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# Summer Training Report on Diesel Locomotive Works, Varanasi

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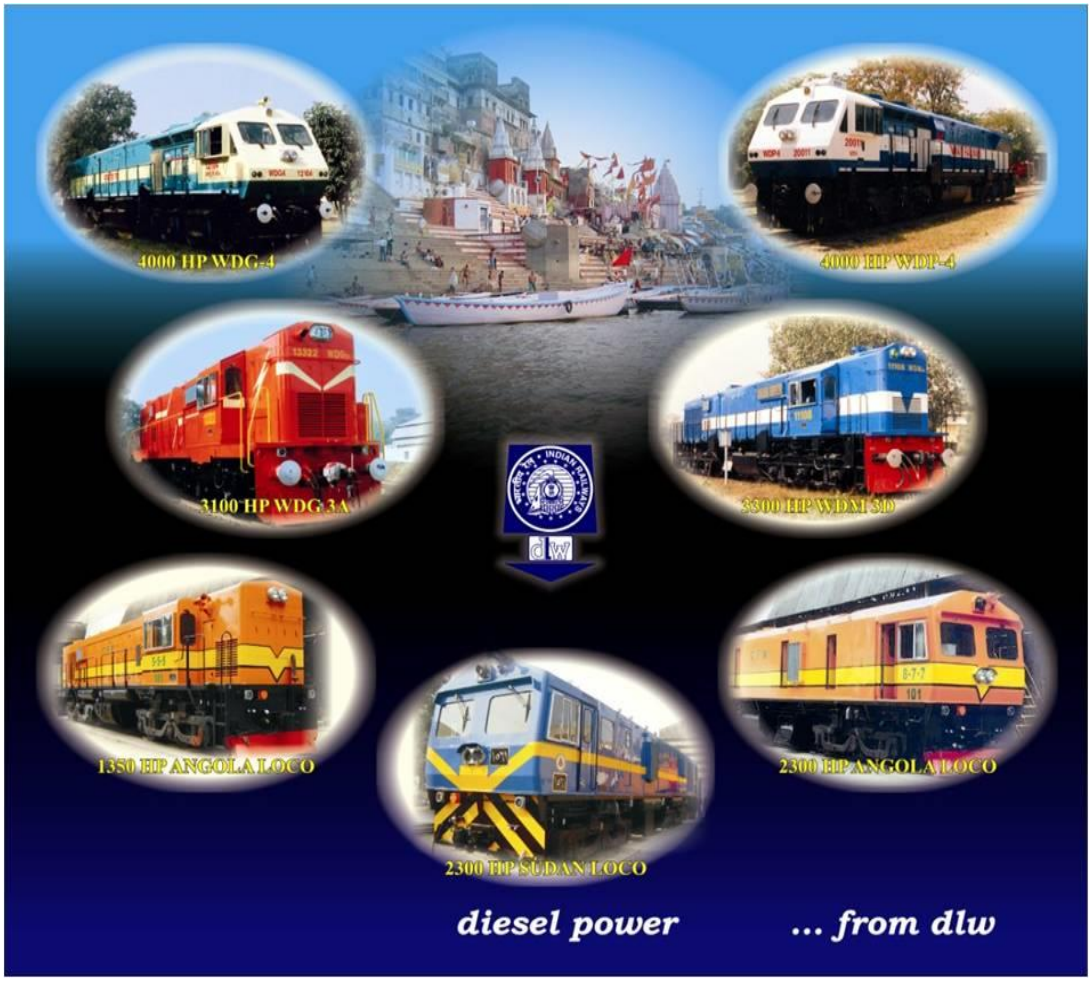


## ABOUT INDIAN RAILWAYS

- The first railway on Indian sub-continent ran over a stretch of 21 miles from Bombay to Thane.
- The formal inauguration ceremony was performed on April 16th, 1853, when 14 railway carriages carrying about 400 guests left Bori Bunder at 15:30 amidst the loud applause of a vast multitude and to the salute of 21 guns.
- Indian Railways is the world's largest govt sector having employees over 13 million.
- Indian Railways is divided into 16 zones headed by GM (General Manager).
- Mughlasarai, MGS Division of ECR (East Central Railway) is the largest Marshalling Rail yard of Asia.

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- DLW was setup in 1961 in Varanasi under as manufacturing unit under the ministry of Indian Railways.

## PRODUCTION UNITS

- Chittaranjan Locomotive Works, Chittaranjan
- Diesel Locomotive Works, Varanasi
- Diesel-Loco Modernization Works, Patiala
- Integral Coach Factory, Chennai
- Rail Coach Factory, Kapurthala
- Rail Wheel Factory, Bangalore

## OTHER INDEPENDENT UNITS OF INDIAN RAILWAYS

- Central Organization For Railway Electrification, Allahabad
- Central Organization For Modernization of Workshops, New Delhi

## IMPORTANT MAINTENANCE WORKSHOPS ON I.R.

- T.R.S. (Traction Rolling Stock) of Diesel & Electric Loco Shed, Mughalsarai
- Southern Railway Workshop, Ponmalai (Golden Rock), Tiruchirapalli
- Rail Spring Karkhana, Gwalior

## ABOUT DLW

DLW was set up in 1961 in collaboration with ALCO/USA in Varanasi, the city that awakens to faith, devotion & peace of mind, is one of the few loco builders in the world & largest of Asia with Vertical Integration: In-house manufacture of components & sub-assemblies. In the process of switching over to production as per EMD loco technology was transferred in contract with EMD/General Motors for manufacturing of passenger and freight versions of 4000 HP locomotives, including 710 series engine & manufacturing of Diesel Generating Sets (DG Sets).

The foundation stone was laid on April 23rd, 1956 by Dr. Rajendra Prasad, the first President of Republic of India, the DLW rolled out its first Locomotive on January 3rd, 1964. From then to till date DLW has served more than 6000 locos to the nation including Railways, Non-Railways customers & global market.

### DLW Milestones-

| | |
|---|---|
| Jan 1964 | First loco turned out |
| Jan 1976 | Enters export market |
| Dec 1977 | First DG set manufactured |
| Oct 1993 | 3100 HP locomotive produced |
| Oct 1995 | Contract with General Motors |
| Feb 1997 | ISO 9002 certification obtained |
| Mar 2001 | ISO 9001 and 1401 certification |
| Oct 2001 | 3300 HP Locomotive produced |
| Mar 2002 | First indigenous freight locomotive of GM design produced |
| Nov 2002 | 3600 HP Engine produced |
| Apr 2003 | First indigenous passenger locomotive of GM design produced |

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| | |
|---|---|
| Sep 2005 | OHSAS 18001 obtained |
| 2006 | 5000th locomotive produced |
| Mar 2007 | 4500 HP Locomotive produced |
| Mar 2009 | 257 locomotives manufactured in 2008-09, highest ever locomotive production. |

## QMS, EMS & OHS MGMT. SYSTEMS AT DLW

DLW is certified with-

| | |
|---|---|
| *ISO 9001:2008 | for Quality Management |
| *ISO 14001:2004 | for Environment Management |
| **OHSAS 18001:2007 | for Occupational Health & Safety Mgmt. |

*All the above three mgmt. systems are integrated.*

*ISO: International Organization for Standardization

**OHSAS: Occupational Health and Safety Assessment Series

## DLW MISSION & VISION

**MISSION-**

To be a world class manufacturer of Diesel - electric Locomotives

**VISION**

We shall achieve our vision through Continuous Improvement in the areas of-

- Product Quality
- Research & Development
- Supplier Partnership
- Human Resource Development & Team work with emphasis on Core Competence leading to Customer Satisfaction & Business Excellence.

## MANUFACTURING ACTIVITY

With the laid of first foundation stone by the first President of Republic of India, Dr. Rajendra Prasad on April 23rd, 1956 opened a golden chapter in the history of Indian Railways to make India technologically self-sufficient in the field of Diesel traction. Since inception every step DLW takes is in the direction of development with latest technological advancement, strong collaboration with its technology partners & involvement of workers DLW has been manufacturing high quality locomotives & Diesel Generating sets (DG sets) for Indian & global market. Each & every member of this organization is involved in the process of manufacturing of high quality standard locomotives from raw materials like plates, forgings & castings transforming them in diesel locomotives. Quality & dedication for work is what DLW is known for.

The manufacturing activity at DLW is broadly divided into 3 major Divisions-

I. Block Division
II. Engine Division
III. Loco Division

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# I. BLOCK DIVISION


The block division is concerned with cutting & fabrication of steel plates using positioners & manipulators. These positioners help in correct positioning of massive 6tonnes steel fabrication for high quality welding. After welding weld joints are radiographically & hydraulically tested. The ready block is then heat treated in the furnace to normalize the weld monts for subsequent machining. Crankcase having close engineering tolerances is machined on highly advanced 5-axis computer controlled Portal milling machine, Angular boring. This special purpose machine is used for boring holes at 45° in cylinder block for assembly for pistons in the liners.

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## CYLINDER BLOCK- ALCO ENGINE

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## *CYLINDER BLOCK- GM ENGINE*

## BLOCK FABRICATION

A. Set up & tack weld of sub assembly of block (250 hrs)

B. Main Fabrication of block (850 hrs)

C. Heat Treatment

D. Shot Blasting

E. Inspection

F. Dispatch- to machine shop

**Fabrication time-** Total Time Required for block fabrication is 1100 man hours (50 days).

## A. SET UP & TACK WELD OF SUBASSEMBLY OF BLOCK (250HRS)-

### Welding processes involved in fabrication of block

- SMAW (Shielded metal arc welding )
- SAW (Sub merged arc welding )
- SAW (Tandem)

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- GMAW (MIG &MAG)
- FCAW (GAS SHIELDING)

**Main parts involved-** FR, Spline, Saddle, outside wall, Middle Deck, In Side wall, Top Deck, Lifter Block

**Main types of Welding Involved-**

| | |
|---|---|
| – Saddle to Spline | SMAW-T1 |
| – Outside wall to Saddle | SMAW-T1 |
| – Middle deck to Spline and OWL | SAW –T2 |
| – Top Deck to OWL,IWL, | SAW –T2 |
| – Spline to IWL | SAW –T1 |
| – FR to Saddle | SMAW-T1 |

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# Set-Up Of Spline & Saddle


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## ***Set-up of saddle & foundation rail***

