass/PTO:

(2) For non-Railway employees/non Railway organizations/ Honarium individual passes.

(a) Card pass

First class	Rs 150/-
Second class	Rs75/-

(b) Duty check pass

First class: full fare but Maximum of	Rs 50/-& minimum of Rs 10/-
Second class: full fare but maximum of	Rs 30/-& minimum of Rs 5/-

Punishment for loss of Pass/PTO:

(3) ForG R P/P&T/Railway Magistrate:

(a) First class/first class A/white pass	Rs 35/-
(b) Second class	Rs12.50/-

Punishment for loss of Pass/PTO:

(4) Post retirement cheqe pass:

(a) First class/first class A/white pass Rs 25/-

(b) Second class Rs 10/-

(5) For not putting dates on privilege/duty cheque pass after commencement of journey:

(a) First class/first class A/white pass Rs 25/-

(b) Second class Rs10/-

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)
Lesson- XVIII:P.L. Bonus & GIS Session-50: Terms of Payments PLB, GIS Monthly subscription, Payment at retirement.

Scheme of Productivity Linked Bonus:

The scheme for the grant of productivity linked bonus to Railway Employees which has been introduced in 1979 is briefly stated as under:

(1) Applicability: The Scheme shall cover all employees in service on or after 1.4.79 as stated below:

(a) All Railway servants excluding Railway Protection Force and Railway Protection Special Force.

(b) Casual labour with temporary status and substitutes with not less than 120 days continuous service.

(c) Casual labour on daily wages employed in projects who have completed 180 days continuous service.

Group Insurance Scheme

The existing Insurance Scheme as mentioned above has been replaced by a new Group Insurance Scheme for the regular employees of the Central Government. The scheme is wholly contributory and self financing. It came into force w.e.f. 01.01.82. It has become compulsory for the employees who enter into Central Government service after 01.11.80 and will be optional for the employees already in service on 01.11.80. If any employee wanted to opt out of the scheme, he was allowed to exercise an option to the effect upto 31.12.1980. Those who are willing to be governed by this scheme need not exercise any option. The employees ho have opted out of the new scheme will continue under the existing Insurance Scheme as mentioned above.

Note: According to Fifth Pay Commission report the rates of monthly subscription and amount insured are as under:

	Monthly Subscription	Amount insured
Group 'D'	Rs. 30/-	Rs. 30,000/-
Group 'C'	Rs. 60/-	Rs. 60,000/-
Group 'B'	Rs. 120/-	Rs. 1,20,000/-
Group 'A'	Rs. 240/-	Rs. 2,40,000/-

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13 SESSIONS:14)

Lesson-XIX:Allowances & Overtime Session-51: Various Types of Allowances & Eligibility

---

1.8.3 Overtime:

The overtime allowance shall be paid at the rate of 1½ times the ordinary rate of pay in cases where overtime worked is within the limits of rostered hours and statutory hours. But where the overtime is worked beyond the statutory limits, payment shall be made at two times the ordinary rate.

Various Types of Allowances:

1. Dearness Allowance.
2. Compensatory City Allowance.
3. House Rent Allowance.
4. Washing Allowance.

5. Over time Allowance.
6. Night Duty Allowance.
7. National Holiday Allowance.
8. Nursing Staff Allowance.
9. Non Practicing Allowance.
10. Daily Allowance
11. Transfer Allowance
12. Conveyance Allowance
13. Allowance in lieu of kilometerage.
14. Breach of Rest Allowance
15. Out Station Detention Allowance
16. Accident Allowance
17. Outstation (Reliving) Allowance
18. Officiating Allowance
19. Breakdown Allowance
20. Special Allowance to Gate man
21. Extra Duty Allowance
22. Teaching Allowance

.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)
Lesson-XX: P.F. Session-52: Meaning, Rate, Withdrawal

Provident Fund:

Provident Fund:

Provident Fund means a fund in which the subscription of the employees are received and held on their accounts along with the interest accruing on such subscription.

Every Railway employee on completion of one year's service is entitled to joint the Provident Fund, and a P.F. Account number is allotted to him by the Chief Accounts Officer. It has been made compulsory for every Government servant to contribute to a General Provident Fund except those employees who are re-employed after final retirement from Government service and also those employees whose services were pensionable even before 16.11.57, the date of introduction of Pension scheme of the Railways.

A Railway servant who is subscribing to the S.R.O.F. (non-contributory) shall be exempted from making any subscription to the state Railway Provident Fund during the last 3

months of the service. The discontinuance of the subscription would be compulsory and non optional. (R.B. No. F(E) III-85/PF/1/13 of 7.7.86 (N.R. S. N. 9024)

Special Contribution to Provident Fund:

Admissibility – Formerly this used to be "Gratuity' which meant a gift given to an employee as a reward for satisfactory and faithful service 'Gratuity' being attachable could be a cause of inconvenience to the employees, as such it was decided to rename it 'Special Contribution to Provident Fund'. Assets of provident fund are not attachable under the P.F. Act.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)

Lesson-XXI: Pension Rules Session-53: Pension Rules.

Pension Scheme:

Kinds of Pension: Pension is divided into two categories i.e. Ordinary Pension and extraordinary Pension.

Ordinary Pension – It is further divided into four classes viz –

(a) **Compensation Pension -** This pension is grated to those employees who are discharged from service on account of abolition of the posts held by them and failure of the administration to provide other suitable jobs of more or less equal status and emoluments.

(**b)** **Invalid Pension –** This is granted to those employees who are found unfit for further service on account of some physical or mental infirmity. If however the unfitness is directly due to the irregular or intemperate habits, no pension will be granted.

(c) **Superannuation Pension –** This is granted to the employees when they attain the age of superannuation i.e. the age of retirement.

(d) Retiring Pension – This is granted to the employees who retire on completion of 30 years of satisfactory service either at their own option or on the orders of administration. Three month's notice for such retirement is necessary.

Extraordinary Pension:

This pension is granted to an employee who is injured and to his family when he is killed or succumbs to the injuries sustained while in the proper execution of his duty.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13 SESSIONS:14)

Lesson-XXII:DCRG Session-54: Amount of DCRG, Emoluments.

Death-Cum-Retirement Gratuity

Amount of D.C.R.G. – This gratuity will be paid to the pensionable employees, on their retirement, or to their families in the event of their death while in service. This will be granted in addition to the ordinary gratuity or monthly pension that may be admissible to the employee under the rules. The rate of death-cum-retirement gratuity is one-fourth of the monthly emoluments for each completed six monthly period of qualifying service subject a maximum of 16½, times of the emoluments. The amount of D.C.R.G. shall not exceed Rs. 3.5 lakh w.e.f. 01.04.96. In the event of death of an employee while in service the gratuity will be subject to the following minima:

1. If death occurs in the first year of service two months' emoluments.
2. If death occurs after completion of first year service but before completion of five years service six months' emoluments.

3. If death occurs on or after 5 years of service but less than 20 years 12 months' emoluments.
4. If death occurs on or after 20 years of service half of monthly emoluments for every completed 6 monthly period of qualifying service subject to a maximum of 33 times provided that amount of death gratuity shall in no case exceed Rupees 3.5 lakh.

Note: There will be no ceiling of reckonable emoluments for calculating gratuity.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)
Lesson-XXIII: D&A Rules Session-55: Minor Penalties.

D & A R (1968), H.O.E.R. AND ACTS

1. Penalties:

Two groups of penalties are laid down under rule 6 of D&AR 1968 viz major and minor penalties.

1.1 Minor Penalty:

Are those where a Simple procedure is followed as laid down in the D&AR 1968 except where with holding of increment with cumulative effect for any period or with holding of increment exceeding 3 years without cumulative effect or effecting the pensionary benefits adversely, an inquiry.

1.1.1 Minor Penalties:

i) **Censure -** Though this is one of the lightest punishment and there is no loss to the employee yet it can affect his merit when considering his suitability for higher promotion.

ii) **With-holding of promotion for a specified period –** This penalty should be imposed only when an employee is due promotion in near future.

iii) Recovery from pay of the whole or part of any pecuniary loss caused to the Govt. by negligence or breach of orders.

iii-a) With-holding of privilege passes or PTOs or both – This penalty deprives an employee only from the traveling facilities and not any monetary loss. Whenever this penalty is to be imposed the number of sets of passes and PTOs to be withhold should be clearly indicated and not the period.

iii-b) Reduction to a lower stage in time scale of pay for a period > 3 years, without cumulative effect & without adversely affecting the pension. In case if it is felt necessary to impose a penalty for > 3 years with cumulative effect & affecting pensionary benefits adversely enquiry becomes a must.

iv) Withholding of increments of pay for a specified period with further directions as after the expiry of such period, this will or will not have the effect of postponing the future increments of pay.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)

Lesson-XXIII: D&A Rules Session-56: Major Penalties

1.2 Major Penalty:

Major penalties are those where a detailed procedure as laid down in article 311 of the constitution of India is a must to be followed.

1.2.1 Major Penalties:

i) Reduction to a lower sate in the time scale of pay for a specified period with further directions as a whether on the expiry of such period this will or will not have the effect of postponing the future increments of pay while imposing this punishment it should clearly be mentioned. The number of stages by which the pay of the employee has been reduced, the period for which reduced and whether this is to have cumulative effect or otherwise.

ii) Reduction to a lower time scale of pay, grade, post or service with or without future effect with further directions regarding conditions of restoration to the grade, post or

service from which the railway servant was reduced and his seniority and pay on such restoration to that grade, post or service.

iii) **Compulsory retirement –** This penalty should be imposed on an employee when it is felt that the employee should not be retained in service any more and where the gravity of offence is such that it does not warrant removal or dismissal from service. In case of compulsory retirement the employee looses his job only and also does not place any bar on future employment in Govt. service.

iv) **Removal from Service –** This shall not be a disqualification for future employment under the government or railway administration.

v) **Dismissal from service –** Shall ordinary be a disqualification for future employment under the government or railway administration.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)

Lesson-XXIV: Service Conduct Rules Session-57: Explanation and understanding of different Conduct rules.

Railway Service Conduct Rules:

1. **Short Title –**These rules may be called the Railway Services (Conduct) Rules, 1966 and come into force at once.
2. **Definitions –** In these rules, unless the context otherwise requires:
   i) gazetted officers holding posts in the Railway Board, the President;
   ii) other gazetted officers, the Railway Board;
   iii) non-gazetted officers in the Railway Board, the secretary, Railway Board.
   iv) Other non-gazetted officers in offices directly under the administrative control of the Railway Board, the Heads of the officers concerned; and
   v) Other non-gazetted officers, the General Managers of the Railway Administrations concerned.

3. **General – (1)** Every Railway servant shall at all times:
   i) maintain absolute integrity;
   ii) maintain devotion to duty; and
   iii) do nothing which is unbecoming of a Railway servant.

2. (i) Every Railway servant holding a supervisory post shall take all possible steps to ensure the integrity and devotion to duty of all Railway servants for the time being under his control and authority;
   (ii) Every Railway servant shall, in the performance of his official duties, or in the exercise of powers conferred on him, act otherwise than in the best judgment except when he is acting under the direction of his official superior.
   (iii) The direction of the official superior shall ordinarily be in writing, and where the issue of oral direction becomes unavoidable, the official superior shall confirm it in writing immediately thereafter, and
   (iv) A Railway servant who has received oral direction from his official superior shall seek confirmation of the same in writing as early as possible whereupon it shall be the duty of the official superior to confirm the direction in writing.

3. Promptness and Courtesy.
4. Observance of Government policies.
5. Prohibition of sexual harassment of working women.
6. Employment of Near Relatives of Railway servants in Private Undertaking enjoying Government Patronage.
7. Taking Part in Politics and Elections.
8. Joining Associations or Union by Railways Servants.
9. Demonstration.
10. Connection with Press or other Media.
11. Criticism of Government
12. Evidence before Committee or any other Authority.
13. Unauthorized Communication of Information.
14. **Subscription –** No Railway servant shall except with the previous sanction of the Government or of the competent authority ask for or accept contributions to or otherwise associate himself with the raising of any funds of other collections in cash or in kind pursuance of any object whatsoever.
15. Gifts – Save as otherwise provided in these rules, no Railway servant shall accept or permit any member of his family or any person acting on his behalf to accept any gift.
16. Dowry.
17. Public Demonstrations in honour of Railway servants.
18. Private trade or Employment.
19. Sub-letting and vacation of Govt. accommodation/
20. Investment, Lending and Borrowing.
21. Insolvency and Habitual Indebtedness.
22. Movable, Immovable and Valuable Property.
23. Vindication of Acts and Character of Railway servants.
24. Canvassing of Non-official or other Influence.
25. Restriction regarding Marriage.
26. Consumption of Intoxicating Drinks and Drugs.
27. Prohibition regarding employment of children below 14 years of age.
28. Interpretation.
29. Delegation of Powers.
30. Repeal and Saving.
31. Obligations to abide by all Administrative Instructions.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)
Lesson- XXV: Session-58: Manpower Planning & Training Welfare Measures in Railways, PNM, JCM & PREM..

Death-Cum-Retirement Gratuity

Amount of D.C.R.G. – This gratuity will be paid to the pensionable employees, on their retirement, or to their families in the event of their death while in service. This will be granted in addition to the ordinary gratuity or monthly pension that may be admissible to the employee under the rules. The rate of death-cum-retirement gratuity is one-fourth of the monthly emoluments for each completed six monthly period of qualifying service subject a maximum of 16½, times of the emoluments. The amount of D.C.R.G. shall not exceed Rs. 3.5 lakh w.e.f. 01.04.96. In the event of death of an employee while in service the gratuity will be subject to the following minima:

1. If death occurs in the first year of service two months' emoluments.

2. If death occurs after completion of first year service but before completion of five years service six months' emoluments.
3. If death occurs on or after 5 years of service but less than 20 years 12 months' emoluments.
4. If death occurs on or after 20 years of service half of monthly emoluments for every completed 6 monthly period of qualifying service subject to a maximum of 33 times provided that amount of death gratuity shall in no case exceed Rupees 3.5 lakh.