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## *Middle deck setup*

## *Ready subassembly*

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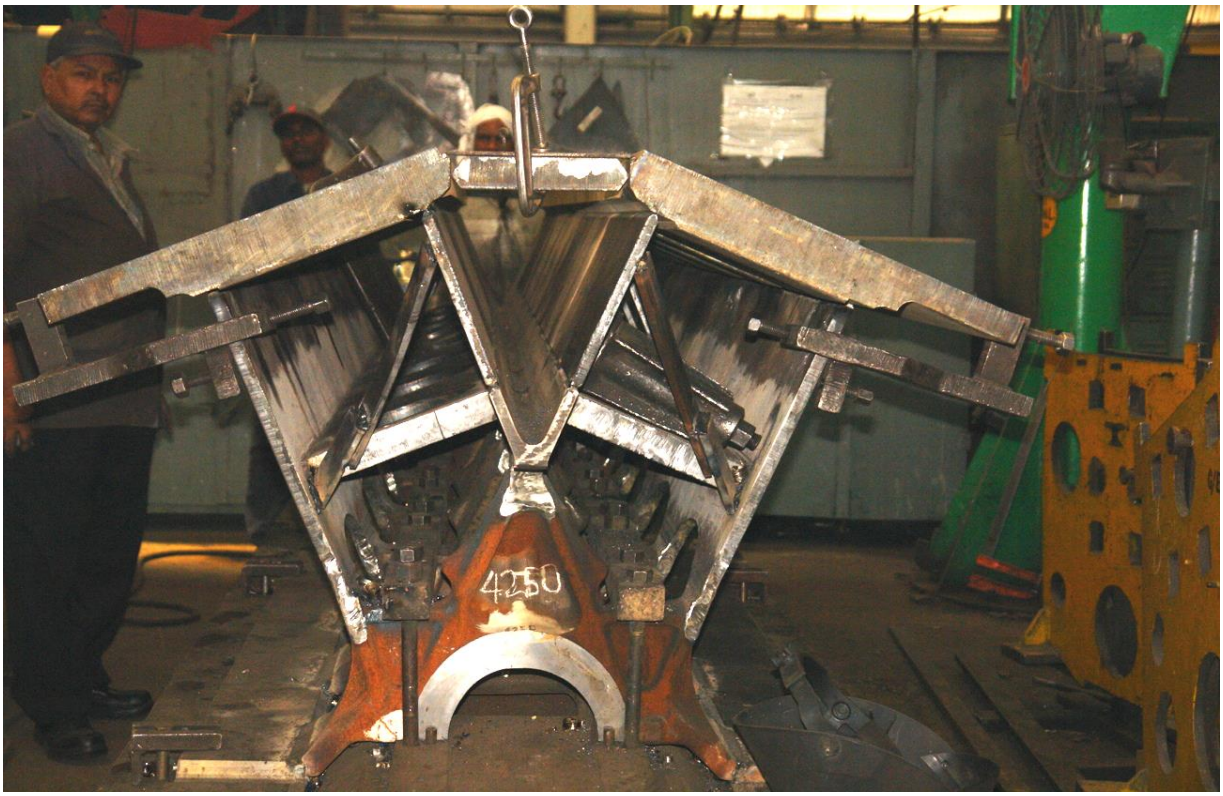



# PRINCIPLE OF SMAW

Electric arc set up between the end of a coated metal electrode and the work piece. Molten metal droplets and the molten weld puddle are shielded from the atmosphere by the gases produced from the decomposition of the flux coating.

## Selection of Electrodes-

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*Rutile – E 6013

*Iron powder – E6020

*Low hydrogen upon basis of flux coating – E 7016, E7018

*Cellulose – E6011

## SAW (Submerged Arc Welding)

The arc, the end of electrode and molten pool remains completely hidden and are invisible being submerged under a blanket of granular flux. The continuously fed bare metal electrode melts and acts as filler rod.

### SAW Equipments-

- A wire feeder to drive the electrode to the work through the contact tube of a welding head.
- A welding power source to supply electric current to the electrode at the contact tube.
- Flux feeding system.
- A means of transferring the weld joint.

## External SAW

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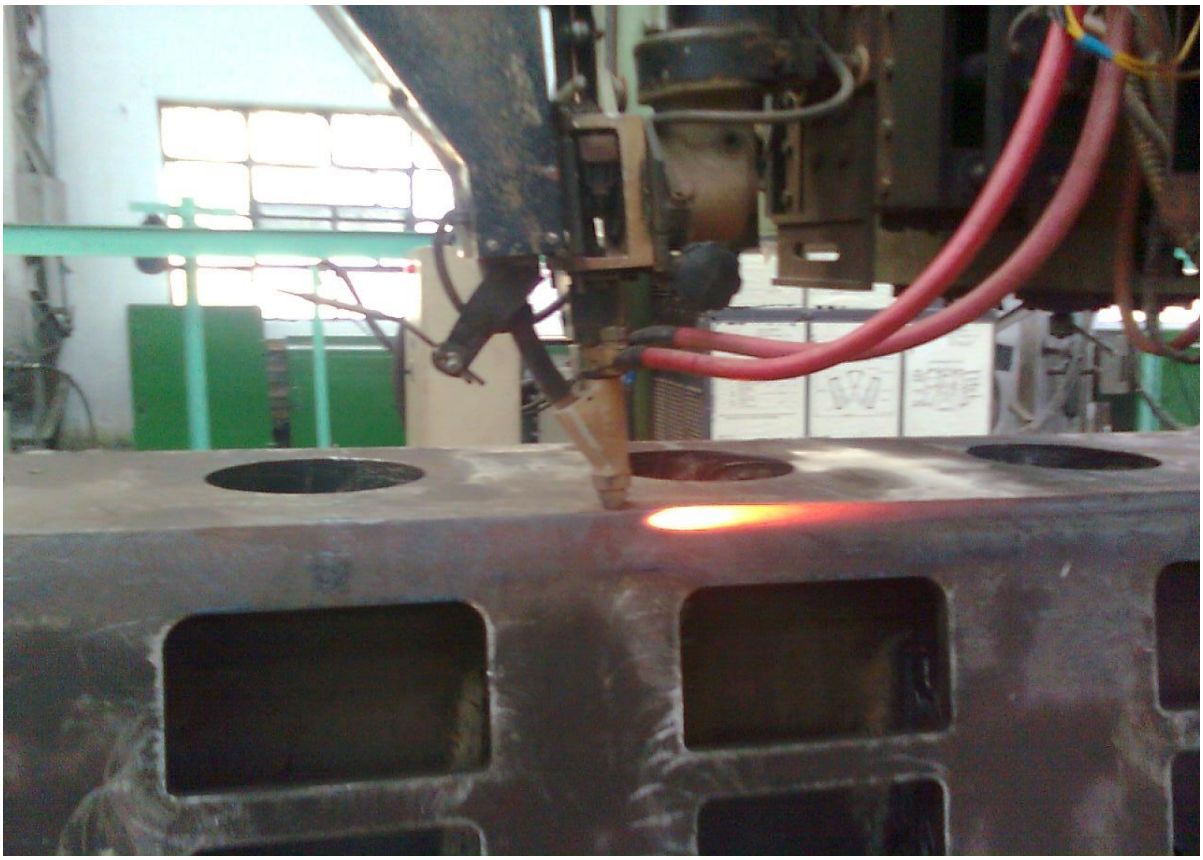

***Internal SAW***

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## SAW Consumables-

Continuous bare wire in the form of coil and dry granular flux are used in combination as saw consumables.

- Size- 5/32”, 7/32”, 4.7mm
- AWS-5.17
- F7A6-EM12K
- F-flux
- 7x10000psi
- A- condition of the HT in which test is conducted
- 6- tells the minimum temp

## *Center Pivot Welding*

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## B. MAIN FABRICATION OF BLOCK (850HRS)-

**Main parts involved-** Cam bearing support, rib, water compartment, side sheet, fuel shelf component, end plates, top deck center

### Main types of Welding Involved-

- GMAW- (MIG)
- SAW
- FCAW

***Setup rib, cam bearing and water compartment***

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***Fuelshelf welding***

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# Gas Metal Arc Welding (GMAW)

Gas Metal Arc Welding is a welding process which joins metals by heating the metals to their melting point with an electric arc, produced between continuous consumable electrode wire and the metal being welded.

## GMAW equipments-

- Welding power source - cv characteristic
- Wire feeder- control supply of wire to welding gun
- Supply of electrode wire
- Welding gun- delivers electrode wire and shielding gas to the weld puddle.
- Shielding gas cylinder-provide the supply of shielding gas to the area.

## GMAW Consumables-

***A-***Wire- AWS-SFA 5.18

- ER70S-3 (0.9mm)
- E70 C -3M-H4 (1.2mm,1.6mm)

***B-*** Shielding Gas

- ARGON+$CO_2$ (82%+18%)

***C-*** WIRE

- AWS- SFA 5.20

  E 70 T-1 (2mm), Shielding Gas- $CO_2$

# MIG Welding

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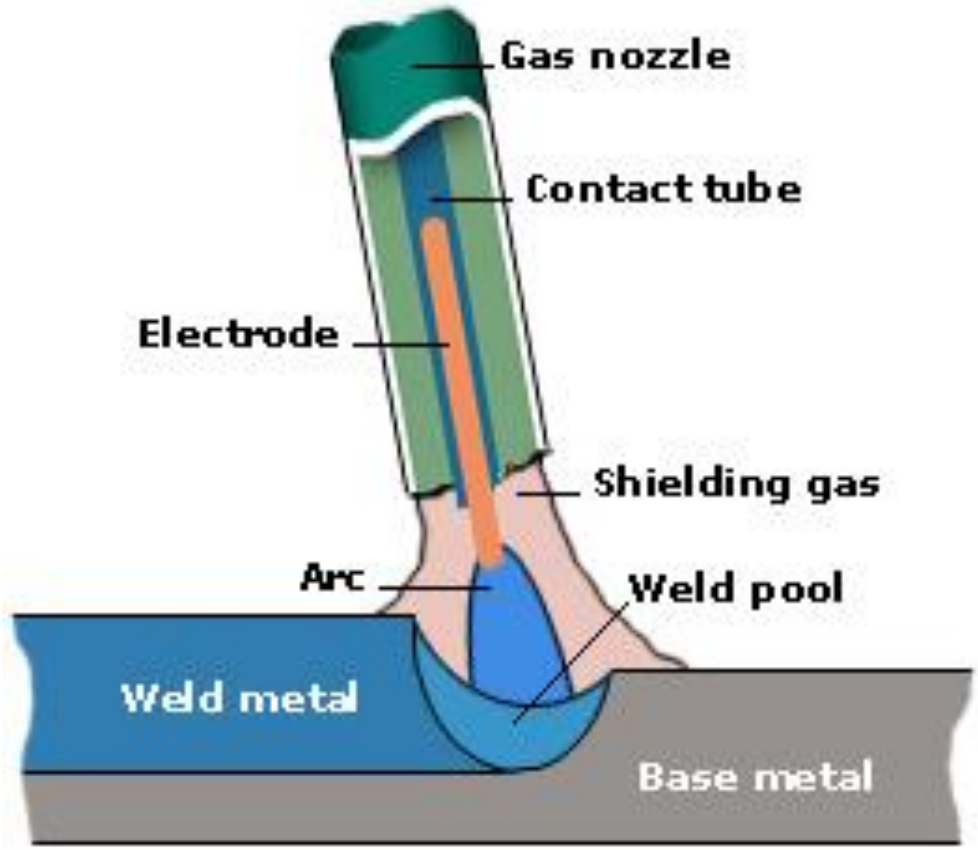
- MIG welding is a semi-automatic or automatic process
- It utilizes a continuous wire feed as an electrode
- An inert or semi-inert gas mixture is used to shield the weld from contamination
- The process can be used to a wide variety of metals, both ferrous and non-ferrous.




## Flux-Cored Arc Welding

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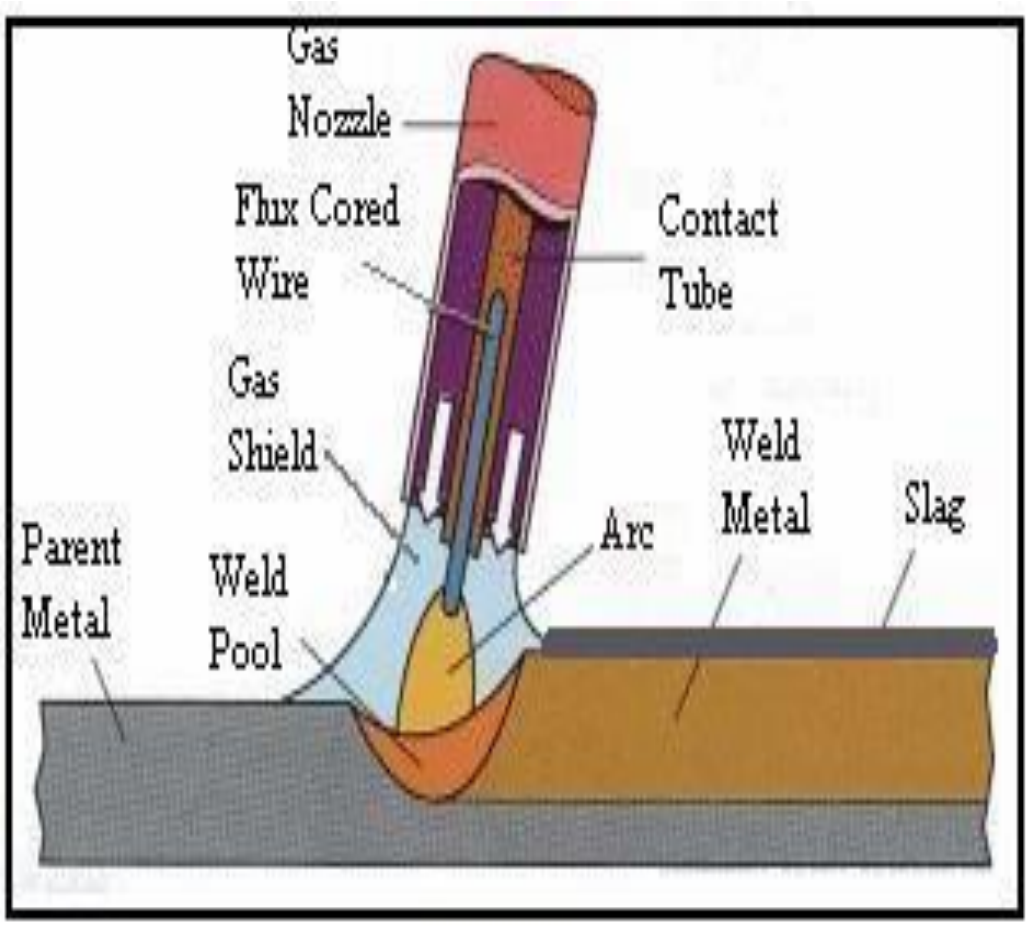
- Flux-cored arc welding (FCAW), utilizes similar equipment as MIG.
- But it uses wire consisting of a steel electrode surrounding a powder fill material.
- The cored wire is more expensive than the standard solid wire and can generate fumes or slag



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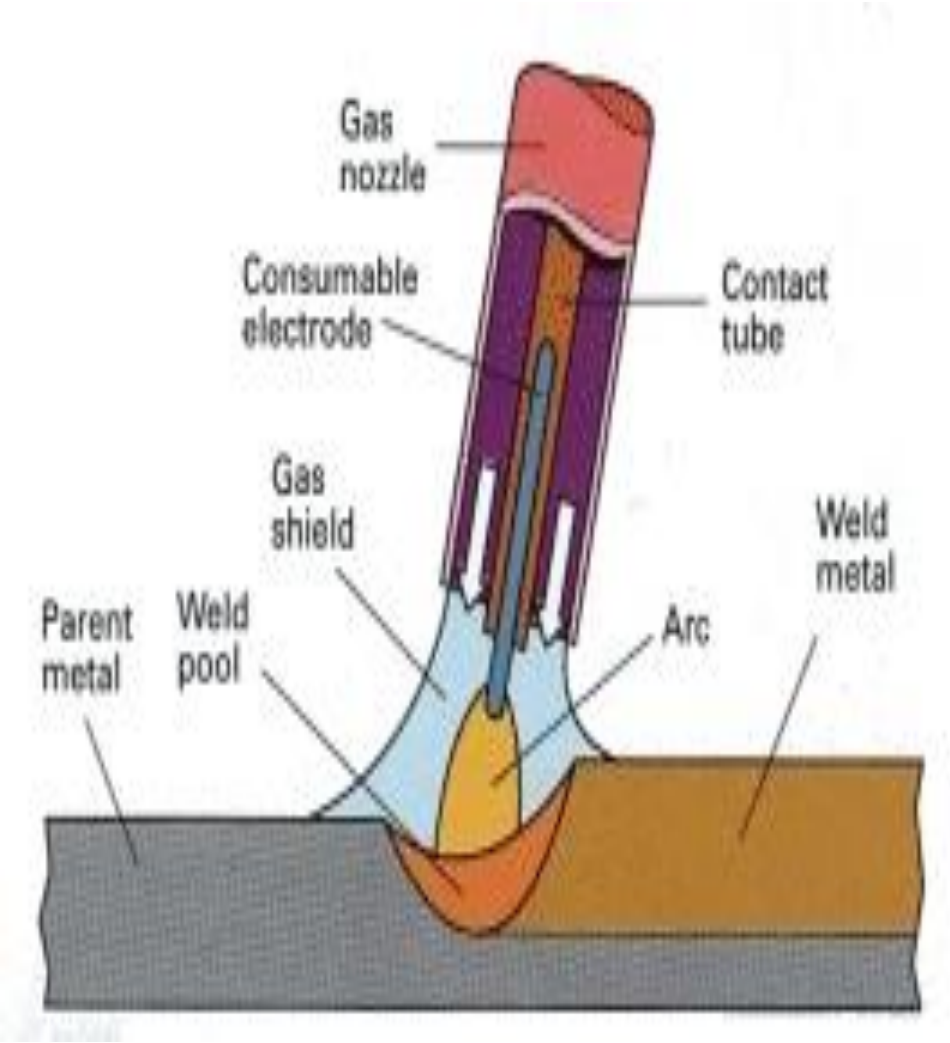
# Metal-Cored Arc Welding

- Metal-cored arc welding (MCAW), utilizes similar equipment as MIG
- But it uses wire consisting of a steel electrode surrounding a Metallic Powder fill material
- The cored wire is more expensive than the standard solid wire and can generate low fumes and no slag.



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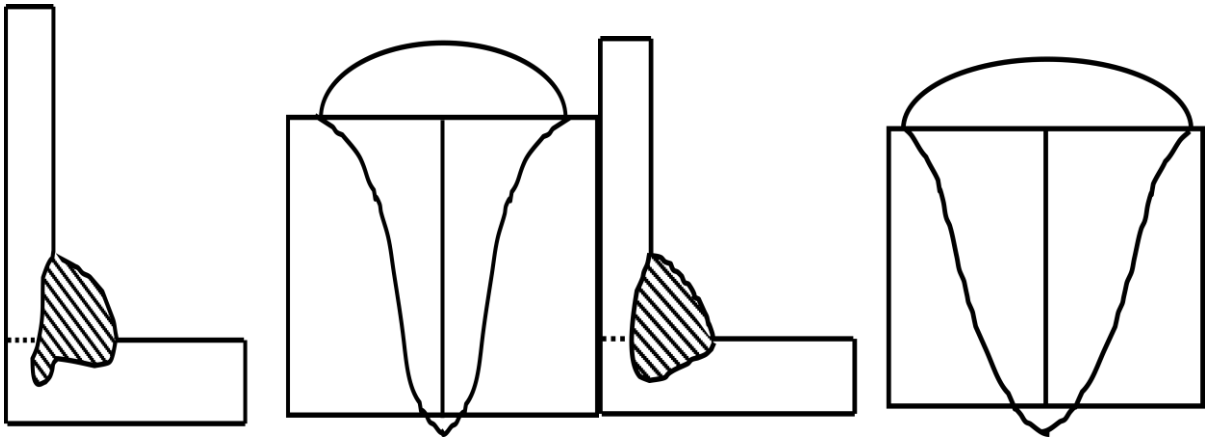
## ***Penetration-***



Nugget profile along the cross section of a weld bead: (a) solid wire & (b) metal cored wire. Solid wire shows “deep finger” penetration.

## C. HEAT TREATMENT-

The ready block is heat treated in the furnace to normalize the weld mont for subsequent machining.

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## *D. SHOTBLASTING*

## *E. INSPECTION*

**Deposition Efficiency-** Deposition efficiency is defined as the percentage of usable metal deposits to the weight of consumable consumed for making the deposit. It describes a measure of the "waste" during a welding process and calculated as –

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$$\text{Deposited efficiency} = \frac{\text{Weight of weld metal x100}}{\text{Weight of consumable}}$$

**Weld Bead Shape-** Weld bead shape depends on-

- gun angle
- direction of travel
- electrode extension (stick out)
- travel speed
- thickness of base metal
- wire feed speed (weld current), and voltage

$$\text{Operating Factor} = \frac{\text{pure arc time}}{\text{total welding time}}$$

SMAW-25% GMAW- 45% SAW- 55% FCAW-40%

## Common Welding Defects

- Cracks
- Distortion
- Incomplete penetration
- Porosity & Blow hole
- Inclusions
- Under cutting
- Over lapping

## Common Reasons of defects

- Lack of know how ,know why and experience
- Welding process characteristics
- Base metal composition
- Defective welding filler metals
- Joint design
- Welding environment (wind, fit up, temperature)

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# II. ENGINE DIVISION

Around 3000 components are assembled with high standard workmanship for uninterrupted production & smooth supply of cutting tools to machine shop & independent tool room is functioning efficiently. Light & heavy machine components such as gears, connecting rods,

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camshafts etc are machined & all the engine components are assembled in EES (Engine Erection Shop).

**Engine Division consist of-**

- HTS (Heat Treatment Shop)
- LMS (Light Machine Shop)
- SAS (Sub Assembly Shop)
- EES (Engine Erection Shop)
- ET (Engine Testing)

## HTS (HEAT TREATMENT SHOP)

Heat Treatment is the controlled heating and cooling of metals to alter their physical and mechanical properties without changing the product shape.

**Purpose-** To develop wear resistance & hardness on parts, Softening, Hardening & Material modification

**Principle-** By heating & cooling, change internal structure of the material, important of that is of material modification.