Note: There will be no ceiling of reckonable emoluments for calculating gratuity.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)

Lesson-XXVI: Objectives and understanding of Various Acts Session-59: Minimum Wages Act, Factory Act, Industrial Dispute Act, Contractor Labour Act& Workmen Compensation Act.

1.9 Payment of Wages Act (P.W.A.):

The payment of wages act provides the following -

- Payment of wages promptly and at regular intervals.
- Specifies the deductions which can be made.
- Fixes the wage period within which payment must be made.
- Furnishes the summary of earned wages and unpaid wages.

1.9.1 Other Special Features:

- Applicability - Drawing salary upto Rs. 6500
- Wages - All remunerations including salary and allowances.

- Wage period > One month
- Time for payment < 1000 employees – within 7 days.
  > 1000 employees – within 10 days
- Form of payment > Coins, notes, cheque, M.O., D.D.
- Authorised deductions - Fines, absence, damage,, House rent, Electricity, loans, lawn charges, I.T. charges, P.F., G.I.S. etc.

1.10 Minimum Wages Act (MWM):

The minimum wages act provides the following-

- To secure minimum rates of wages
- To prevent exploitation of unorganized labour.
- Prompt payment of wages & overtime.
- Specifies deductions.

1.11.1 Applicability:

This shall be applicable to departmental or contractor's labour. It shall not be applicable to the staff working on time scale and governed under HOER.

Rostered duty hours –

Maximum working hours –

1.12 Workman's Compensation Act (WCA):

Workmen's compensation act of 1923 is meant for the following –

- To provide for the payment of compensation by certain employers to their workmen in case of accident involving injuries and their dependents in case of accidents resulting in death of the worker.
- To set up special machinery to deal with the claims falling under this act.
- To ensure precision in the validity of claims for compensation.

1.12.1 Application:

(i) The act should be confined to industries which are more or less organized.

(ii) The only workman whose occupation is hazardous should be included.

1.12.2 Workmen:

Includes a person who is a railway employee not employed in any administrative, divisional or sub-divisional office of a railway & not employed in any such capacity as specified in Schedule II. This will not include a person whose employment is of casual nature and who is employed for work not connected with employer's trade.

1.12.3 Disablement:

Disablement may be of following three types –

(i) Temporary partial disablement

Means such disablement which reduces temporarily, earning capacity of a workman in any employment in which he was engaged at the time of accident resulting in disablement.

(ii) Permanent Partial Disablement:

Means such disablement which permanently reduces the earning capacity of a workman in every employment, which he was capable of undertaking at the time of accident resulting in the disablement.

(iii) Total disablement:

Not only reduces the earning capacity of a workman but incapacitates him from all work which he was capable of performing at the time of accident.

1.13 Important Points to be Taken Care of In D & AR Cases:

- SF-5 prepared by Executive is to be got vetted from APO's.

- Normally in cases of bribery, punishment of removal/dismissal from service should be imposed and if it is not done so, the reason's should be recorded.
- In accident cases due to carelessness, there is a collision between trains, staff responsible should generally be awarded punishment of removal/dismissal and if it is not done so the reasons to be recorded.
- Similarly, passing signals in danger warrants major penalty and if it is not done so the reasons to be recorded.
- Group 'C' & 'D' staff found responsible for unauthorized possession of Government/Railway land and subsequent construction of residential building on it to be awarded major penalty.
- The punishment of WIT/WIP have no effect on seniority unless specifically ordered in punishment.
- If it is decided not to take further action, the decision should be conveyed to delinquent employee within a period of two months.
- Service Book should be consulted before passing orders regarding WIT/QIP as WIT/WIP at the maximum of scale becomes infructuous.
- Since the enquiry is a must before imposing penalties of WIT for more than 3 years of WIP for any period or if the penalty of WIT is likely to effect adversely the pension, it should be ensured before awarding WIT for less than 3 years also that the employee is not due retirement during the currency of WIT.
- Stoppage of post retirement complimentary passes is not a recognized penalty under D&AR.
- Temporary status Casual Labour/Substitutes are also governed by D&AR.
- Orders for issue of show cause notice intimating the nature of punishment has been dispensed with.
- In case if any employee reports for duty after absence of more than 90 days. He should not be put back to duty. (GM/NCR's decision-1992)
- In case of suspension the charge sheet should be issued within 3 months & if not, reasons for suspension be communicated on expiry of 3 months.
- It is the responsibility of the employee to inform the administration regarding his arrest or conviction failing which this concealment in itself well be good and sufficient cause to initiate disciplinary action.

SUB DISCIPLINE - ESTABLISHMENT(LESSONS: 13SESSIONS:14)
Lesson-XXVII: HOER Session-60: Classification and Duty roster

---

1.8 Hours of Employment Rules (H.O.E.R.):

In order to regulate the hours of employment and periodic rest to the railway employees, the rules were incorporated in the Indian Railway Act by an amendment in 1930 & hours of employment rules were issued finally in 1961.

1.8.1. Application:

"Hours of employment" means the time during which an employee is at the disposal of the employer. This includes effective or continuous work and periods of inaction when the worker must be present on duty, although not exercising physical activity always. It does not include the recognized intervals. These rules are applicable to all the staff except-

(i) Categories of staff governed by the factories act, the Indian Mines Act or the Indian Shipping Act.
(ii) R.P.F. staff.

1.8.2 Classification:

The railway employees are classified in the following 4 categories –

(i) Intensive – Only that staff is declared as "Intensive" whose work is of strenuous nature involving continuous concentration of mind or hard manual labour with little or no periods of relaxation. The statutory hours of duty for his category are 45 hours a week on the average in any month where as rostered duty hours are 42 and they must have a minimum of 30 consecutive hours of rest in a week.

(ii) Essentially Intermittent – The staff whose daily hours of duty include periods of in-action aggregating to 6 hours or more (including one such period of < one hour and two such periods of < ½ an hour each) during which although they are required to be on duty but not called upon to display either physical activity or sustained attentions, are declared as essentially intermittent such as waiting room bearers, sweepers, bhistees etc. The statutory hours of duty for E.1. staff are 75 hours in a week where as rostered duty hours are 72. They must avail a minimum of 24 consecutive hours of rest including a full night.

(iii) Excluded – A railway employee is said to be in excluded category if he belongs to anyone of the following category-

- Staff of Railway schools imparting technical training or academic education.
- Certain staff of medical department such as assist. Surgeons, matrons, sister incharge mid-wives etc.
- Staff employed in confidential capacity.
- Armed guards
- Supervisory staff such as inspectors, superintendents foremen, chargemen etc.

For excluded staff no statutory limit for the hours of employment has been seen prescribed but duty of Railway administration is to see that employees do not come across with unreasonable conditions.

(iv) Continuous – The employees who are neither classified as intensive nor essentially intermittent nor excluded are classified as continuous such as guards, drivers, T.T.Es, Clerks, typist, Gangmen etc. Statutory hours of working for this category are 54 in a week on average in a month where as rostered hours of duly are 52. The staff must be allowed a rest 30 consecutive hours each week.

SUB DISCIPLINE –ESTABLISHMENT,ACCOUNTS,STORES &RAJBHASHA
(LESSONS: 13 SESSIONS:14)
Lesson–XXVIII: Awards Session-61: Different Awards.

Award:

Policy of recognizing the services of the railway employees for their outstanding performance on the Railways is already in vogue. For this purpose a number of schemes have been introduced from time to time in the various fields of railway working. The General Managers have also been delegated powers to grant awards to the Railway employees (upto Senior scales) to the extent of Rs. 2000/- in each case. Award for meritorious services have also been extended to the officers upto the level of H.O.Ds and recommendations made by the General Manager for such awards from J.A. grade officers and above are considered by the Department of Railways, so as to facilitate such awards being granted at the central function to be organized under the auspices of the Boards. The Railway employees are also eligible for consideration for awards under "Prime Miniter's "Shram Award" scheme for awards to workmen in recognition of their outstanding contribution towards the production

and for showing exemplary zeal and enthusiasm in their duties. (R.B. No. E(G)86-AWI-23 of 31.7.86 (N.R. S. No. 9028).

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)

Lesson–XXIX: Estimates Session-62: Definition & Necessity of Estimates.

Estimate:

It a statement prepared to give an idea of expenditure to be incurred on a work in order to obtain sanction of competent authority and to see that work is financially justified.

Types of Estimates:

(i) Abstract Estimate:

Is prepared for obtaining administrative approval to form a reasonably accurate idea of the probable expenditure and to gauge adequately the financial prospect of the proposal. It avoids the expense and delay in preparing estimates in detail at a stage when the necessity or the general desirability of the works proposed has not been decided by the competent authority.

(ii) Detailed Estimate:

On receipt of administrative approval for a project, detailed estimate for various works should be prepared and submitted for obtaining technical sanction of the

competent authority. It should be prepared in sufficient detail to ensure that abstract estimate sanctioned by the competent authority is not likely to be exceeded. No work should be commenced till a detailed estimate is sanctioned & adequate funds are allotted.

(iii) Supplementary estimate:

Is prepared for new items of works which ought to have been included in the main estimate already sanctioned. This is prepared in the same form and same degree of detail as the main estimate and for all purposes should be treated as part of the main estimate.

(iv) Revised Estimate:

As soon an it becomes apparent that there is increase in rate or change in quantity due to change in design and expenditure is likely to be exceed the amount provided in the detailed/construction estimate, a revised estimate for whole work is prepared in the same form & same degree of detail as the main estimate. Comparative statement of excess & saving under each sub head is prepared and submitted for the sanction of the competent authority.

(v) Project Abstract Estimate:

The abstract estimate of a construction project should be submitted for the approval of the Railway Board accompanied by the expenditure involved the major item of works such as land acquisition, preliminary survey, structural Engineering Works, major/minor bridges, tunnels, P.Way etc.

(vi) Construction Estimate:

When it is decided to under take the execution of works, a final location survey is done and based on this survey detailed estimates are prepared. These detailed estimates are collectively called the Construction Estimate.

(vii) Completion Estimate:

Is prepared in supersession of a construction estimate showing the following particulars:

- Amount of sanctioned estimate
- Actual expenditure of all works.
- Commitments on that date.
- Anticipated further outlay.
- Total estimated cost.
- Difference between the sanctioned estimate and estimated cost.

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)

Lesson–XXIX: Estimates Session-63: Kinds of Estimates & their Vetting.

Types of Estimates:

(i) Abstract Estimate:

Is prepared for obtaining administrative approval to form a reasonably accurate idea of the probable expenditure and to gauge adequately the financial prospect of the proposal. It avoids the expense and delay in preparing estimates in detail at a stage when the necessity or the general desirability of the works proposed has not been decided by the competent authority.

(ii) Detailed Estimate:

On receipt of administrative approval for a project, detailed estimate for various works should be prepared and submitted for obtaining technical sanction of the competent authority. It should be prepared in sufficient detail to ensure that abstract estimate sanctioned by the competent authority is not likely to be exceeded. No work

should be commenced till a detailed estimate is sanctioned & adequate funds are allotted.

(iii) Supplementary estimate:

Is prepared for new items of works which ought to have been included in the main estimate already sanctioned. This is prepared in the same form and same degree of detail as the main estimate and for all purposes should be treated as part of the main estimate.

(iv) Revised Estimate:

As soon an it becomes apparent that there is increase in rate or change in quantity due to change in design and expenditure is likely to be exceed the amount provided in the detailed/construction estimate, a revised estimate for whole work is prepared in the same form & same degree of detail as the main estimate. Comparative statement of excess & saving under each sub head is prepared and submitted for the sanction of the competent authority.

(v) Project Abstract Estimate:

The abstract estimate of a construction project should be submitted for the approval of the Railway Board accompanied by the expenditure involved the major item of works such as land acquisition, preliminary survey, structural Engineering Works, major/minor bridges, tunnels, P.Way etc.

(vi) Construction Estimate:

When it is decided to under take the execution of works, a final location survey is done and based on this survey detailed estimates are prepared. These detailed estimates are collectively called the Construction Estimate.

(vii) Completion Estimate:

Is prepared in supersession of a construction estimate showing the following particulars:

- Amount of sanctioned estimate
- Actual expenditure of all works.
- Commitments on that date.
- Anticipated further outlay.
- Total estimated cost.
- Difference between the sanctioned estimate and estimated cost.

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)

Lesson-XXX: Tenders Session-64: Different types of tenders.

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)

Lesson-XXX: Tenders Session-65:Power for Invitation of tenders & NIT.

Contract Management & Estimates:

1. Main Components of the Contracts:

The contract system includes the following:

- Pre Tender Planning
- Invitation of Tenders
- Submission of Tender
- Opening of Tenders
- Preparation of Briefing Notes by Tender Committee
- Consideration of Tenders & Award of Contract

1.1 Pre Tender Planning: Shall be based on the following –

(i) Decision of the form of Tender –

Depending upon the scope and nature of work, urgency, completion period, availability of local contractors and approved list of tenderers a decision is required to be taken for the form of tender. These tenders may be either:
(a) Open tender
(b) Limited tender
(c) Single tender

(a) Open Tender: In case of open tenders wide publicity is made through the news papers by sending to various Govt. Offices and tenders invited in the most open public manner. Publicity is also made through (CPRO PRO (Public Relation Officer). Open tenders may also be invited in the event of insufficient response from limited tenderers, work is of special nature, non availability of experienced contractor or ring formation is suspected and to test the market rate periodically.

(b) Limited Tender: These tenders are invited from the contractors borne on approved list to save time, for carrying out the works of smaller value upto the value of Rs. 1 crore Min. number of tenderers on the approved list should not be less than 10.

(c) Single Tender: In special circumstances the offer is taken from single firm after recording reasons, prior finance concurrence & approval of competent authority & approval of competent authority and not exercised in routine works. This may be invited in the following situations:

- Accident/Derailments/Breaches involving dislocation of traffic.
- When the work is of specialized nature or inescapable situation.

Power for inviting single tender rest with GM only on the recommendation of Principal Chief Engineer with finance concurrence.

Note: Global tenders are invited to make purchases from outside the country. Railway Board officers and the officers above GM are entitled to invite these tenders.