### *Heat Treatment Process*

1. Annealing
2. Normalising
3. Hardening
4. Induction hardening
5. Tempering
6. Carburizing
   i. Pack
   ii. Gas Carburizing
7. Stress Relieving
8. Lubriting

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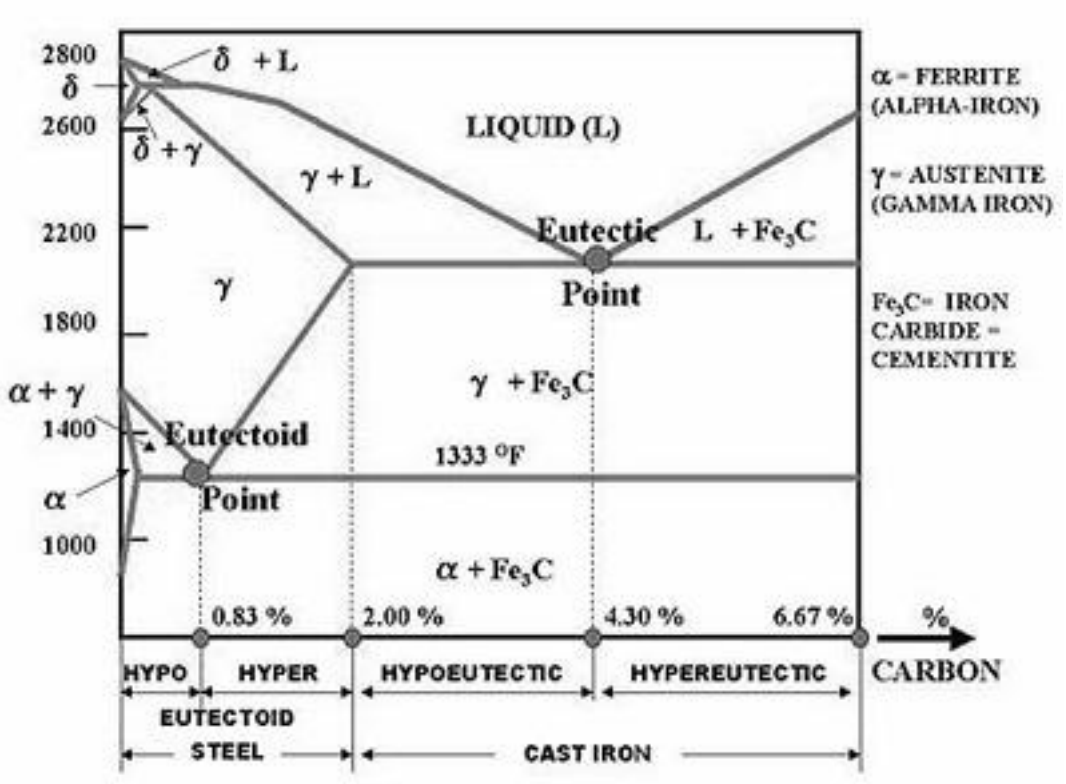
1. ***Annealing-*** It is softening process. It is process of heating above upper critical temp ($920^0$C) and cooling in furnace itself.

   **Purpose-** to remove internal stress & to refine grain size

   **Example-** S pipe, to reduce hardness for machining

## Iron-Carbon equilibrium diagram




2. ***Normalising-*** Heating upto upper critical temp ($880^0$C) and holding definite time at the same temp then uniform air cooling.

   **Purpose-** to remove internal stress

   **Example-** Welded Job, Copper Tube, Gas Cutting Job, TMS job.

3. ***Hardening-*** Heating upto upper critical temp($840^0$C) and holding definite time at the same temp then quench in water or oil. In this process austenite change into Martensite (Hardened Structure). Example- Thrust Plate, Pin, TMS job, Gear.

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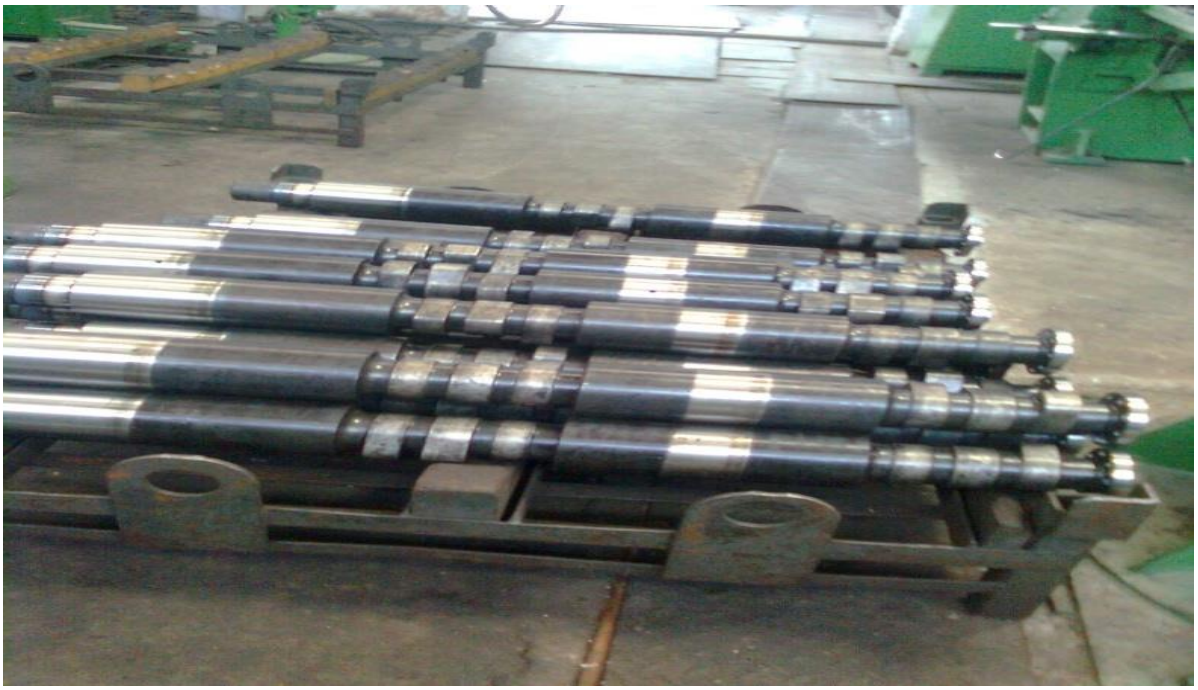
4. ***Induction hardening-*** This is a process of Surface hardening. It works on principle of mutual induction. Hardening by high frequency AC current voltage 410-450, temp-840$^0$C, Quenching pressure 14-30psi, Quenching Water Temp- 20-30$^0$C. Example- Cam Shaft(1050Cr)(Hardness-58/62Rc,Casedepth-120-250Thou),
MPP(AISI8620)(Hardness-58/62Rc, Case depth-120-250Thou)



5. ***Tempering-*** To give some energy to the job for developing properties. Heating below Lower critical temp (150-680$^0$C ) hold for some time and then air cooling. Martensite change in temper martensite. It is done to remove brittleness, to improve ductility, to remove quenching stress, for uniform hardness. Example- All hardened job.

6. ***Carburizing-*** It is done to increase the % of C on the surface of the material. Carburizing temp.-920-930$^0$C, Fe3C compound, $CO_2$, CO,

$$CO+C=2C+O_2$$

i. **Pack Carburizing-**

- Charcoal,
- BaCO3,
- CaCO3,
- Na2CO3

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- Total weight 30% of total job weight
- Box sealed by Sodium Silicate

ii. **Gas Carburizing-** Fluid (liquid) Homo Carb fluid (Iso propyl alcohol is used. Example- MPP, Impeller gear, Fulcrum Pin, Cam roller, Drive Shaft, Idler Shaft

**Carburizing and Hardening- Main Piston Pin**

7. ***Stress Releiving –*** It is a process of heating upto lower critical temp and holding definite and the slow cooling to remove internal stress. Example- Engine Block- $640^0$C/ 10hrs, Camshaft- $450^0$C/ 4hrs.

8. ***Lubriting-*** In this process job is dipped in solution of Phosphoric acid and water at $90^0$C temp for 1Hr. and then rinse from fresh water. It is done so for initial lubrication for rust prevention. Example- Gear, Liner sleeve, Cam roller.

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# ***Lubriting Tank***

***Cam Shaft Process-***

- Stress Releasing $450^0$C/4Hrs
- Straightening
- Induction Hardening $840^0$C
- Strengthening
- Tempering
- Inspection
- Dispatch

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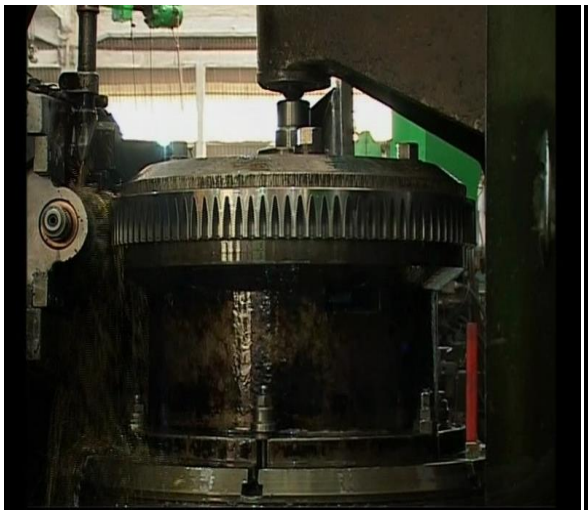
# LMS (LIGHT MACHINE SHOP)

- Cam shaft for ALCO Engines & Stiffer Unit are being manufactured.
- Cam lobes are manufactured by- CNC Cam Milling(3-axis) made by HMT in 2003 costs Rs 2,39,58,380
- All the lobes i.e. Air, Fuel, Exhaust are at different angles.

## Machines used in LMS

- **WIDMA CNC Single Spindle Horizontal Gundrilling Machine-** to make through hole in Camshaft
- **SUNDSTRAND-** for making OD & neck diameter of Connecting rod cap by fixture & for milling jig is used. Diameter is measured in terms of thou(1000 thou = 1inch)
- **CNC Rotary Table Surface Grinder-** 3-axis(Y, Z, B) for grinding of intermediate rings
- **Gear Hobber-** built in 1974 by Churchill costs Rs 6,20,606
- **Gear Cutter-** for cutting of involute teeth on gears
- **Gear Shaver-** to maintain P.C.D. made by National Broach Machine Corp., Deteroit, Michigan
- **Landis Grinder-** for grinding valve bridge which is used in cylinder made by Landis Tool costs $26,080.35



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## Cam Gear location in ALCO Engine


## Cam Gear Material Specification-

Material - Alloy Steel (Forge & Harden)

C Content - 0.43 to 0.48%

Mn - .75 to 1.0%

P - 0.04% maximum

S - .04% minimum

Si - .20 to .35%

Ni - .40 to .70%

Cr - .40 to .60%

Mo - .15 to .25%

Hardness - 332 to 364 BHN

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## Machining Process

- Chuck, Finish OD, Co-bore - CNC VTL
- Reverse, Finish OD and Taper Bore - CNC VTL
- Lifting & Mounting Holes
- Teeth cutting on gear hobbing machine
- Gear profile grinding/Shaving
- Inspection
- Broach Key Way
- Locking hole
- Burr removal
- Number Punch
- Dispatch to HTS for Lubrite

## Chuck, Finish OD, Co-bore - CNC VTL

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## Teeth Cutting on gear Hobbing Machine