(ii) Fixation of Earnest money, Security deposit and Performance guarantee:

(a) Earnest Money – Tenderer is asked to deposit earnest money with the tender for due performance and to keep the offer valid till date as specified in the tender and not resile from the work and modify terms & conditions. The amount of earnest money deposited should be sufficiently large to be a security against loss in the event of contractor faling to undertake the contract or to furnish the require security within the appointed time after the acceptance of tender or until such time as the sums due to him form a sufficient guarantee as the case may be. The earnest money of unsuccessful tenderer should be return as early as possible on finalization of tenders. The earnest money shall be deposited.

(i) A 2% of the estimated tender value for the works costing upto Rs. 25 crore, rounded of to the nearest multiple of Rs. 10 & shall be applicable for all modes of tendering.

(ii) For works estimated to cost Rs. 23 crore – Rs. 50 lacs 1% of the excess of estimated cost beyond Rs. 25 crore.

Form of Earnest Money: - Earnest money may be accepted in the forms of cash NSCs, 10 or 12 years National Defence Certificates. A deposit in post office saving bank, National Defence Bonds. IRFC Bonds, Govt. Securities at 5% below the market value & deposit receipts or demand drafts of Nationalized Bank with the concurrence of RBI.

(b) Security Deposit – If the tender is accepted, the earnest money deposited by the contractor with his tender shall be retained by the Railways as part of security for the due and faithful fulfillment of contract by contractor. The balance amount of SD may be deposited by tenderer in cash or may be recovered from the on account bills. In case of defaulting contractor the railway may retain amount due for payment to the tenderer not more than 10% of the total value of contract. The rate/mode of recovery for SD value shall be as under:

(i) SD for each work should be 5% of the contract value.

(ii) Rate of recovery should be @ 10% from on account bills till full SD value is recovered and no other form of recovery like bank guarantee, fix deposits etc. shall be accepted.

SD shall be return to the tenderer after physical completion of the work as certified by the authority competent to sign the contract. If this authority is of the rank lower than JA grade, then concerning JA grade officer will issue the certificate after ensuring that all the contractual obligations have been fulfilled by the contractor and nothing is due on the part of contractor against the concerning contract. An unconditional "No claim certificate" shall be obtained from the tenderer before releasing the security deposit.

(c) Performance Guarantee –

(i) The successful bidder should give a performance guarantee in the form of an irrevocable bank guarantee amounting to 5% of the contract value.

(ii) The performance guarantee should be furnished by the tenderer after the issue of acceptance letter but before signing of the agreement preferably within a period of 15 days.

(iii) Performance guarantee shall be released after satisfactory completion of the work and maintenance period is over. Procedure for release as in case of security deposit shall be followed.

(iv) Performance guarantee payable by the tenderer may be in any of the form of cash, irrevocable bank guarantee, a deposit in post office saving bank. NSC's 10 or 12 year National Defance Certificates Bonds, Guarantee bonds, deposit receipts, pay orders and demand drafts of any Nationalized Bank, Government securities & UTI certificates 5% below market value FDR In favour of FA&CAO(C) free from encumbrance may also be accepted.

(iii) Preparation of Tender Documents:

The officials should visit the siteand carryout detailed survey & assess the availability of material and other infrastructure facilities for smooth running of contract and to minimize problems at later stage. Preparation of tender documents before invitation of tenders is a must. These documents are given as below.

(a) Framing of tender schedule:

(i) Choice of items and their description

- Covered by SOR
- Not covered by SOR

(ii) Estimation of quantity under each item – To be preceded by effective site investigation, detailed design & drawings.

(iii) Estimation of unit rates for NS items

(b) Incorporation of Slandered/Special specification.

(c) Incorporation of period of completion.
(d) Incorporation of special of completion – Need, Items, Price variation clause. Advance, Quality & Progress.

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)
Lesson-XXXI: Railway BudgetSession-66: Parliamentary Control over Railway Finance, Public Accountability, Canons of financial Propriety.

Parliamentary Control Over Railway Finance:

The Parliamentary control over Railway finance is exercised by the following Committee either before the submission of demands to Parliament for voting or after the expenditure is incurred and the annual accounts are closed as indicated.

(i) Railway Convention Committee:

Based on the recommendation of Acworth Committee in 1920-21, a convention commonly known as 'Separation Convention' was adopted by a resolution on 20th September 1924 under which this Committee was formed, for periodical examination of Railway finance and working and also to review the rate of dividend payable by the

railway to General Revenue. This Committee normally meets after every five years to review the Railway finance and recommend the changes to be made in railway finance.

(ii) Estimates Committee:

This is a Parliamentary Committee for examination of such of the estimates as it may deem fit or are specially referred to it by Parliament or the Speaker. This committee has:

(a) to report what economies, improvements in organization, efficiency or administrative reform, consistent with the policy under – laying the estimates may be effected:
(b) to suggest alternative policies in order to bring about efficient, and economy in administration:
(c) to examine whether the money is well laid out within the limits on policy implied in the estimates: and
(d) to suggest the form in which the estimates shall be presented to Parliament.

There are maximum 30 members and are elected by the Lok Sabha every year. No Minister is elected.

(iii) Discussion of Railway Budget:

During the period of discussion of Railway Budget, any member of Parliament may ask a question for the purpose of obtaining information on a matter of public importance with the special cognizance of Minister to whom it is addressed. They raise questions of various kinds viz., starred questions, unstarred questions and short notice question in Lok Sabha and Rajya Sabha and the Railway Minister has to answer these suitably.

(iv) National Railway Users Consultative (Council:

To secure better representation of railway Users and afford more frequent opportunities for Consultation between railways and Railway Users on matter relating to the service rendered by Railway a National Railway Users consultative Council was formed in 1953. The members of the Council hold office for a period not exceeding two years. The Council consists of about 70 persons appointed by the Minister of railways from various Ministries including Ministry of Railways, Committee, organizations and eminent persons who take interest in railway problems. The council meets at least once a year. The Minister of railways will preside at the meeting of Council.

The Council have to consider:

(a) such matters relating to the services and facilities provided by Railways
(b) matters within the scope of the function of Zonal Committees as are referred to it: and
(c) questions relating to staff discipline and appointments will not be brought before Council.

(v) Committee on Subordinate Legislation:

Committee on Subordinate Legislation, which scrutinizes and report to Parliament that the Powers to make regulations, rules, sub rules, bye-laws etc., conferred by the Constitution or delegated by Parliament are being properly exercised.

(vi) Committee on Government Assurances:

Committee on Government Assurances, which scrutinizes whether the assurances, promises, undertakings, given by Ministers from time to time, on the floor of the Lok Sabha and Rajya Sabham have been implemented within the minimum time.

(vii) Public Accounts Committee:

Public Accounts Committee, which examines the accounts of sum granted by Parliament for expenditure, to satisfy:

(a) that the money shown in the accounts as having been disbursed were legally available for and applicable to the service or purpose to which they have been charged;
(b) that the expenditure conforms to the authority which governs it; and
(c) that every re-appropriation has been made in accordance with the provisions made in the behalf under rules framed by Competent authority,

This Committee consists of not more than 22 members to be elected by both the Houses of Parliament every year from amongst their members according to the principle of proportional representation by means of the single transferable vote. A Minister is not elected and if a member, after his election of Committee is appointed as Minister he shall cease to be a member of Committee from the date of such appointment.

The term of office of member of the Committee shall not exceed one year. The Chairman of the Committee is appointed by the Speaker from the members and if Dy. Speaker is a member, he shall be appointed as Chairman. The Committee has its own programme and procedure. The Committee takes up examination of the Audit Report and Appropriation accounts after they have been duly placed before the Parliament with the approval of the President.

(viii) Member of Parliament:

In addition, any member of Parliament may address the Ministry of Railways, or a Railway Administration, on any matter concerning Railway working. Members may also ask questions in both the Houses of Parliament on issues connected with Railway working.

Public Accountability

Public accountability, may be defined as to how Government of India is accountable to people. From the very fact that the Parliament itself, having been elected by the people, representing whole of the country, is accountable to the problems faced by public. The Railway Minister, one of the members of Parliament is accountable to people, for all problems concerning Railways.

Any Member of Parliament may also ask question, for the purpose of obtaining information on the matters of public importance within the special sphere of Railway Minister to whom it is addressed for which he and the management under his control are responsible to answer to the satisfaction of the House.

Further the powers of approval or vote of action, policies, general and specific, policy direction rest with Railway Minister. All projects and development are included in programmes with his approval. Responsibilities of co-ordination, planning activities and the demand of finance on Railway rest with him. Thus the Railway Minister is the main instrument of controlling Railway Management and working of Railways and through him Railway Management is accountable to public.

The Railways are owned and managed by Government of India. The Railway Management is therefore accountable to the Parliament for the efficient operation of this vital transport system in the country. The annual revenue budget of the Railways is based on specific performance/targets for movement of freight and passenger traffic, and comprises the estimated amount of money required to be spent to achieve the specified targets. The annual works budget provides for additions, restoration and replacement of assets to enable the railways to progressively increase their capacity for meeting the transport needs. Parliamentary financial control is designed to keep a watch over the performance of managers entrusted with handling and disposal of public funds. The budget grants voted by Parliament and the appropriations sanctioned by the President are thus the limits upto which expenditure can be incurred by the Central Government during a financial year on the specific purposes for which the grant and appropriations have been obtained. While it is the duty of the Railway Board as the controlling authority in respect of the total amount of each Grant voted by Parliament and appropriations sanctioned by the President, to watch the progress of expenditure and to restrict the aggregate expenditure within the amount of grant

or appropriation placed at their disposal, it is the responsibility of the individual Railway Administrations to exercise similar control over the allotments made to them.

SUB DISCIPLINE - ACCOUNTS (LESSONS: 3 SESSIONS:6)

Lesson-XXXI: Railway Budget Session-67: Railway Budget, Budgetary Terms, Budgetary Cycle, Demand of Grants, Expenditure classification, Works Programme

---

BUDGET

Introduction: Before 1924 the Railway Finance was merged in the General Finance of Government of India. In order to relieve the General Finance from violent fluctuations caused by incorporation of Railway Estimates and to enable railways to carry out a continuous policy based on the necessity of making fair and definite return to General Revenue and also with a view to introduce flexibility in the administration of Railway Finance in build up railway resources, to have provisions to equalize dividend, a committee known as Acworth Committee was appointed. This committee have recommended for separation of railway

Finance from the General Finance in 1920-21. Based on the recommendation of Acworth Committee, a convention commonly known as 'Separation Convention' was adopted by a resolution on 20th September 1924 under which the railway Finance was separated from General Finance subject to periodical revision. This Convention Committee normally meets after every five years to review the Railway Finance.

Definition: A statement of estimated annual receipt and expenditure whether on Capital of Revenue account of Central Government is prepared by the railway Board (Based on individual Railways estimated receipt and demands for expenditure) and laid before the Parliament. In other words it can be said that under Article 112 of Constitution of India, the President will call upon a statement from railways showing the estimated income and out-lay amount that has to cross the Consolidated Fund of India. These statements are known as 'Budget;.

Consolidated Fund of India: Under article 226 of the Constitution of India, a Consolidated Fund is defined as reservoir to which all the Government earnings flow (credited) and from which the expenditure of Government when so authorized by the Parliament is made (debited). Central Government is having Consolidated Fund of India, whereas the State Governments are having Consolidated Fund of States and Union territories are having Consolidated Fund of Union territories.

Authorized Expenditure (Appropriation Bills)

Under article 114(1) of Indian Constitution, after the Budget is voted by the Parliament and appropriations sanctioned by the President an Appropriation Bill is passed. It becomes Appropriation Act and this Act authorizes Government to withdraw money from Consolidated Fund of India to the extent sanctioned for incurring expenditure. It should be borne in mind that though the expenditure is voted by Parliament and Appropriations sanctioned by President, the amount cannot be drawn from Consolidated. Fund until it is authorized by the act Similarly, all the Railway earnings and receipts should be deposited to this fund excepting those authorized such as causing infringement of any Law or Act and normally station earnings cannot be utilized for any other purpose.

Expenditure:

The expenditure is divided into two classes viz. Voted and Charged.

Voted expenditure is that for which the provision of funds is subject to the Vote of Parliament.

Charged expenditure is such class of expenditure for which the President accords sanction. This generally covers the following types of expenditure:

(1) Interest, sinking fund charges and redemption charges on loans and debts.
(2) Salary, allowances and pensions payable to or in respect of Comptroller and Auditor General of India.
(3) Any sums required to satisfy any judgment, decree or award of any court or arbitrational tribunal.
(4) Any other expenditure declared by the Constitution of India or by Parliament by law to be so charged.

The proposal of railway in respect of amount required to meet the expenditure of the year is submitted in the shape of demands when presented to the Parliament and after the vote of Parliament is obtained, the same very demands are known as Grants.

The Budget is presented to Parliament under following demands:

Demands for Grants

S. No.	Group	Demand No.	Name of demand	Classification
1.	Policy formation and services common to all railways	**1**	Railway Board	
		2	Research Audit and Misc. Establishment	
2.	General Superintendence and services on railway	**3**	General Superintendence	**'A'**
3.	Repairs and Maintenance	**4**	Repairs and Maintenance of Way and Works.	**'B'**

		5	Repairs and the Maintenance of motive powers	**'C'**
		6	Repairs and Maintenance of Carriage and Wagons	**'D'**
		7	Repairs and Maintenance of Plant and Equipment	**'E'**
4.	Operation	8	Operating Expenses Rolling Stock and Equipment.	**'F'**
		9	Operating Expenses Traffic	**'G'**
		10	Operating Expenses Fuel	**'H'**
5.	Staff Welfare Retirement Benefits and Misc.	11	Staff Welfare and Amenities + Payment of Medical Staff.	**'J'**
		12	Misc. working Expenses + Payment of RPF Suspense.	**'K'**
		13	PF pension and other Retirement benefits.	**'L'**
6.	Railway Funds and Payment to General Revenue	14	Appropriation to Funds.	**'M'**
		15	Dividend to General Revenues, Repayment of Loan taken from General Revenues, and Amortization of over Capitalization.	
7	Works Expenditure	16	Assets – Acquisition and Replacement (Accident compensation will however be shown under Demand No. 12.)	**Capital DRF, DF, OLWR**

Note: Expenditure on Medial Department is charged to Abstract (J) and cost of security Department (RPF) is charged to Abstract (K).

The Budget Estimates are prepared by Railway Administration for the following, and the figures are shown in thousands of rupees:

(a) Earning Estimates (Receipts)
(b) Revenue Budget (demand Nos. 3 to 14)
(c) Capital Budget (demand No. 16)
  (i) Woks Programme.
  (ii) Rolling Stock Programme
  (iii) Stores Transactions (demand 16, Cap. 7100)
  (iv) Workshop Manufacturing Suspense
(d) Civil Grants.

SUB DISCIPLINE - STORE(LESSONS: 1 SESSIONS:3)

Lesson-XXXII: Introduction to Engg. Stores& Inventory Control

Session-68: Stock heads of Accounts, Disposal of released and surplus materials.

Stores

1.1 Necessity:

Stores are required to carryout the day to day repairs of track, buildings or structures. Subordinate incharge is the custodian of stores, its proper accountal and submission of returns etc.

1.2 Classification of Stores:

Stores are broadly classified in following three categories –

(i) Imprest stores

(ii) Surplus stores
(iii) Charged off stores

1.2.1 Imprest Stores:

These are the items kept as standing advance for the purpose of meeting day to day requirement for repairs, maintenance and operation of rolling stock including consumable stores such as cotton waste, oils and grease etc. are termed as imprest stores so long as they are under the control of executive units. Normally after assessing the monthly requirement of consumption three months quantity is sanctioned by their controlling heads and the same may be drawn from stores depot.

Imprest stores may be –

(a) P. Way

(b) Other than P. Way – Include rail clusters, emergency girders, pipes, specials (water supply fittings) cement etc.

1.2.1.1 Special Features of Imprest Stores:

- Scale of imprest stores is fixed by Chief Engineer in consultation with the Divisional Engineer of the section, keeping in view the track/building structure.
- Stores are stacked separately and displayed by a board.
- Stores should not be transferred to other stock holder unless permitted by Divisional Engineer in case of emergency.

1.2.1.2 Submission of Returns:

Returns shall be submitted every quarterly i.e. ending March, June, Sept. & Dec. by 5^{th} of the following month. Returns ending Sept. & March are designated as half year ending returns in which the return shall be submitted for all the items whatever are bome on imprest ledger irrespective of the fact whether transaction has been done or not where as in case of quarter ending returns i.e. ending June, Dec., return shall be submitted in favour of only those items in which the transaction has been made. The return shall be prepared by the stock holder counter signed by ADEN of the sub-division and submitted in the division in two copies. Out of which one copy of the return will be submitted to DEN/Sr.DEN of the section and another copy to store depot where posting shall be done in the ledger of stock holder through ledger cards and recoupment of the material shall be effected through the stores van or wagons obtained from the operating department.

1.2.2 Surplus Stores:

Stores which are surplus to our requirements and include materials received from renewals, replacements or from dismantled works. Surplus stores should be kept as minimum as possible by returning all second hand serviceable material o DS-8.

1.2.2.1 Submission of Returns:

Returns shall be submitted every quarterly but the return shall be submitted to the divisional authorities in 3 copies duly signed by ADEN of the sub Divisional out of which one copy will be submitted to DEN/Sr. DEN of the section, another copy to store depot and 3^{rd} copy to track supply officer (T.S.O).

1.2.3 Charged Off Stores:

These are the stores which have been charged to the final heads of revenue working expenses but still in the custody of that department and will be issued to the consuming subordinates as and when required. Charged off stores are classified as below.

1.2.3.1 Consumable Stores:

Cotton waste, K. Oil, soap, duster etc. are classified as consumable stores. Monthly scale of consumption is fixed by DEN of the section with the approval of C.E. Return for consumable stores to be submitted half yearly.

1.2.3.2 Petty Stores:

Building material such as ballast, bricks, surkhi, lime, sand cement etc. are classified as petty stores to carryout day-to-day repairs. No. scale is fixed for building material required for maintenance.

1.2.3.3.Material at site stores (MAS):

Stores which are obtained for specific work are classified as MAS stores. These are requisitioned by DEN of the section and supply of material is taken directly at/near the site. These stores are kept outside the account of any other category of stores. The left over material is transferred else where and taken into account. Returns for MAS stores shall be submitted quarterly.

1.2.3.4 Tools & Plants:

Scale of T&P is fixed by the Chief Engineer in consultation with DEN of the section. A total requirement of subordinate's labour and a small reserve will form the basis for scale. Return of the T&P shall be submitted in the division by the close of financial year every year in the month of April. If replacement of worn out, damaged or lost articles is required a requisition for the same shall be submitted to the division with an explanation of the circumstances in which the replacement is applied for.

1.3 Dead Stock:

All the furniture & plant of office and rest house under the control of a subordinate is categorized as dead stock. The items should be numbered and a brief description written in dead stock register to avoid replacement. All the items of dead stock should be verified by stock should be verified by stock holder every year where as 20% items of dead stock shall be checked by ADEN every year Dead stock return shall be submitted to Divisional Engineer in the month of April each year.

SUB DISCIPLINE - STORE(LESSONS: 1 SESSIONS:3)

Lesson-XXXII: Introduction to Engg. Stores& Inventory Control

Session-69: Indenting procedure, Issue note and Write-off statement.

2.1 Issue Note:

This form is used when some material is issued to some other stock holder. It is prepared in 5 copies, original copy is kept as office copy, four copies are given with material to the receiving authority. Consignee will send 2^{nd} & 3^{rd} copy duly verified to the issuing authority. Consigner will send the verified copy to DAO and consignee will also send 4^{th} copy of issue note to D.A.O. keeping the 5^{th} copy as o/c.

2.2 Pairing of Issue Note:

Pairing is done by Accounts department after receiving the copy of the issue note from indenter as well as from issuing authority, if tallied will be filed otherwise query will be done from the issuing authority.

2.3 Red Issue Note:

When any material which is booked either by passenger or goods train, is lost due to some theft, the consignee will inform the Station Master regarding the less quantity received. In case the material lost is traced out in due course it will be given to the consignee otherwise red issue note for the quantity which is lost or short will be given to Station Master of delivery station or traffic staff. Material is then written off after conducting the enquiry by stores & traffic department.

2.4 Numerical Ledger:

Due to computerization of stores accounting of ordinary stores have been reclassified on the basis of trade group and end use, now to save clerical man hours and to have error free accounting system, stores have been codified with 8 digits. The first two digits denotes major group, next two digits denote their sub group, next three digits relates to a particular item & last one is called 'check digit'.

2.5 Engineering Plant Reserve:

The purpose of engineering plant reserve is to avoid losses from forced sales of serviceable and useful plant left over from special works. The plant and machinery such as welding machine, truck, Jeep, boiler, compressor etc. Whatever has been purchased against sanctioned estimated works is disposed of and completion report is drawn. Since its value obtained will be far less, such material is sent to general store (without DS-8). A committee of 3 persons is nominated by Chief Engineer to inspect the plant and valuation is done. Now this assessed depreciated value is credited to previous work in which these were procured and CR is drawn. Depreciated value and cost of repair shall be the value of plant which will be debited to the work going to be undertaken.

SUB DISCIPLINE - STORE(LESSONS: 1 SESSIONS:3)

Lesson-XXXII: Introduction to Engg. Stores& Inventory Control

Session-70: Stock verification and Inventory Control Technique.

3.1 Stock Verification:

Stores are verified by stock verifiers of the accounts department as per programme decided jointly by officers of engineering & stores department, besides the surprise verification by inspecting officials of engineering, vigilance department etc..

3.2 Object of Stock Verification:

- Updating of ledgers
- Material as available on ground should tally with the book balance.

- Not only the numbers but also the material on ground should tally with the specification & description shown in numerical ledger.
- To know the shortage and excess of material.
- To check the standard of upkeeping of stores.
- To check the material which is not in use for long time.
- Whether quantity of T&P is as per scale.

3.3 Frequency of Stock Verification:

The stores shall be verified as per following frequency –

Material at site (MAS)	→	Once a year
Imprest stores	→	Once in 2 years
T & P	→	Once in 3 years

3.4 Departmental Stock Verification:

Each stock holder is supposed to do the verification of his store once in 6 months at his own accord. He may do so by verifying certain items every month provided te whole stock is verified during 6 months i.e. prior to April and October every year before submitting the half yearly returns. The ADEN's verification of stock with stock holder should be confined to important items of charged off stores, surplus stores and the items which are liable to deteriorate in addition to imprest stores.

3.5 Overhauling of Stock:

After completion of stock verification, ledgers of stock holders are scrutinized by Inspector stores Accounts (I.A.S.). It is seen that stores indented & supplied by stores are properly accounted. Stock sheets having irregularity if any is submitted to Accounts Officer, then he takes up the matter with controlling officer.

3.6 Stock Sheet:

If the physical balance or stock agrees with the book balance, no stock sheet need be prepared. The official concern will merely make an entry in the ledger card bin card to show that the physical balances agree with the book balances. The entry should be initialed by the official making the entry & the official incharge of the ledger section. In case of access shortage of stock the official should prepare department stock verification sheet on form no. 1260-S. Stock sheet for irregularities if any is prepared in 4 copies. Original copy is sent to Accounts Officer. Explanation of the stock holder is recorded on 2^{nd} & 3^{rd} copy and submitted to Divisional Engineer/Sr. Divisional Engineer who retains 3^{rd} copy and forwards 2^{nd} copy to Accounts Officer for further action. 4^{th} copy is kept as office copy by stock verifier.

4.1 Stock and Non-stock Items:

4.1.1 Stock Items:

Stock items are those items which have regular turnover and required in day-to-day working frequently & atleast 2 times in a year. Annual consumption is likely to be more than Rs. 2000. As regards the procurement of stock items, the demand is sent by consignee, items are recognized by P.L. Number.

4.1.2 Non-Stock Items:

Non stock items are those items which do not have regular turn over, not required frequently. These items are planned by the users department. The requirement with complete specification, detailed description of items is submitted to their feeding stores depot on requisition form No. S-3102. One requisition is prepared for one item only in duplicate. Carbon copy is kept by indenting officer.

As the procurement of items always take some time, advanced planning should be done. The demand is sent by consignee, last purchase particulars if any are given on requisition, the items are procured as per details given by consignee.

5.1 Inventory Control:

In Railways the demands are mainly for-

(i) Maintenance activities.

(ii) Production activities in Railway Workshops

(iii) For projects or works

Materials required by Railways are manufactured for the specific use of Railways & not normally required by other users hence sufficient time is required by the manufacturer to produce the items on receipt of contract and if not possible to procure these items as & when required. Any failure to supply the vital items immediately on demand brings the Railway operation to a stand still. Also it is not advisable to procure items in bulk which will result in blocking of large capital. Hence there is no need for inventory control to maintain lowest levels of stocks with highest service levels. Inventory control also aims at reducing the inventory carrying cost which comprises:-

- Cost of physical storage of inventory
- Interest on money locked up in inventory
- Opportunity cost – the capital could have been used in profitable way but blocked in inventory.
- Obsolescence & depreciation.
- Cost involved in stock verification
- Pilferage and other losses.

SUB DISCIPLINE - MEDICAL AWARENESS PROGRAMME
(LESSONS: 1SESSIONS:2)
Lesson-XXXIII: Medical Awareness Programme Session-71: Family Welfare, AIDS, Family Management & First Aid..

SUB DISCIPLINE - MEDICAL AWARENESS PROGRAMME(LESSONS: 1 SESSIONS:2)

Lesson-XXXIII: Medical Awareness Programme. Session-72: Stress Management & Disaster Management.

l?k }kjk ljdkjh dkedkt d fy, Lohdkj dh xb Hkk"kk dk jkt Hkk"kk ekuk x;k gA Hkkjr ljdkj u jkt Hkk"kk d :i e fgUnh dk Lohdkj fd;k g ft ldh fyfi nouk xjh gkxh rFkk ljdkjh ik;ktuk d fy, vdk dk :i Hkkjrh; vdk dk vUrjk"Vh; :i gkxkA

jkt Hkk"kk og Hkk"kk g ft l l?k vFkok dkb jkT; vFkok ljdkj fof/k }kjk viu ljdkjh dkedkt e i;kx d fy, Lohdkj dj y A og fdlh jkT; e ,d l vf/kd Hkh gk ldrh g A

lfo/kku dh v"Ve lph e 'kkfey lHkh 22 Hkkjrh; Hkk"kk,] jk"VHkk"kk, dgykrh g A ;g Hkk"kk, fofHkUu i;ktuk d fy, mi;kx dh tkrh g A

jkt Hkk"kk fu;ek d vuikyu dh nf"V l Hkkjrh; HkHkkx dk 3 {k=k e ckVk x;k g&

¼d½ d {k= & fcgkj] gfj;k.kk] fgekpy insk] e/; insk] jkt LFkku] mRrj insk] mRrjkpy] >kj[k.M] fnYyh rFkk vMeku ,o fudkckj }hi leg A
¼[k½ [k {k= & xt jkr] egkjk"V] itkc rFkk l?k 'kkflr insk pMhx< A
¼[k½ x {k= & 'k"k lHkh jkT; vkj dUn 'kkflr insk A

dUnh; ljdkj d depkfj;k dk fgUnh fo{k.k ;ktuk d vUrxr if{k.k nu d fy, fuEufyf[kr rhu ikB;Øe g&

ick/k & ;g ikjfEHkd ikB;Øe g vkj bldk Lrj ikbejh Ldy dh fgUnh d Lrj d cjkcj g
ioh.k & bldk Lrj fefMy Ldy dh fgUnh d Lrj d cjkcj g A
ikK & bldk Lrj gkbLdy dh fgUnh d Lrj d cjkcj g A

jkt Hkk"kk vf/kfu;e 1963 dh /kkjk 3¼3½ d vUrxr vku oky fofHkUu idkj d dkxtkr fuEu idkj g&

1- ldYi 2- lkekU; vkns'k 3- fu;e 4- vf/klpuk, 5- i'kklfud vkj vU; fjikV ;k il foKfIr;k 6- lln d fdlh lnu ;k lnuk d le{k j[kh xb i'kklfud rFkk vU; fjikV vkj vU; ljdkjh dkxtkr 7- djkj 8- ijfeV 9- fufonk lpuk vkj mud ik:i 10- lfonk, 11- vuKfIr ;k vuKk i= 12- vkj{k.k pkV fu;eku lkj mDr dkxtkr vfuok;r% fgUnh o vxth e f}Hkk"kh tkjh fd; tku pkfg, A

lfo/kku dh v"Ve vulph d vuPNn 344¼1½ vkj 351 d vUrxr mfYyf[kr Hkkjrh; Hkk"kk, &

1- vlfe;k	2- mfM;k	3- mn	4- dUuM
5- dsehjh	6- xtjkrh	7- rfey	8- ryx
9- itkch	10- ckXyk	11- ejkBh	12- ey;kye
13- lLdr	14- flU/kh	15- fgUnh	16- dkd.kh
17- uikyh	18- ef.kijh	19- Mkxjh	20- efFkyh
21- lFkkyh	22- ckMk		

dUnh; ljdkj d dk;ky; l {k= ^d* o ^[k* e fdlh jkT; ;k l?k jkT; {k= d i=kfn ekeyh rkj ij fgUnh e gkr g vkj ;fn bue l dkb Hkh i=kfn vxth e Hkt tkr g rk mud lkFk mudk fgUnh vuokn Hkh Hktk tkoxk A yfdu {k= ^x* e fdlh jkT; ;k l?k jkT; {k= fdlh dk;ky; ;k 0;fDr dk i=kfn vxth e gkx A

DISCIPLINE: - GIPSD (Lessons: 07Sessions: 07)

Lesson-I: Communication **Session-1:** Communication Skills and Importance in Railway Organization.