## Gear profile grinding/Shaving

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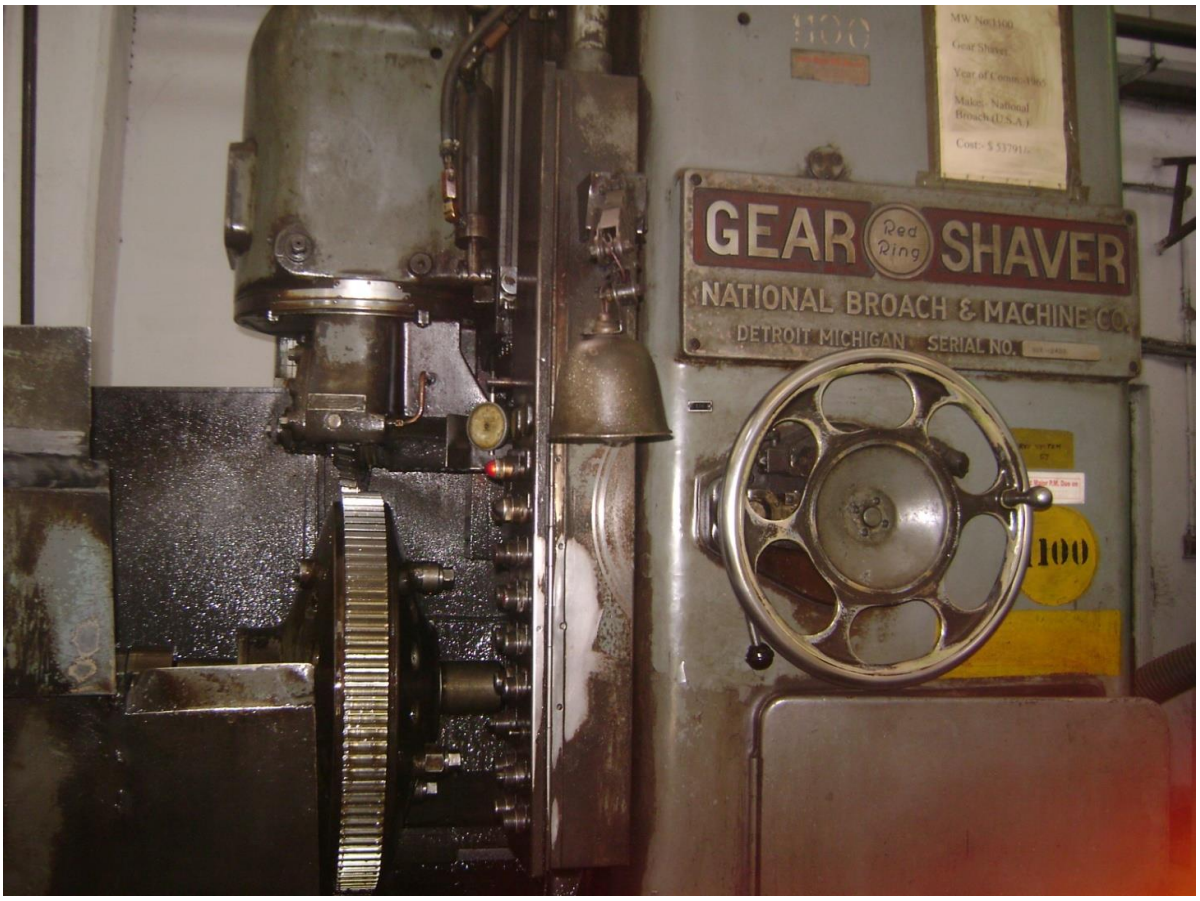


## Stiffer Unit Camshaft

- Stiffer unit cam shaft is important part of the engine, which operate the engine valves (Air, Fuel & Exhaust) with better perform
- SUC plays an important role in engine up-gradation
- 1st Loco – 14962 (2003) upgrade  engine 3300HP

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## Features of SUC

- Simplicity
- Maintainability
- Reliability
- Durability
- Fuel economy

## SAS (SUB ASSEMBLY SHOP)

1. Lube oil & water pump assembly
2. Governor & fan drive assembly
3. Camshaft & Crankshaft vibration damper assembly
4. OST assembly
5. Hot oil Shutdown
6. Fuel pump support assembly
7. Valve lever & control shaft assembly

## Over Speed Control – Over Speed Trip Assembly

If the engine speed should increase to the specified limits, the over speed mechanism will shut down the Engine. (Tripping Range 1035 – 1050 RPM)

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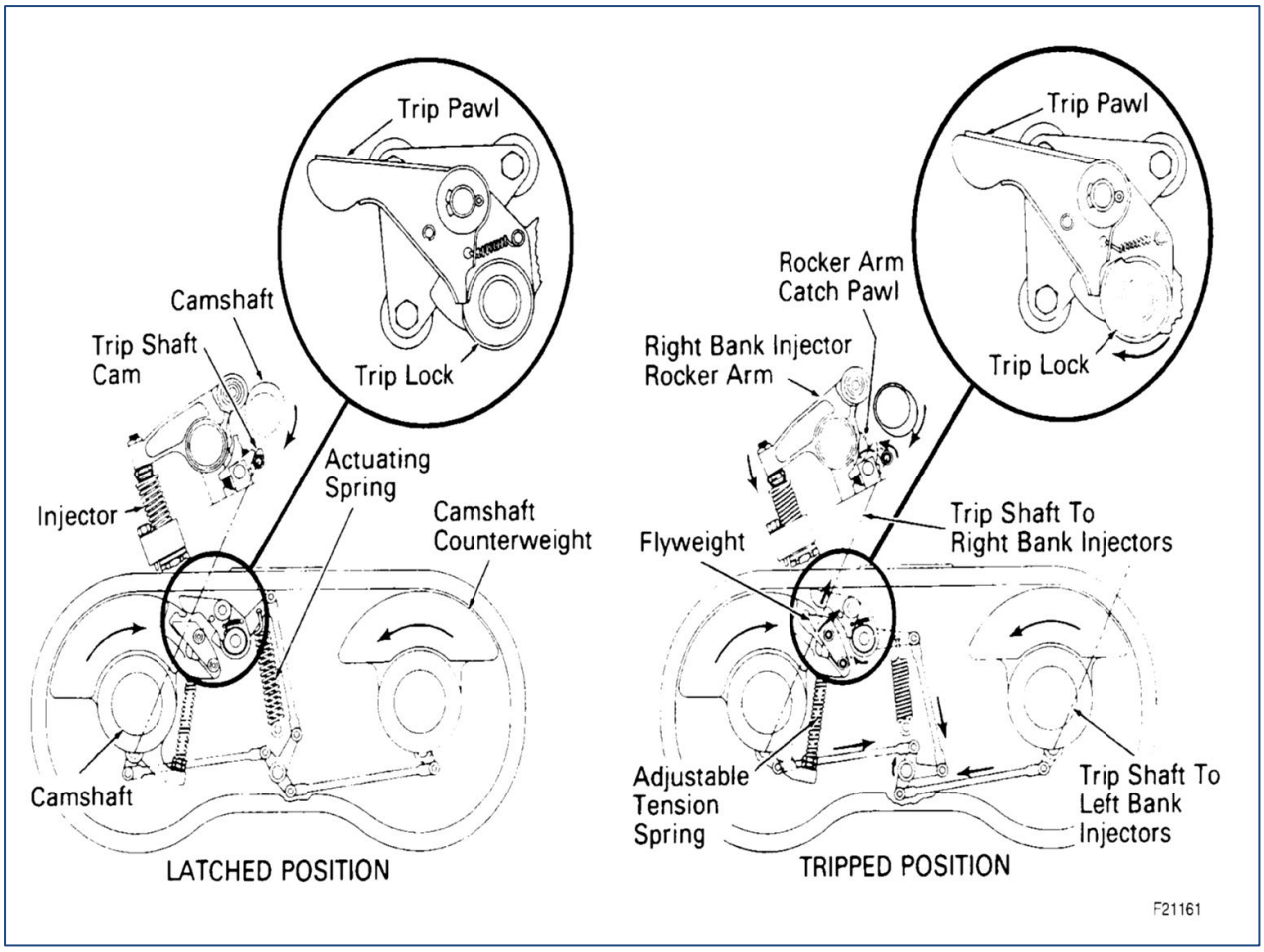


## Hot Oil Shutdown- Thermostatic Valve

When oil temperature rises to 121°-126°C (250°-260°F), the thermostatic valve will open and the pressure oil is allowed to pass through the valve and drain into the governor drive housing. The governor senses the resultant low oil pressure and initiates an engine shutdown.

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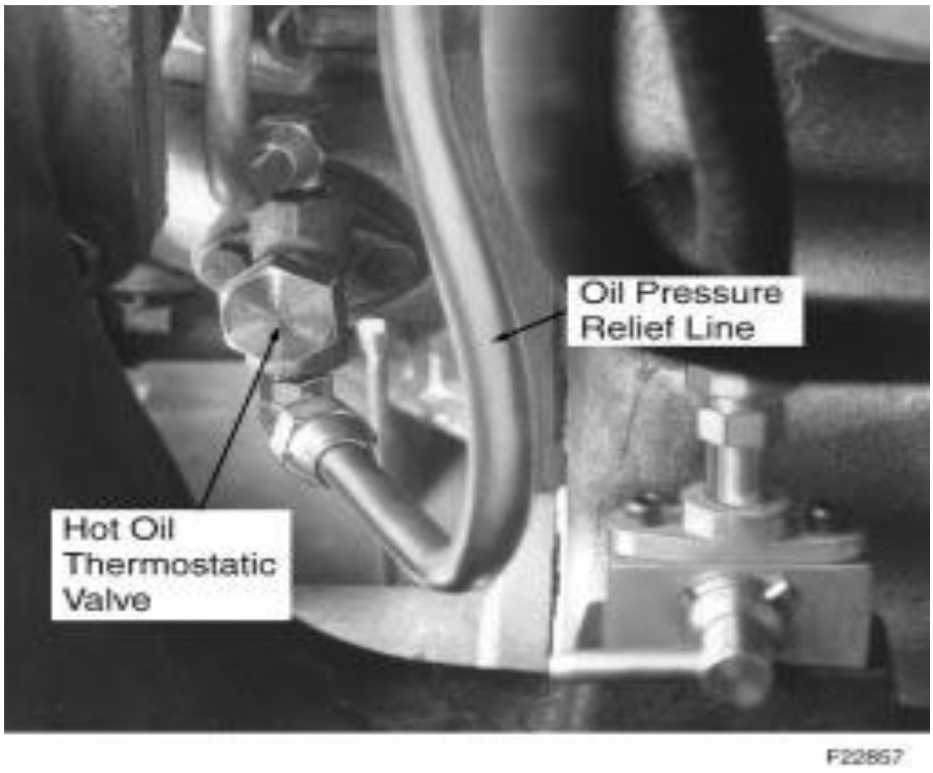


## Other Accessories, Assemblies & Components Fitted On Power Pack

- Vibration Damper
- Fuel Oil Header
- Fuel Oil Piping
- Water Piping
- Pumps: Water, Lube Oil, Scavenging Pump
- OST Housing
- Piston Cooling Tube
- Governor Drive Housing
- Fuel Oil Filter
- Flywheel (Engine Coupling)
- Head Frame & Cover
- Exhaust Manifold

## EES (ENGINE ERECTION SHOP)

Various engine components machined In-house & procured from train are assembled in the EES. In DLW mainly 2 types of engines are assembled namely GM (General Motor) engine & ALCO (American Locomotive Company) engine. Both are 16 cylinders but the different is