What Is Communication

Communication is the transfer of information from a sender to a receiver with the information being understood by the receiver.

It is the means by which organized activity is unified.

It may be looked upon as the means by which social inputs are fed into social systems.

It is also the means by which behavior is modified, change is effected, information is made productive, and goals are achieved.

Communication Skill

Communication skill is the technique by which more and more information are despatched and received.

Importance of Communication in Railway

As we know for better work culture, Communication is the powerful tool in any organization and Railway is not exception. In Railway there are different branches which are in function and for effective, progressive and productive working there is permanent need of better communication. In Railway organization as because of better communication we could know about progress and short comings by means of better method of communication.

Type of Communication

1. One way Communication
2. Two way Communication

One Way Communication

This is the communication which flows from upward to downward only. Here order is passed from upward to downward. Hence it is known as One Way Communication. Here only one is despatches and other receives.

Two Way Communications

This is the communication which flows on either side and it is the method by which receiver also sends message to the despatch. This method is very much useful and there is wider scope of communication. In present mode of organization, Two Way Communication is widely used.

Effective Communication

Make sure you clarify our ideas before communicating
Test the real purpose of each communication
Be mindful of the physical and human setting whenever you communicate
Consult with others, wherever appropriate, in planning communication
Always consider in any communication overtones, as well as the basic content, of your message
Create an opportunity to convey something of help or value to the receiver
Always follow up your communications.
Communicate with tomorrow in mind as well as today.
Make your actions support your communications
Strive not only to be understood but to understand- be a good listener.

DISCIPLINE: - GIPSD (Lessons: 07Sessions: 07)

Lesson-II: Motivation **Session-2:** Motivation Skills.

Motivation

Motivation can be defined as the processes that account for an individual's intensity, direction, and persistence of effort toward attaining a goal.

- The three key elements in our definition are intensity, direction, and persistence.
- Intensity is concerned with how hard a person tries.
- High intensity is unlikely to lead to favorable job-performance outcomes unless the effort is channeled in a direction that benefits the organization.
- Motivation has persistence dimension. This is a measure of how long a person can maintain his effort.
- Motivated individuals stay with a task long enough to achieve their goal.

Motivation Skill

It is the skill by which in any organization man is inspired to do more and more work and productivity is increase because man loves happily.

How to Identify Motivation in Others

- Energy
- Commitment
- Staying Power
- Skill
- Single-Mindedness
- Enjoyment
- Responsibility

The Golden Rule of Motivation

You will never inspire others unless you are inspired yourself.
Example is the great seducer.
Hall marks of Good Example.
Act in the open
Be spontaneous
Be expressive
Be self effacing (No trumpets)

DISCIPLINE: - GIPSD (Lessons: 07Sessions: 07)

Lesson-III: Leadership **Session-3:** Types of Leadership & Leadership Skills.

Leadership

Leadership is a quality of man (coupled with skill and technique) by virtue of which he is capable to lead the society in a positive and constructive direction.

Leadership Skill

It is the inherit quality of a man by which every one follows him have faith on particular Leader who is awakened impartial and of positive attitude.

Type of Leadership

1. Autocratic
2. Participative
3. Free- Rein

Autocratic Leadership

It is the Leadership of a dictating nature and every one has to follow what the Leader orders. There is no scope of argument in this type of leadership.

Participative Leadership

It is the Leadership in which every one has its own role to play and each and every one takes part for reaching a solution.

Free-Rein Leadership

It is the Leadership in which every individuals is free to take his own decision and not dependent to each other.

Core responsibilities of a leader

- To achieve the task.
- To build a motivated teem
- To develop the individual

DISCIPLINE:- GIPSD(Lessons: 07Sessions: 07)

Lesson-IV: Inter Personal Relations

Session-4: Need for Inter Personal Relations in Railway Organization

---

Inter Personal Relation in Indian Railway

Actually to say Inter Personal Relation is based upon human value and human touch. In any organization human behavior and value plays a very important role to build up a foundation of healthy work culture and amicable work environment. In Railways which is also a vast organization, there is also a need of good human relations and human values in between workers to workers, workers to management.

By adopting good human relations, human touch and human behavior, we can solve most of our problems and there by developing well working environment.

For example if a man has got some domestic problem etc then organization should handle the situation by providing human approach and sympathy to the particular for creating good work culture and efficiency.

Need For Inter Personal Relation

To day's world is full of challenges and to meet the challenge in day to day working in organization inter personal relation are required to be made strong enough for better human relation to build up a good work culture and productivity by putting in maximum effort in the improvement of human relation.

DISCIPLINE:- GIPSD(Lessons: 07Sessions: 07)

Lesson-V: Attitude Building Session-5: Important of Positive Attitude.

ATTITUDES -

The term "attitude" frequently is used in describing people and explaining their behavior. For example- He has a poor attitude. I like her/his attitude. Our workers turn out poor quality products because they have poor attitudes. More precisely, an attitude can be defined as a persistent tendency to feel and behave in a particular way towards some objects. For example Ram does not like working in

The Importance of positive attitude

(1) Increase productivity.
(2) Fosters team work.
(3) Solves problems.
(4) Improves quality.
(5) Makes for congenial/cordial atmosphere.

(6) Breeds loyalty.
(7) Increase profits.
(8) Better relationship with employers, employees and customers.
(09) Reduces stress.
(10) Helps a person become a contributing member of society and an asset to the country.

(11) Makes for a pleasing personality.

(12) Wastage control/cost control.

the night shift. He has a negative attitude towards his work assignment.

DR. WALTER DOYLE STAPLES

Attitudes are the result of choices you make decisions to believe or not believe in particular aspects of your life. For example- some people choose to adopt firm beliefs in honesty, integrity, resourcefulness, efforts and respect for fellow human beings**.** There are three basic components –

(1) Emotional
(2) Informational
(3) Behavioral

(1) **The emotional components**- it involves the person's feelings or affect positive, neutral or negative about an object. The expression of emotions- either positive like customer service representative, negative like Police Officer or neutral like a academic administrator or public servant.

(2) **The informational component -**consists of the beliefs and information of individuals has about the object. It makes no difference whether this information is real or correct.
(3) **The behavioral components-**consists of a person's tendencies to behave in a particular way towards an object. Only behavioral components can be directly observed.

Factors that determine our attitude

(1) Environment
(2) Experience
(3) Education

Environment –

Home -Positive or negative influence
School-
Office or Work place (Supportive or over critical supervisor)
Media: (Television, Newspapers, Magazines, Radio, Movies)

Culture background
Religious background
Traditions & beliefs
Social environment
Political environment

Experience

Behavioral change & attitude depends on sound experience of different areas

Education

Through formal & informal education both we gain the knowledge. Proper use of knowledge skill & assertive behaviour give force to positive attitudes. Knowledge is power.

STEPS TO BUILD

STEP-I Change focus, look for the Positive.

STEP-II Make a habit of doing it now.

STEP-III Develop an attitude of gratitude.

STEP-IV Get into a continuous education program.

STEP-V Build a positive self esteem.

STEP-VI Stay away from negative influence.

STEP_VII Learn to like the things that need to be done.

STEP-VIII Start tour day with a positive

POSITIVE ATTITUDE

(1) **The adjustment function**: Attitudes often help people adjust to their work environment. Well treated employees develop a positive attitude.

(2) **The Ego- defensive function**: Attitude also helps them to defend their self images. For example decisions of older managers are continuously challenged by a younger manager.

(3) **The value expressive function**: Attitudes provide expressing their values. For example a manager who believes strongly in the work ethic will reflect this value of work ethic.

(4) **The knowledge function** Attitudes help supply standards and frames of references that allow people to organize and explain the world around them.

Barrier to changing attitude

(1) Prior commitments
(2)Insufficient information's

Attitude can be changed through

(1) Providing new information.
(2) Continuous education programme.
(3) Use of fear.
(4) Resolving discrepancies.
(5) Influences of friends & peers.
(6) The co-opting approach
(7) Do it now habit.

DISCIPLINE:- GIPSD(Lessons: 07Sessions: 07)

Lesson-VI: Team Work Session-6: Team Work and Team Building

Team Work

In this system of all work in a coordinated and composite manners if any one fails then another man backs up and fulfils the objectives with out any problem and void ness is not felt.

CORE COMPETENCIES OF A LEADER/Team Building

- Team work is the sine-qua-non for excellence in performance.
- It is like an orchestra playing at a concert-there can not be music without Harmony.
- Samgachchadhvam Samvadaddhvam Samvo Manansijantaam

(Let us move together, let us speak together-Rig Veda)

- Synergy
- Identification with the organization and with the employees
- Shared vision

Team Building (Characteristics of effective teams)

- Active participation
- Open Communication
- Informal Climate
- Clear Roles and work Assignments
- Style Diversity
- Self-Assessment.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

- **HISTORY OF COMPUTERS:**
- The abacus is the earliest known calculating device. It was probably first used in China 2000 or 2500 years ago. It consist of a rectangular wooden frame with rods carrying round beads.
- The first Mechanical calculating machine was made in 1642 by the great French mathematician, Blasé Pascal (1623-62). He was son of the tax superintendent in Paris. To help his father with tax calculations, Pascal invented the calculator at the age of 18.

Charles Babbage differential machine: - In 1823, Charles Babbage (father of computer), a professor at Cambridge university, developed the concept to design a calculating machine called engine which could store data and perform arithmetic operation.

Mark-I: - in 1944 Howard professors developed automatic calculating machine which called mark-I digital calculator. IBM (international business machine) corporation built this computer.
Electronic numeric integrator and calculator (ENIC): - the first electronic computer fit

in 1945 by a team of professor at university of Pennsylvania called (ENIC) it was

heavy machine consisting of 18,000 vacuum tubes, 70,000 resisters, 10,000

caisitor,60,000 switches and having large size occupying 15,000 squire feet of space.

Universal automatic computer (UNIAC): -

This is first computer made by a private company called IBM.

- In 1969 Intel was commissioned by a Japanese calculator company to produce an integrated circuit, a computer chip, for its line of calculators.
- Instead of "hardwiring" the logic of the calculator into the chip he created what is now called a microprocessor, a chip that can be programmed to perform the operations of a calculator; i.e., a computer on a slice of silicon.

Generations of computers

First Generation: --1942 to 1955

Electronic component:- vacuum tube
Advantages:- Helped in calculation and computational work.
Disadvantages: -Big size, very costly, slow speed, high power requirements, and no operating system.
Second Generation: - 1955 to 1964
Electronic component:- Transistors
Advantages: - Smaller size, less cost.
Disadvantages: - No operating system

Third generation: -1964 to 1972

Electronic component:- Iintegrated circuits(IC)

Advantages:- Used operating system and high level language
Disadvantages:- Initial problem with manufacturers

Fourth generation: -1972 to onward
Electronic component:- Microprocessor chips for CPU and memory(VLSI)
Advantages: - low cost, excellent speed and reliability.
Disadvantages:-less powerful than main frame needed

Classification of computer: - On the basis of size:

1: - Super Computer: - Computer system character by very large size and very high processing speed are called supper computer. Super computers are mainly being used for weather forecasting computational build dynamics, remote sensing, bio-medical application. Example – param-10000 (the fastest computer of world ,made in India)

2. Mainframe Computer: - A large computer system that has capability to support more powerful peripheral device and technical.

3. Mini Computer: - A reliability best but small and compare to mainframe is a mini computer the smallest category of the computer. Consisting of microprocessors and associated storage and output input devices.

4. Personal Computer: - PC is so named because it is designed for personal use. IBM for most computer manufacturing company in the world.

Hard ware and software :

Hard ware: - All the parts of a computer that we can see or touch are hardware i.e. monitor ,CPU,mother board ,other PCBs ,input and output devices .

Software: - Set of instructions and collection of Data which make the computer work is called software .Without software, the computer will do nothing. The computer hardware on its own has no intelligence and therefore must be supplied with instructions to performs a task .There are two types of Software:
(1)System software (2)Application software

(1)System software: -The software that runs the computer is called **System software** . It is the most important software which consists of Operating System and Utilities

(2)**Application software: -** These programs are designed to enable the computer to accomplish a specific task.For example Microsoft Word, Excell, Powerpoint.

Data : A collection of raw facts is called Data. Computers organize and present data in a meaning full way.
Input and Input Devices : Data is provided by the user, User can give numbers,words, sound or pictures as input. The parts of computer we use to give the input are called Input devices. Keyboard, mouse, scanner mic. Are example of input devices.

Process : the work done by the CPU on the given DATA is called processing.CPU is the brain of the computer. Like we use our brain to solve problems similarly computer solves the problem using its CPU.

Output and output devices : processed or meaningful data is called output.The output is either displayed on the monitor or printed on the paper. The parts of the computer system which give output from the CPU are called output devices.Monitor,Printer are example of output devices .

DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–II: Basics of Computer **Session-2:** Parts of Computer and their functions.

COMPUTER :

Computer is an electronics device which perform a number of tasks ie Arithmetical & logical operations. It can accept and store data, process it and can produce the output. A computer works very fast and is very accurate .

PARTS OF A COMPUTER

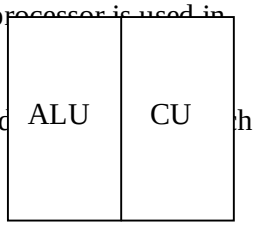
Computer Consists of following parts

- The Computer
- The Monitor
- The Keyboard
- The Mouse
- The Floppy Diskette Drive
- The CD-ROM Drive
- Peripherals

CPU :

CPU is actually a small electronic device inside the computer mounted on motherboard. Central Processing Unit(CPU) carries out all calculations and comparisons and sends it to the relevant output device . Microprocessor is used in CPU.

It has two parts.



1. ALU(Arithmetic Logic Unit) : It performs all arithmetic and h as addition, subtraction, multiplication and division .
2. CU(Control Unit): Functions of all other parts of a Computer are controlled by the control unit .

Monitor : The Computer Monitor is the video display unit consists of a television picture tube(CRT) to display the inputs and outputs.

Keyboard: The Keyboard is the primary input device used to communicate with the computer. A computer keyboard closely resembles a conventional typewriter keyboard with the addition of numerous keys that are used specifically for computing functions**.** All keys are arranged like those on a type writer .There are some extra keys with the keyboard of a computer like Control (ctrl) and altar (alt) key which have special functions associated with it in combination with other keys.

Mouse: - A mouse is a pointing device, which rolls on a small rubber ball or with optical and light arrangement which has two or three buttons on the top. The mouse is

another input device used to point at objects on the computer monitor and select them named for the resemblance of the wire coming out of it and a mouse's tail, the mouse was introduced to computing in the early 1980's when Macintosh created its graphical user interface (GUI). Using the mouse and keyboard in combination allows the computer user substantial latitude in how to accomplish a wide variety of tasks.

Basic mouse operations: -

Click: - Press and release the left button on the mouse.

Double click: - Click the left button of the mouse twice rapidly.

Drag and drop: - Holds down the left mouse button while you are moving the mouse and release it at the desired position.

Point: - Move the mouse.

Computer Memory: The memory of computer stores data and instructions. There are two types of memory :-

1.Internal Memory 2.External Memory

Internal Memory: A computer needs to store data before processing it Data is stored in internal memory of computer. It is known as the primary memory. There are two types of Internal memory (1) ROM (2) RAM

ROM (Read Only Memory):It is the permanent memory chip that is put in the computer when it is manufactured. It is provided on motherboard , the information can be used by computer for its functions but can not be changed .

RAM (Random Access Memory): RAM (Random Access Memory) is the place in a computer where the operating system, application programs, and data in current use are kept so that they can be quickly reached by the computer's processor.

RAM is much faster to read from and write to than the other kinds of storage in a computer, the hard disk, floppy disk, and CD-ROM. The data in RAM stays there only as long as computer is running. When computer is turned OFF, RAM loses its data. When computer is turned ON again, operating system and other files are once again loaded into RAM, usually from hard disk.

External Memory : Storage Devices: - External memory is needed because as soon as the computer is turned off, RAM loses it's data .This is why it is important to save data from RAM to external memory or storage device. Different types of storage devices are explained below

(i)Hard disk: - It is a group of large metal or plastic disks permanently sealed in a container. Read-write heads and access mechanisms are also in built within the container are not generally removed from their disk drives. Smaller size of Winchester disk is used in mini computer and PCs. the capacity of hard disk is about 40 G.B to 180GB or more.

(ii) **Floppy disk: -** Floppy disk is widely used storage device. Floppy diskettes are normally used as a temporary storage containers or transportation media for data. Now days two sizes of disk are commonly available- 5.25 inches and 3.5 inches A standard floppy diskette can hold 1.44 MB of computer data. These disks are economical and very flexible to use. Floppy disks are not as reliable or fast as the internal storage device. They are also the primary vector of virus infection in the computer .

(iii) CD-ROM(Compact disk ROM): - The Compact Disk-Read Only Memory (CD-ROM) disk is most commonly used storage device and has become the primary storage medium of data and distribution medium for software to consumers. It is a small optical disk in which laser beam is used to store and read information. It consists of concentric circles containing millions of pits and plateaus which correspond to on/off bits of data. CD-ROM are two types CD-R and CD-RW.

CD-R: This type of CD-ROM is "Read Only" ie. they are recordable disks. Data can be written on them only once.

CD-RW : They are re-writable CDs. Data can be written on them again and again.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–II: Basics of Computer **Session-3:** Operating Systems of Computer

---

OPERATING SYSTEMS FOR COMPUTERS:

An operating system is a set of program that runs on a computer to simplify the use of the computer for the user. The operating system manages the use of peripheral devices such as printers, monitors and keyboards. In addition the operating system will run other programs and display the results. In order to carry out these functions the operating system has to require a systematic structure for the inputs and outputs; there is a definite structure to files and there is a systematic way in which the files are stored on the data storage devices. Without an operating system a computer is not able to perform tasks.

TYPES OF OPERATING SYSTEM

- MS DOS
- WINDOWS(95,97,98,2000,XP,Vista)
- UNIX
- LINEX

WINDOWS **Operating System :** The Windows is an advanced, most capable , popular and user friendly operating system invented by Microsoft company. This operating system uses a graphical interface(pictures or icons instead of text).

Components of Windows:

The desktop: -This is the large, background area of the Windows screen, from where we can access different component of Windows.

Changing pattern of desktop: -

*Using the right mouse button click on the empty area of the desktop.

*Select properties.

*Click the down arrows on the scroll bar right of the pattern box.

*Select one of the patterns then click ok.

Control panel: -

Ø It customizes the window environment.

Ø Choose start→settings →control panel.

The icon: -Icons are the small pictures on the desktop, which represents the programs and executable files.

Changing the icon: -

*Right clicks the desktop and chooses the properties from context menu.

*Click effect tab.

Start Button: The Start button lets you know quickly open your programmes and documents

Menu bar: -This has the list of programmes .

Scroll bar: -Helps to move through the document that does not fit within the window.

The title bar: -

*The upper band of every window is known as the title bar.

*You can not move the window around your desktop in case it is not maximized

*The title bar is highlighted when the window is active.

*You can have a number of applications open at a time but can work with just one.

The task bar: -It is the rectangular bar that appears at the bottom of screen.

Hiding the task bar: -

*Using the right mouse button click on the empty area of the taskbar.

*Select properties.

*Click on task bar option tab.

*Select the auto hide and then click ok.

Setting the date and time: -

- Double click on the **date/time** icon.
- Select the digits for the month in the date box.
- Click the up down to select the month.
- To change the time repeats the same process.
- Click ok button.

Loading screen saver: -

- Click the down arrow to the right of the drop down list box named screen saver.
- Select one of the screen savers from the list.
- Click preview.
- The selected screen saver appears

Creating a folder: -

- From the tree pane select the directory under which you want to create a sub directory
- Choose file →new →folder
- Type the name of the new directory and press enters.

Deleting a directory: -

- Select the directory.
- Choose file → delete.
- If you want to delete the file or the folder. Click yes in the dialog box.

File commands: -

Moving: -

- Select the file to be moved and then drag them as a group to the new destination.

Or

- Select the file to be moved.
- Choose edit→ cut.
- Select the directory where it has to be moved.
- Choose edit → paste.

Copying: -

- Select the file to be copied.
- Hold the CTRL key. Drag the selection to destination.

Or

- Choose edit→ copy.

- Select the directory where it has to be copied.
- Choose edit → paste.

Renaming files: -

- Select the item to be renamed.
- Choose file → rename.
- Current name get selected, type in the new name.
- Press enters or clicks out side the file name.

Word pad: -

- It is used to create documents of any disc.
- Clicks start button→program→accessories→word pad.

Starting paint: -

- Original artwork can be created and moved into other window applications as follows.
- Click start button →program →accessories →paint.

Calculator: -

- It is used to solve mathematical problems.
- Click start button→program→accessories→calculator.

Notepad: -

- It is used to review and edit sort text files.
- Click start button→program→accessories→notepad.

Deleting files: -

- Select the files.
- press Del or choose file→delete
- Click yes buttons in the delete dialog box.

Accessories→Notepad

Wordpad

Calculator

Entertain

Games

Paint

Short cuts that is used in windows:

1. Ctrl+a	select all
2. Ctrl+x	cut
3. Ctrl+v	paste
4. Ctrl+c	copy
5. Ctrl+s	save
6. Ctrl+n	new
7. Ctrl+o	open
8. Ctrl+p	print
9. Ctrl+z	undo
10. Ctrl+y	redo
11. F1	help

12. Ctrl+l	left align
13. Ctrl+r	right align
14. Ctrl+e	center align
15. alt+f4	close window
16. Ctrl+b	bold
17. Ctrl+I	italic
18. Ctrl+u	underline

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–II: Basics of Computer **Session-4 & 5:** Operating Systems of Computer

---

Practical demonstration of different components of Windows operating system in computer room

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-6:** MS Word

Microsoft Office:

Microsoft Office is very popular and widely used application software suite which consists of different application software i.e Word, Excel, PowerPoint, Access etc

MS Word:

Microsoft Word is all you need for typing letters, documents, reports etc. Very easy to learn, the user-friendly.

Starting MS- WORD

Start → Program → MS-Word

OR

Click on the icon of micro soft word on the desktop.

COMPOMENTS OF THE WORD SCREEN

©Title bar.
©Vertical scroll bar.
©Horizontal scroll bar.
©Vertical scroll bar
©Menu bar
©Formatting and standard tool bar
©Status bar

Opening a new document

©Select file
©new
©Click general tab and select blank document
Or
©Select office 97 templates option button.

Opening an existing file

©Choose file©open
©Choose the file to be opened and click on the open button.

Moving information

©Select the text
©Select edit
©cut
©Place the cursor where the text has to be copied.
©Select edit > paste.

Copying information

©Select the text
©Select edit
©copy
©Place the cursor where the text has to be copied.
©Select edit
©paste

Inserting special characters

©Choose insert©symbol

Undo

©Choose edit ©undo

Repeat

©Choose edit©repeat

Creating the dictionary custom dictionary

©Choose tools©options
©Select the spelling and grammar tab.
©Click dictionaries button
©Choose new button
©Select the directory where the dictionary is to be stored.
©Choose save button.

Changing font and font size

©Select the text for formatting.
©Choose format ©font.
©Click on the font tab.
©Click on the down arrow of the font color of the font.

Indents and line spacing

©Place the insertion paint in the paragraph, which has to be indented.
©Choose format©paragraph
©Click on the indents and spacing tab.
©Enter the distance to indent in the left and right boxes.

Setting margins

©Position the cursor where, margin settings have to be changed.
©Choose file ©page setup
©Click to desired dimension boxes.
©Change paper size and orientation by switching to paper size tab.

Paper orientation

©Click file ©page setup ©paper size.
© Choose portrait or landscape in the orientation group box.

Headers and Footers

©Choose page setup ©margins tab and set marring of header and Footer in the from edge box.
©To enter a header that repeats on all pages choose.
© View © Header and Footer.
©Enter the text for the header in the header text box.

Borders and shading

©Select the portion of the document, which requires boudoirs.
© Choose format © borders and shading.
©Click on the borders tab.
©In the setting area choose any one of the setting.
©In the style box you can choose the of line the color of the line and the width of the line.
© On the page border tab, choose the type ok border to be application.
©On the shading tab, choose the type.

Views

©Word offers six unique views.

Print preview

© It is used to see the entire page at a reduced size
© Choose file © print preview

Web layout view

©It is designed to be used while creating a web page Irwin reading document on the screen.

©Choose view ©web layout

Normal view

©It is default document used box typing, editing and for mating
© Choose view © normal view

Out line layout view

©It is used to look at the structure of the document.

Creating tables

©Move the cursor to the place where the tables are to be inserted.

©Choose tables button from the standard tool bar or choose insert table from table menu.
©Set the number of row and column.
© Choose ok button

Choose table auto format

©Choose table ©insert table.

© Click the auto format button in the insert table dialog box or click table © table auto format
©Format list box and preview box is used to select the list-suited format.
To apply borers, shading, font color select from format .to applies area.
©To choose rows and columns to apply special formatting. Select the check boxes in the apply special formats to area.
©Click on ok button.

Hyper links

©It is connection betweentwo document or parts of same document and is connected use.

To create a hyper link

©Open the word document in which the hyperlink is to be insert.

©Open the file the contains text or graphics.
©Click insert ©hyperlink.
©Select the object to which the hyperlink will jump in the destination file.
©Hold the right mouse button and drag the selection where you want the hyperlink.
©Choose create hyperlink here.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-7&8:** MS Word

Practical demonstration of different components & Tools of MS Word in computer room

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-12:** MS PowerPoint

MS PowerPoint:

It is a sophisticated presentation graphics package used to create presentation using Auto content wizard.

STARTING POWER POINT

- Choose start ØprogramsØMS. Power Point

CREATING PRESENTATION USING AUTO CONTENT WIZARD

- Start power point.
- Start auto content wizard.
- Select auto content wizard button.
- Click the next button.
- After some information the presentation is created.

CREATING PRESENTATION USING DESIGN TEMPLATE:-

Choose template option. New presentation dialog box appears from which the template is selected.

New slide dialog box appears with a list of 24 pre-designed slide layouts.