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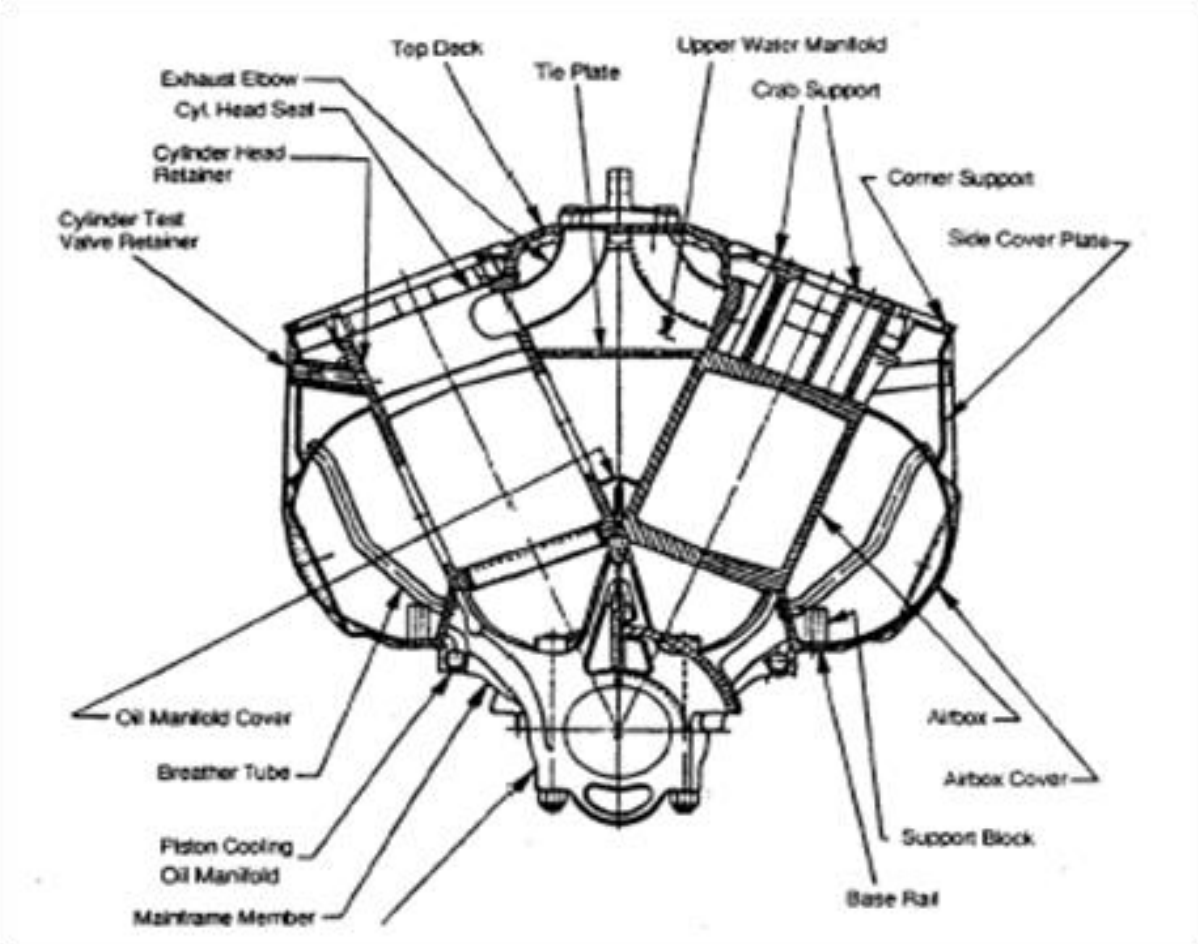
of horsepower, GM engine is capable upto 4500HP whereas ALCO engines are limited only upto 1350-2600HP. In GM, OHC (Overhead Camshaft) is used & in ALCO, SUC (Stiffer Unit Camshaft) is used.

## CRANKCASE




## CRANKSHAFT

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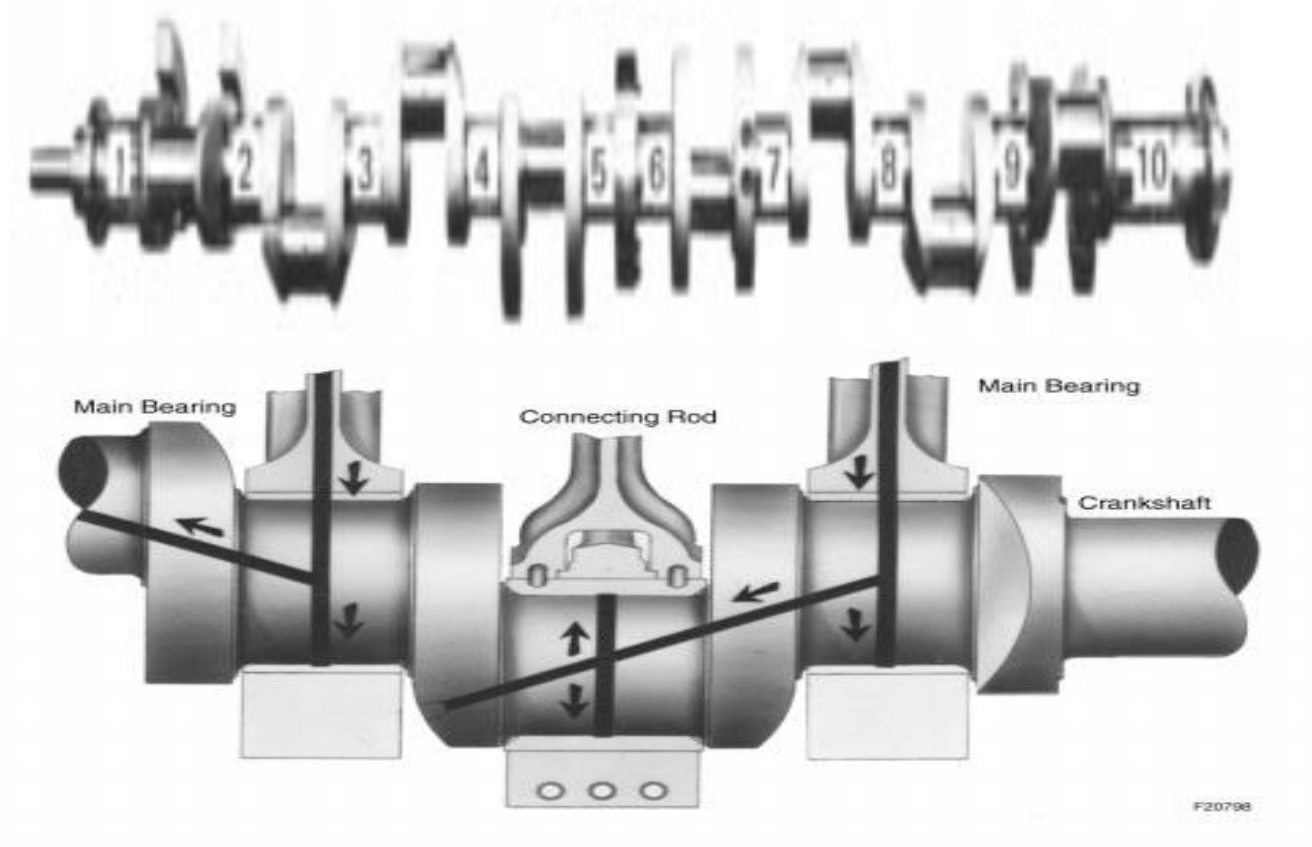


## Crankshaft to be assembled in crankcase

## CAM SHAFT ASSEMBLY

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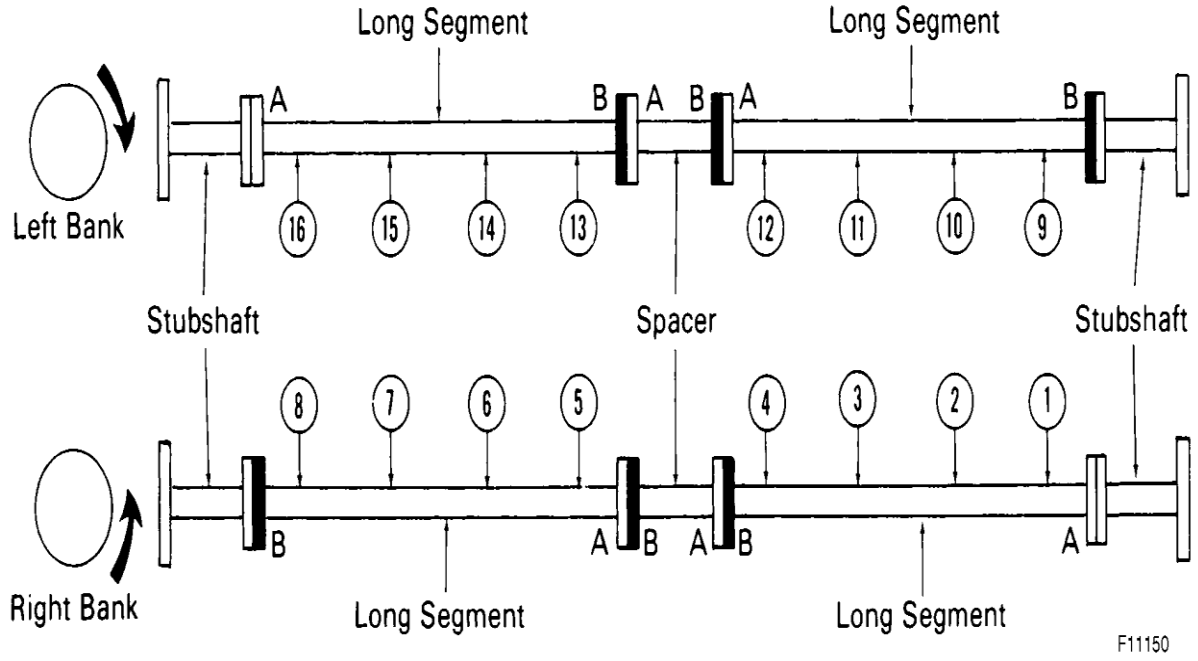
- Overhead camshaft operates the valves directly through Rocker arm assembly.
- No push rod is required
- Two valve bridges with automatic lash adjuster (hydraulic) operate 4 nos. of exhaust valves.
- No clearance is required to be maintained between valve stem and Valve Bridge, thermal expansion is accommodated automatically by hydraulic lash adjuster