CREATING PRESENTATION USING BLANK WIZARD:-

- Start power point
- Select the block presentation.
- Choose the ok button.

A COMPLETE PRESENTATION INVOLVES: -

Ø Creating the presentation.
Ø Applying a presentation design
Ø Formats slides.
Ø Add objects to the presentation.
Ø Apply transitions, animation effects.
Ø Rehearse and add slide timings.
Ø Present the presentation.

OPENING AN EXISTING PRESENTATION

1. This opens up an existing presentation.
2. Select the name of the file from the menu under file name fox.

OUTLINING TOOLBAR

1. Select view ØtoolbarØoutlining
2. Click o.k.

INSERTING A NEW SLIDE

1. Click insertØnew slide.
2. Select the slide layout and click o.k.

DELETING A SLIDE

1. Selected the slide in the out line view
2. Choose editØdelete slide and choose o.k.

PRINTING THE PRESENTATION

1. Click file Ø print.
2. Select the slides to be printed from the print ranger box and click o.k.

SAVING THE PRESENTATION

1. Choose file Ø save.
2. View the name to the presentation and click save.

CLOSING THE PRESENTATION

1. Choose close command from the file menu.
   OR
2. Click on the presentation close button

FORMATING TEXT

TO MAKE TEXT WORD.

1. Select the text tool on the droning toolbar.
2. Set the texts width.
3. The typed text will wrap inside the box.

SHADOW TEXT

1. Add a shadow behind the text
2. Choose formatØfont.
3. Select shadow in the effect box and choose o.k. Button.

ADDING A SHADED BACKGHROUND TO SLIDES

1. Choose format Øbackground.
2. Select on option in the shade box from the background dialog box.
3. Choose apply or apply to all.

APPLYING DESIGNS TO SLIDES

1. Choose format Ø apply design template.
2. Choose the template name to the entire preview.
3. Double click the selected template to apply to all slides.

POWER POINT OBJECTS

(Select an object)

1. Touch any visible part of on object and click the left button of the mouse.
2. To choose all the objects choose editØ select-all.

DE- SELECT AN OBJECT

1. H0ld down the shift key and click the mouse button.

GROUPING JOBJECTS

1. Create a group by selecting more than one object.
2. Select the attributes to all the objects in a group.

UN GROUPING REGROUPING OBJECTS

1. Select the group by clicking on a grouped object.
2. Choose Draw Øungroup or Regroup.

MOVING AN OBJECT

1. Select the object or border and drag the outing to a new location.

ALIGINIG OBJECTS

1. Choose drawØ align.
2. Select the type of command from. FormatØalignment.

ADDING CLIPART

1. Click the insert clipart button on the drawing toolbox.
   OR
2. Double click a clipart placeholder on an auto layout.
   OR
3. Choose insert Øpictureø clipart.

RECORDING A CLIPART OBJECT

- Ø In the slide, select the clipart object.
- Ø Click the Recolor picture button on the picture Tool bar.
- Ø Choose to change color or fills.
- Ø Click and choose a new color bar each color to be changed.

FORMATTING INDIVIDUAL CHART OBJECTS

- Ø Select the object in the chart.
- Ø Right click and choose formatØ object.
- Ø Set options on each dialog fox and click o.k.

WORD ART

- Ø Special effects can be added to the text
- Ø Choose insert Ø picture Øword art

INSERTING A GRAPH

- Ø Click insertØ objects.
- Ø Select through the data on the data sheet and choose editØclear.
- Ø Enter the data in the data sheet.
- Ø Close the data sheet by clicking on the close button.

SOUND AND MOTION CLIPS

- Ø Open the slide.
- Ø Choose insert Ømovies and soundØsounds.
- Ø In the clip art dialog box, select the sound or motion clip.
- Ø Click insert clip to insert object.
- Ø Double click on the icon or object to play the sound or motion clip.

CRATING HYPEARLING TO ANOTHER SLIDE

- Ø In slide view select the text.
- Ø Choose slide show Øaction settings
- Ø Choose the hyperlink option.
- Ø From the hyperlink drop down list select the slide to be linked select a slide and click o.k.
- Ø Choose of to create the hyperlink.

INSERTING AN EXCEL CHART

- Ø Clicks on the chart in excel and choose editØ copy.

- Ø Switch back to power point and click on the graph placeholder on the slide and choose editØ paste.
- Ø Creating notes.
- Ø Involves cover age chapter typing your notes and designing the look of the presentation choose viewØ notes pages select the notes box by clinking inside and start typing.

ANIMATION EFFECTS

- Ø Selects the object and choose slide showØ custom animation.
- Ø In the entry animation and sound group box on effects which can be applicable to the object are displayed
- Ø On clicking the preview button the preview of effects are displayed
- Ø Click on o.k.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-10&11:** MS Power Point

---

Practical demonstration of different components & Tools of MS Power Point in computer room

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-12:** MS Excel

MS Excel :

Ø M.S. Excel is as window based spread sheet.
Ø Excel can graphic objects.

STARTING EXCEL :-

Ø Click start → Programs → Micro soft excel
Ø Double click the icon of M.S. Excel on the desk top.

OPENING A NEW WORK BOOK :-

Ø Select File → New.
Ø In the General tab, select the work book and click on ok.

PRINTING A NEW WORK BOOK:-

Ø Select File → Print
Ø Choose the number of copies and page numbers to be printed.
Ø Click on preview button to view the matter.
Ø Under print what select what to print and click ok.

ADJUSTING MARGINS IN PRINT PREVIEW :-

Ø It displays the current margin settings.
Ø Choose File → Print Preview.
Ø Click the margin button.
Ø Drag the margins you wish to change to its new location.

CHANGING PAGE SETUP :-

Ø You can adjust the setting per page number, paper margin and size of paper.
Ø Choose File → Page setup.
Ø Click the page tab.
Ø Change setting for scaling, paper size, print quality and first page number and click ok to apply.
Ø EDITING THE WORK SHEET :-
Ø Activate the cells whose values needs to be edited.
Ø Double click the cell or press F_2 to change the data.

INSERTING ROWS AND COLUMNS :-

Ø Select an entire row by clicking on the row number.
Ø To select consecutive rows click on the first row and with mouse button pressed drag it to the last row.
Ø Select Insert → Rows.
Ø Similarly select the columns.
Ø Select Insert → Columns

DELETING ROWS AND COLUMNS :-

Ø Select the rows or columns.
Ø Select edit → Delete

Deleting Cells: -

v High lights the cells.

- Choose Edit →Delete.
- Choose the direction in which the adjoing cell have to be moved in the delete dialog box.
- Click OK button.

Cut ,Copy And Paste: -

- Select the data to be moved.
- Choose Edit → Cut or Copy.
- Select the first cell , row or column where the data is to be placed.
- Select Edit→ paste.

Using Drag And Drop: -

- Select the source cell or cells.
- Point any edge of the selection.
- The moue pointer changes to an arrow.
- To move the selection drag drops it in the new location.
- To copy the selection holds the CTRL key while dropping the selection.

Headers And Footers: -

- Headers and footers appear at the top and bottom of the page respectively .
- Choose File → Page set up.
- Select the header / Footer option from the page setup dialog box.
- Click the drop down list of header/footer.
- Press enter to return to the page set up dialog box.

NAMING A WORK SHEET:-

- Double click the sheet table to select it.
- Type a new of the work sheet and press enter.

SELECTING WORK SHEETS :-

- Click the sheet tab.
- To select more than one work sheet hold the CTRL Key.
- To select all work sheets right on any tab and choose select all sheets.

UNGROUPING WORK SHEETS :-

- Right click on any group worksheet tab and choose ungrouped sheets.

INSERTING AND DELETING WORK SHEETS :-

- Choose Insert → Work sheet to insert a new work sheet.
- Choose Edit → Delete sheet to delete the work sheet.

COPYING AND MOVING WORK SHEETS :-

- To mouse within the same work book .Drag the sheets tab to the new location and drop it.
- Hold down the CTRL key while dragging to copy the work sheet.
- To move or copy between work book.
- Select the work sheet.
- Choose edit → move or copy.
- Select the name of the work sheet.
- Click create a copy to copy it and click ok.

COLUMNS WIDTH AND ROWS HEIGHT :-

- Click on the column letter to make it active.
- Select Format → Column
- Click on width option.
- Type in the require size.
- Similarly rows height can adjusted by selecting format → Rows.

CELL FORMATING :-

- High light the cells.
- Choose Format → Cells

CREATING A CUSTOM FORMAT :-

- Select the cells.
- Choose format → Cells.
- On the number page of format cells dialog box chosen custom from category list.
- Click of to apply the custom format.

AUTO FORMATTING :-

§ It applies a standard format to all or part of a work sheet.
§ Select the portion of the work sheet which is to the formatted.
§ Choose format → Auto format.
§ Choose the format from the auto format dialog box.
§ Choose the options button to show formats to apply.
§ Click ok to apply the selected formats.

CONDITIONAL FORMATING :-

§ Formats can be applied to selected cells based on a condition.
§ Select the cells.
§ Choose Format → Conditional formatting.
§ Choose cell value is, or formula is.

CONDITIONAL FORMATING CONTINUES :-

§ Select a conditional operator.
§ In the condition text box enter a value cell reference or formula.
§ Click the format button.
§ Set up a format for this condition and click ok.

TYPES OF CELL REFERENCES :-

§ Relative referencing.
§ Absolute referencing.
§ Mixed referencing.

USING NAMES IN FORMULA :-

q Click on the point in the formula where the cell reference is to be included.
q Click Insert → Name.
q Select paste option from name submenu.
q Select the name of range to be used in formula and click ok.

CREATING NAMES FROM A ROW OR COLUMN OF TEXT :-

q Select the range to be named.
q Choose Insert → name create.
q Select the row or column that contains
q Tables to be used in the create names text box.
q Click ok to apply names.

OPENING AN EXISTING FILE :-

- Click File → Open.
- Click on the file name and then click on open.

SAVING A WORK BOOK :-

♦ Select file → Save.
♦ Click on the save button.

CREATING NAMES FOR RANGES :-

§ Select the cell or range of cells that is to be named.
§ Choose Insert → Name
§ Select define option from name sub menu.
§ In the names in work book text box, type a name and click add.
§ Edit the range coordinates it required from refers to text box.
§ Click on add button to create to create the name.
§ Click on ok.

LINKING WORK BOOKS :-

q Open both dependent and source work book.
q In the dependent work book enter the formula.
q Open the window menu and select the source workbook.
q In the source, work book select the cell where the formula is to be included.
q Finish creating the formula in a normal process.

FINDING RECORDS BASED ON CRITERIA :-

v Choose Data → Form.
v Click on the criteria button and in the field type in the criteria condition.

- Click the find next button.
- To find additional records click find next button.
- Click close button when finished.

CREATING A NEW DATA BASE FROM A FILTERED SUBSET :-

- Filter the active data base to create a filtered subset.
- Select the filtered data base including the column tables.
- Choose edit → Copy.
- Press enter to paste the data base.

FUNCTIONS :-

- They are built in special program which accept data and return a value after performing calculation.

THE FUNCTION WIZARD :-

- Select the cell in which the function is to the inserted.
- Select Insert → Function.
- Select the function category from the paste function dilog box select the paste function dialog box select the function available from the right side.

AUTO CALCULATE: -

- It is used if the result is not be stored in a cell.
- Select the range of cells containing the numeric values.
- Right click on the status bar.
- Select the calculation to be form. performed on the selected cells.
- The result is displayed on the status bar.

COMMONLY USED FUNCTION :-

- Date and time functions.
- Logical function.
- Statically function.
- Math magical function.
- Text function.

GOAL SEEK :-

- It is used to find out the result of a formula if one variable is changed.
- Select the cell, having formula having value to be edited.
- Choose tools → Goal seek.
- Click into value text box and type in the new value.
- Click the by changing cell box and type cell address of cell whose relative value is to be changed.
- Click on ok.
- Goal seek dialog box appears giving the result.
- Click on ok to change the value and cancel to ignore the result.

CREATING A CUSTOM FILTER :-

- Gives access to other ways to set entries.
- Choose Data → Filter → Auto filter
- Choose custom from filter criteria drop down list.
- Set the operation type for the first criterion from the custom auto filter dialog box.
- Set the operation type for the first criterion.
- Enter or select first criterion from the drop down list.
- Set an operator and enter or select the second criterion.
- Set and for a range, set or to filter for move.
- Click ok to apply the custom filter.

FILTER :-

- It is used to see only the records you need.
- Select the cells to be filtered.
- Choose Data → Filter → Auto filter
- Click on the fitter arrow on the cell where filtering is required.
- Choose from the options of the list of criteria drops downs.
- Select an item in the criteria list to filter all other data.

- Ø The all option shows all the records.
- Ø To all option shows all the records.
- Ø To remove the filters choose

  Data → Filter → Auto filter

PIVOT TABLE :-

- ü It is used to create cross tabulated data.
- ü Select the data base to used.
- ü Choose Data → Pivot table and pivot report.
- ü Select M.S. Excel list or data base and click on next button.
- ü Select the data and then click on next button.
- ü Click the finish button on pivot table and pivot chart wizard.
- ü To add a field select any cell and choose Data → Pivot table and pivot chart report.
- ü Click the layout button to open the layout dialog box.
- ü Add fields and click ok to finish.

CREATING SEPARATE PIVOT TABLE BASED ON VALUE :-

- Arrange the pivot table layout so that the field to be sued to separate the table is in page area.
- Select any cell right click and choose show pages.
- Choose the field for which separate pivot table is to be created and click ok.

LINKING WORK SHEET :-

- ♦ Open the source work book.
- ♦ Select the source cell.
- ♦ Select edit → Copy open the target worksheet click on cell where you want the link.
- ♦ Choose edit → Paste special.
- ♦ Select all from paste option button on and name from operations button.
- ♦ Click on paste link button.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–III: Microsoft Office **Session-13&14:** MS Exel

Practical demonstration of different components & Tools of MS Word in computer room

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–IV: Internet &E-mail **Session-15:** Internet & Web-surfing.

INTERNET: The Internet is the worldwide, publicly accessible network of interconnected computer networks that transmit data by packet switching using the standard Internet Protocol (IP).

It is a "network of networks" that consists of millions of smaller domestic, academic, business, and government networks, which together carry various information and services, such as electronic mail, online chat, file transfer, and the interlinked Web pages and other documents of the World Wide Web.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson–IV: Internet &E-mail **Session-16:** e-mail & demonstration for making e-mail ID

Practical demonstration of different components & Tools of Internet explorer,e-mail & making e-mail ID in computer room.

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**)**

ALC:INTRODUCTION:-

Win ALC is the next generation of the well proven Plasser "ALC" track alignment computers. Since the first Plasser PC MSDOS based "ALC" was introduced in 1992 approximately 300 units have been fitted to machines world wide. The program is not tailor made for one specific country but contains all the main elements for world wide applications. The program for the "ALC" has constantly been updated from the first edition with new features being added as an ongoing situation. The PC based "ALC" program had been taken to the limit of the MASDOS operating system so it is a natural progression to change the operating environment to WINDOWS 95, this removing the restrictions of the MSDOS memory limitations and enabling a multi tasking environment that will be already familiar to the majority of people today.

The "Win ALC" system is designed as an addition to enhance and improve the existing PLASSER tamping machines lining and lifting systems. It can be fitted as a bolt on to an older machine or normally is fitted when the machine is built.

TECHNICAL DESCRIPTION OF SYSTEM:

The WIN-ALC system comprises of 4 distinct main parts:

1. The Computer or PC
2. The Display or Monitor
3. The keyboard (also fitted with the pointing device, the mouse)
4. The distance measuring wheel or encoder

Technical data:

System unit
PLASSER Built Dedicated PC :Intel Pentium 100 MHZ
16 Mbytes Memory
70 Ns Starting time
3 ½'1.44MB Floppy Disc drive
959 MB IDE-BUS

The Computer:

LED FUNCTIONS
POWER : on, when computer is running
BACKUP: on, when Computer supplied by the internal power supply (see 'power supply)
BATTRY: on low voltage limit of the power supply, EXIT program and switch.
OFF Computer, is the light still ON, the supply voltage is too low and the computer will be switched OFF automatically.
HARD DISK: on, when hard disc used.

The display:

1= SUN VISORS
2= VISOR LOCKING NUTS
3= QUICK RELEASE TILT ADJUSTMENT
4= TILT ADJUSTER LOCKING HANDLE

The display tilted to optimize the viewing angle for individual operators:

Description of Keys:

Esc	For aborting of menus, entire screen pages and the help mode, and input screens etc.
Ent	Input key OK-key. This key is used for selecting sub menus, menu items and input areas, as well as confirmation of inputs.
Space Bar	Used for placing spaces between words and letters, make the initial selection in a windows selection box, used after the tab key.
Enfg	(Insert) Adding one symbol in front of the cursor.
Entf	Removing a symbol under the cursor. Deleting of a constants, areas, markers, symbols and values.
Pos. 1	(Home) To move the cursor to the top left edge of the input area.

End — To position cursor on the right edge of the input zone and the input are to the right bottom window edge. Select bottom menu item and bottom selecting area.

Picture A — Moves display upwards one page

Picture V — Moves display downwards one page

Cursor Keys — Moving the cursor or blue cursor line up/down, or left/right corresponding to the arrow on the key.

Caps Loc — Change over to capital letters and symbols while key is held in.

Tab — Tabulator jumps the cursor to the right, if shift key is held in the cursor jumps to the left.

Function keys – F

Used especially while working and measuring

Functions while working are used for:

- Help key
- Synchronizing the distance measurement.
- Canceling the warning signal
- Setting of mark points during the measuring run.
- Advancing the position line to the next synchro-point (Only during working mode).
- Setting of a fixed point during measuring run
- Marking of sections with linear versine for the versine compensation.
- Start and end of a fixed point area, is set during the measuring run
- Adding a line, after pressing the key, a new input zone appears above the marked one.
- Deleting the line in which the marked input zone is.

The Mouse:

Built into the keyboard is a unique and versatile “mouse” the Micro Module. MicroModule emulates all of the functionality of a standard two-button mouse. To control the cursor direction and speed, just place your finger on the Mini your finger on the Mini joystick and gently rock in the direction you want the cursor to move. Press softly for slower movements; press harder for fast movements. The primary click button is on the left of the Mini Joystick. It is equivalent to the left click button on a conventional mouse. The secondary click button is located on the right, and is equivalent to the right click button of mouse.

The distance measuring wheel: Located on front bogi

The ALC Power Supply:

The main power supply is taken from external batteries (24VDC), which are charged by the machine’s electric system. In case of low voltage or failure of the main power supply, it will be switched over automatically to an internal UPS supply in the computer. The control lamp “BATT” will come on. Failing main power supply will also causes the screen to non-function. The external system charges the batteries of the internal power supply automatically.

Attention: To avoid discharging the batteries, the computer should not be used for very long periods without running engine. The operating voltage dropping to the lower limit will be indicated by the control-lamp 'BACK UP'. In this case switch off the computer and start engine.
If the BACK UP LED is on with the engine running the main power supply.

Session-18: Introduction to WinALC Software

Introduction of WinALC software and demonstrationof components and tools in computer room

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**) Session-19:** Working in Geometry mode

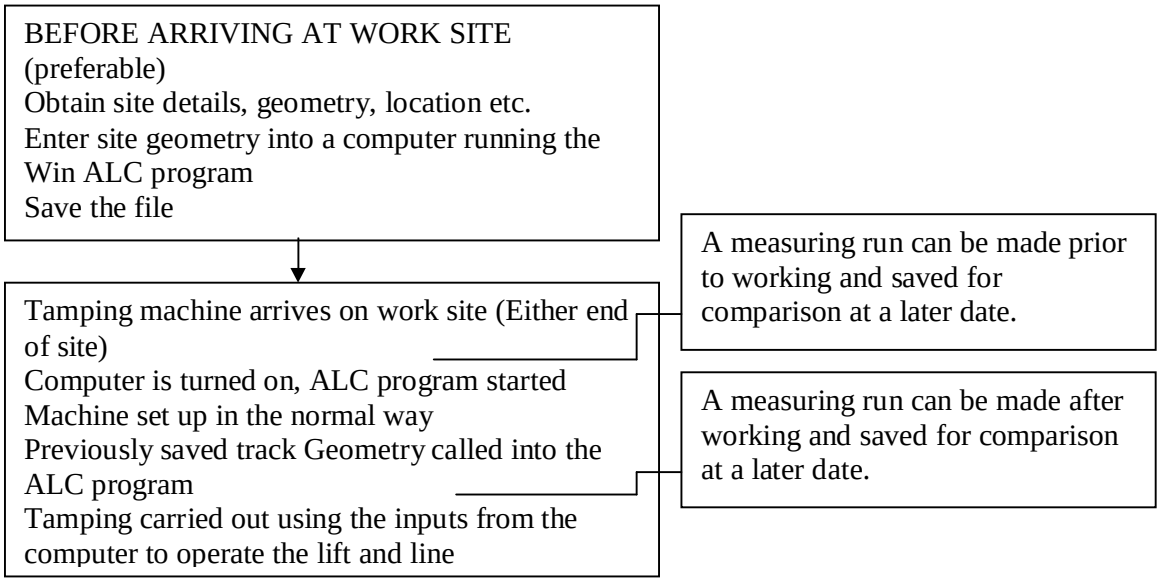
WORKING IN GEOMETRY, MEASURING RUN.

The "ALC" has two methods of enhancing the tampers track alignment systems. "Geometry" method and the "Measuring and compensation" method. In the geometry method the target track geometry is entered into the computer along with design data. For this method of working the exact design and geometry information must be known. A measuring run is not carried out as the computer will automatically input the correct lining and lift information calculated from the data entered.
The "Measuring" method is used where the track data is not known.The data for the track is obtained via a measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radii, etc. After computation by the "ALC" computer the tamper is set to work with the "ALC" automatically entering the computed lift and line data.

ALC Geometry Method:

The geometry method of operating the "ALC" is used when all of the target data for a section of track is known. The data is loaded into the computer at any time prior to work. A measuring run is not used in calculations as all data has been entered, although measuring runs can be made before and after work as a benchmark.

Sequence of Operation



SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**) Session-20:** Working in Geometry mode

Demonstration of working in Geometry mode in computer room with WinALC software

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**)** **Session-21:**Working in Measuring Run mode

THE "MEASURING" METHOD : The measuring method is used where the track data is not known. The data for the track is obtained via measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radius, etc. After computation by the "ALC" the tamper is set to work with the "ALC" automatically entering the computed lift and line data.

Sequence of Operation:

The machine can either measure in the working direction or in the reverse. If the track is measured in the working direction, the tamping machine must reverse back to the start of the work site before commencing tamping. There is a "fast measuring drive" key switch on the front and rear driving desks. These enable the machine to use the second gear of the main drive to make the measuring run.

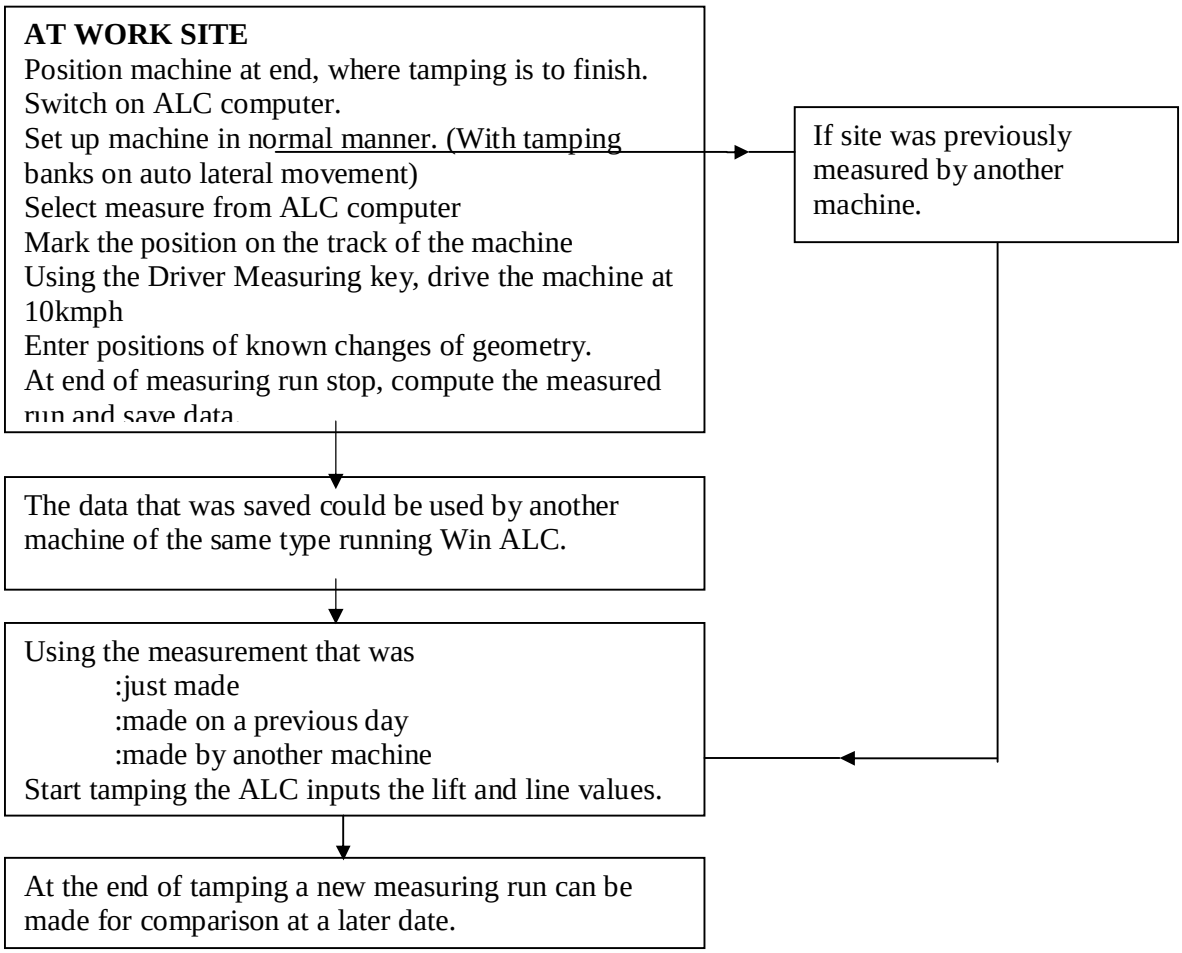
Performing a Measuring Run:

The machine is set up for normal working, although this is not necessary to have the tamping banks running. The tamping banks slew switch on the B2 panel should be set to automatic. If it is on manual the fast measuring function will be disabled. It is advisable to drive the machine for a short distance using the normal working drive. Thus checking that the lifting and lining system is in working order before the start of the measuring run by avoiding errors at the start of the measuring run, due to poor bogie alignment or incorrect pre-loading.

It is important to select the correct float rail. If the wrong rail is selected, the design for the lift will not be correct. It is also a good idea to mark the position of the machine on the rail before the start of the measuring run, so that the machine can be repositioned accurately at the start position after the measuring run has been completed (Forward measuring run). The lining system has to be set to 3-point. Use the can switch to select the datum rail for the longitudinal height recording. The reference rail for the versine recording is selected by turning on the lining system and selecting the required pre-load.

End of Measuring Run: At the end of the measuring run return the key switch to the normal position. The computer will automatically produce a "run in from" the old track geometry to the new target geometry at the beginning and end of the measuring run. The measuring run should therefore only cover the length of rail on which the work has to be carried out.

Sequence of Operation



SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**) Session-22:**Working in Measuring Run mode

---

Demonstration of Working in Measuring Run mode in computer room with WinALC software

SUB-DISCIPLINE:- COMPUTER (LESSONS: 05 SESSIONS:23)

Lesson-V: Automatic Guide Computer (ALC**) Session-23&24:** Working in Design mode

---

Demonstration of Working in Design mode in computer room with WinALC software