## ROCKER ARM ASSEMBLY

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## VALVE BRIDGE

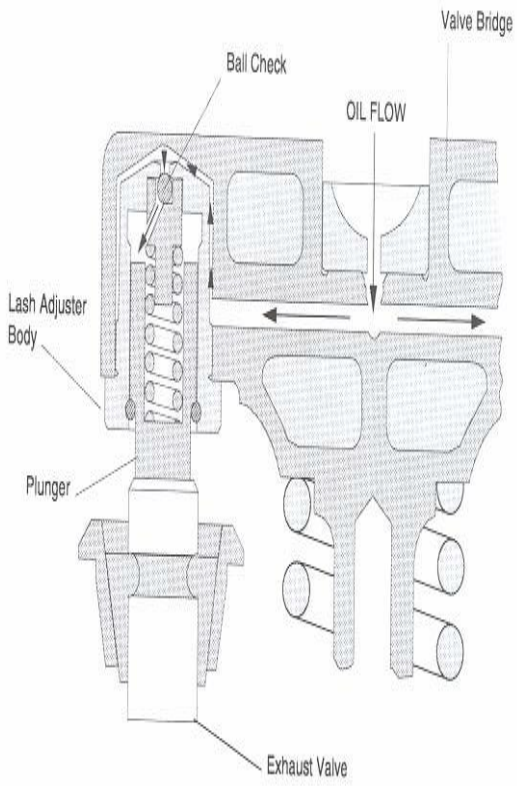


Figure 3.32 *Valve Bridge / Lash Adjuster Cross Section*

## ENGINE ACCESSORY DRIVE GEAR TRAIN

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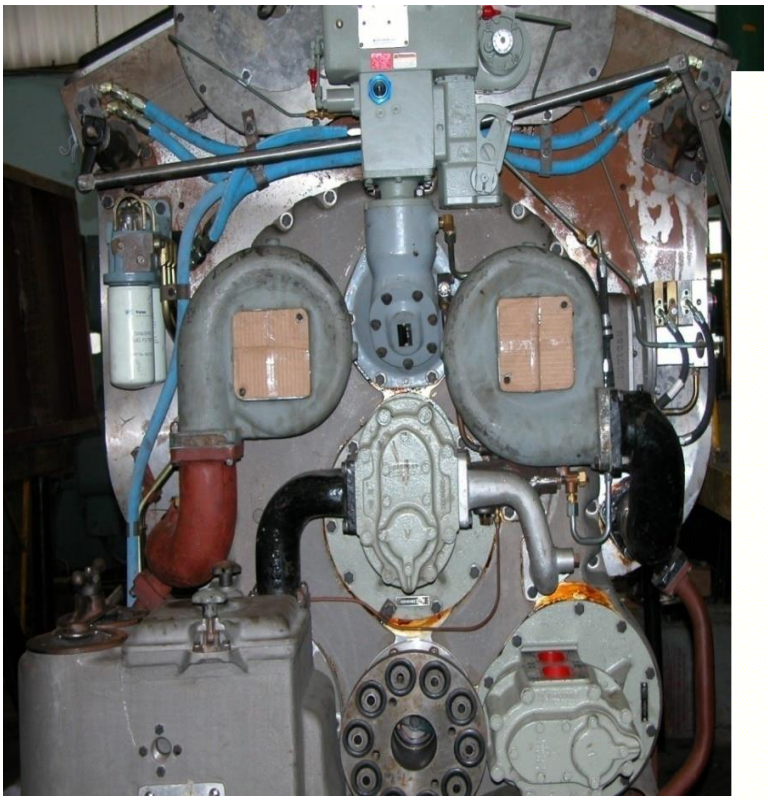

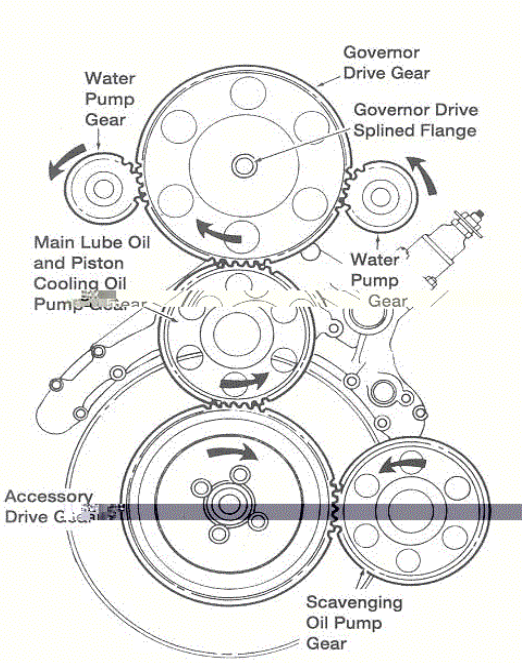


Figure 3.45 *Accessory Drive Gear Train*

## POWER ASSEMBLY

**Concept of Power Assembly-** consisting of con.rod, piston, liner and cylinder head in assembled form as single unit) with easy replacement facility.


***COMPLETE POWER ASSEMBLY***

## LINER & CYLINDER HEAD

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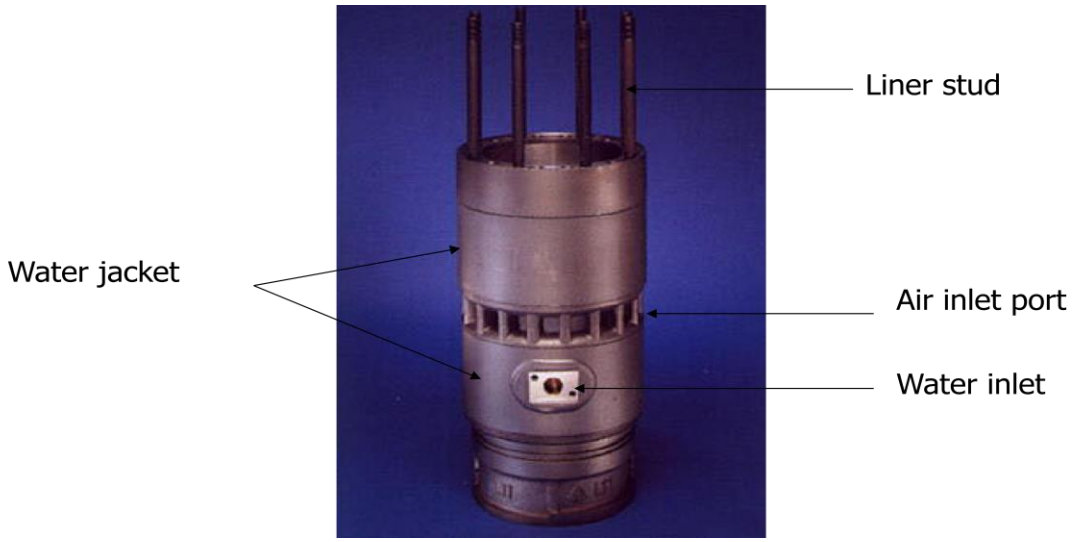


***CI LINER WITH LASER HARDENED BORE***

***CYLINDER HEAD***

***LINER***

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# PISTON & PISTON CARRIER


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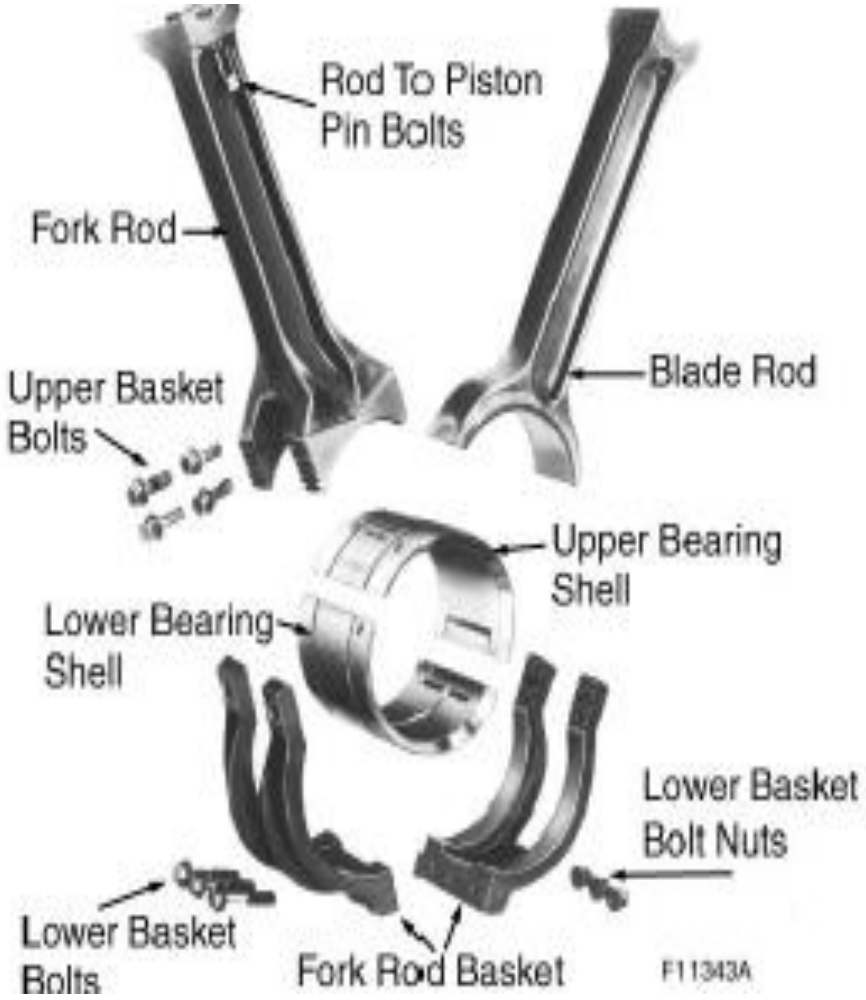
# CONNECTING ROD

- Interlocking Connecting rod design consisting of blade rod and fork rod
  - Same set of bearing is used for both the rods
  - No Offsetting of left and right bank cylinders
- Load on bearing reduced due to increased area. Hence, improved bearing life
- Reduced length of crankcase and crankshaft



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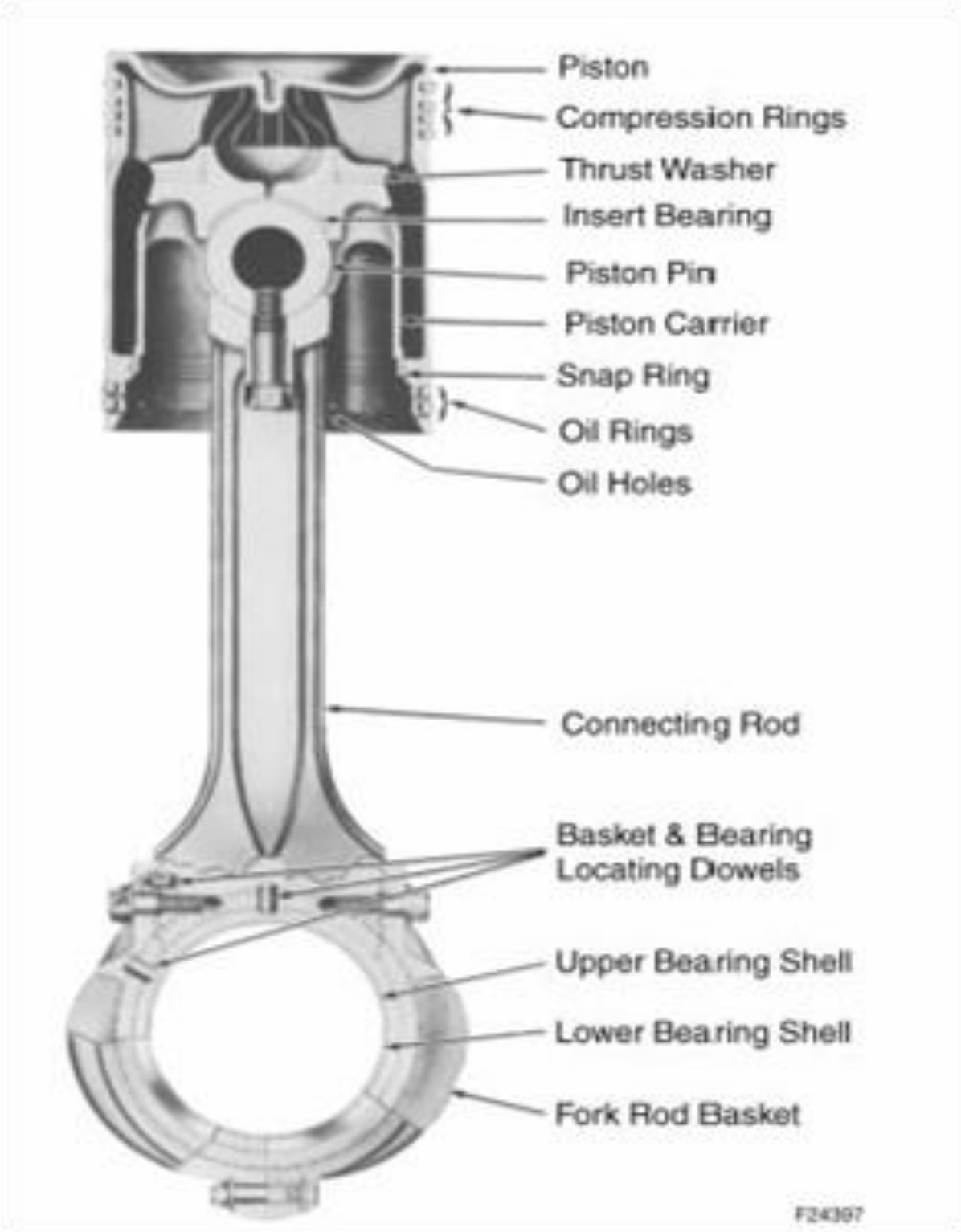

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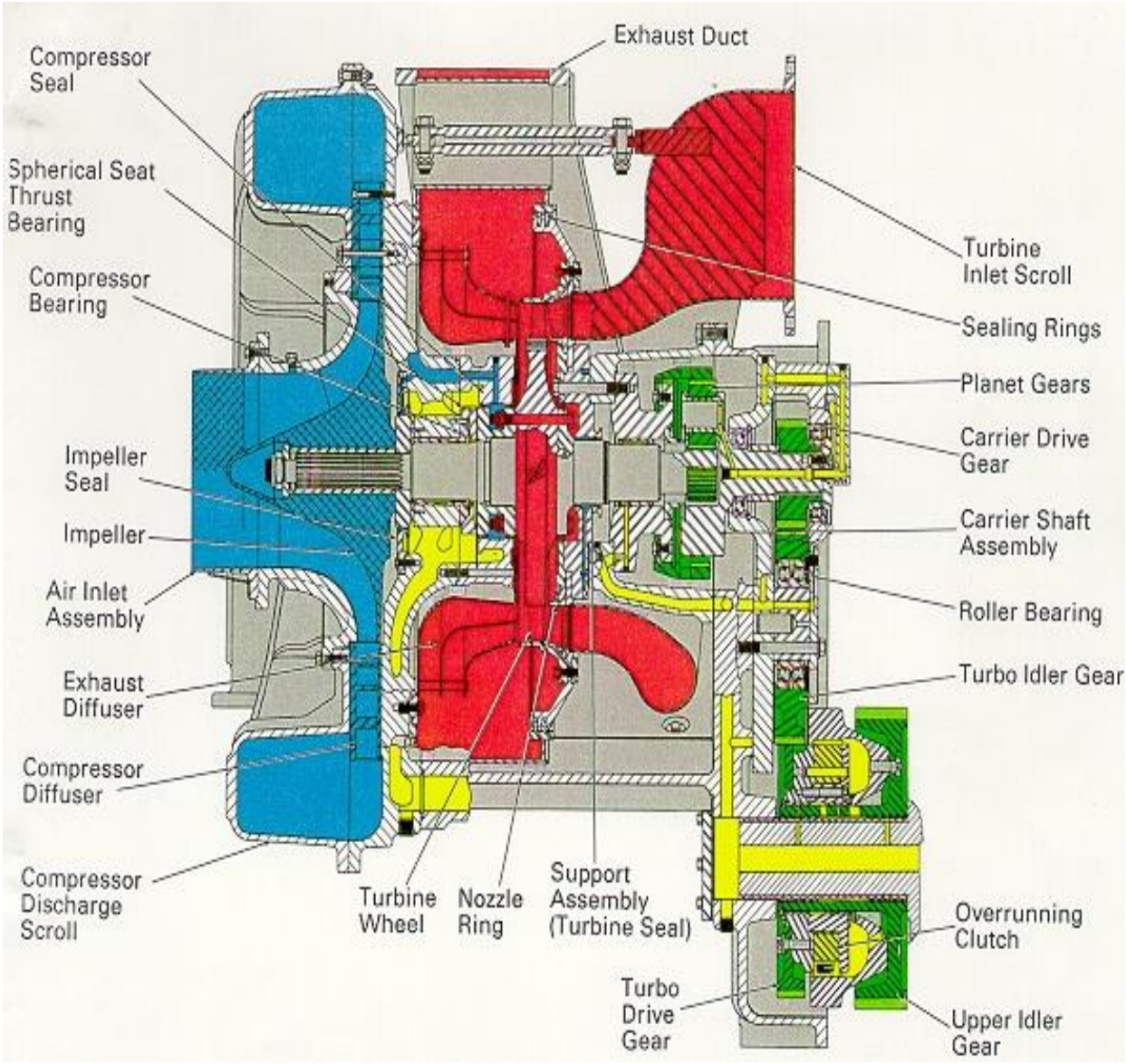
# TURBO CHARGER

- Drive–Mechanically driven (gear drive) as well as exhaust gas driven (turbine) with an over-running clutch
- Rated output – 6.5 kg/sec
- Pressure ratio (Compressor) – 2.8
- Charge air Temp. (after compression) 171°C
- Speed of Turbo (at rated output) – 18,950 rpm
- Lubrication – Engine lube oil and soak back system at starting and stopping of engine.
- Compressor – Single stage, centrifugal type
- Turbine – Single stage, axial flow type



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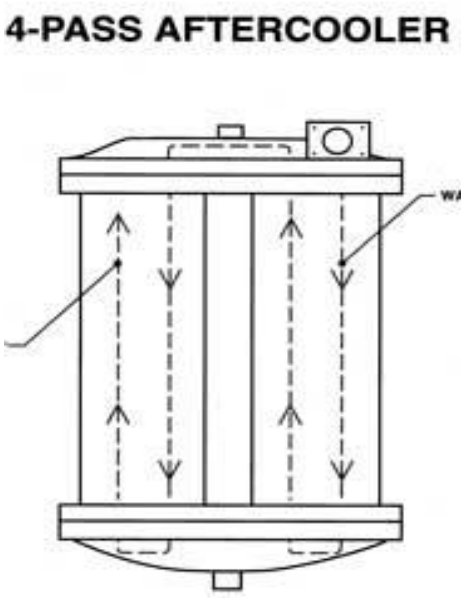
## AFTER COOLER

- 2 nos. after cooler are assembled along with the turbocharger.
- It is used for bringing down the temperature of compressed air received from turbocharger




## EMD TURBO DRIVE ARRANGEMENT

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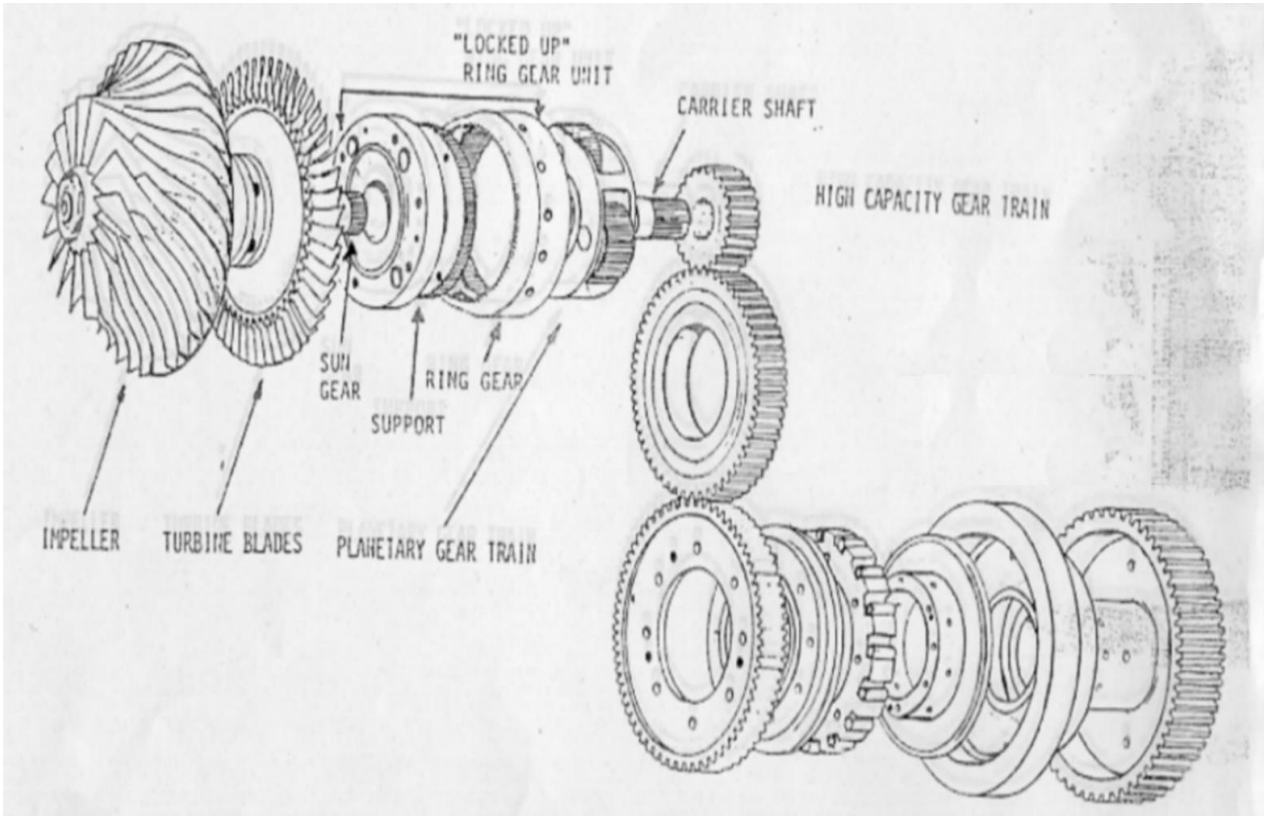


## *ET (ENGINE TESTING)*

After the engine is completely assembled in EES, the quality & performance of the engine is checked on the computer controlled test pads in Engine Testing.

The testing of the engine goes through-

1. Pre Test
2. First Inspection Test
3. Brake in & full load Test

### *1. PRE TEST*

**Water circulation-** engine is filled with water 100±10psi (static pressure) & if there is leakage it is checked

**Fuel circulation-** 50psi from external ump for 15min. if there is any dropege more than 4psi then it is checked

**Lube oil circulation-** Upto 300l oil is filled & then all wastes are removed then again oil is filled. The oil used is of Nomenclature **RR520MG** where RR stands for Rail Road & MG for Multi Grade.

### Lubrication system of engine-

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- **Main lube pump-** for lubrication in camshaft, bearing, geartrains. It is same housing with Piston cooling pump but with different ports
- **Piston cooling pump-** for piston lubrication only
- **Scavenging lube oil pump-** suck to main oil pump & filter
- **Soakback pump-** only for turbocharger (it is mechanical drive at starting & then it is driven by gas) for its bearings & geartrain. Soakback pump is started first when starting the engine to remove residual heat. It also runs after engine is closed.

## 2. FIRST INSPECTION TEST

First of all Alignment is done

i. **Alignment of engine coupling (Flywheel)-**
   - Angular alignment (±10 thou)
   - Radial alignment (±.020 thou or ±20 thou)

ii. **Alignment of Blower drive shaft-** alignment of shaft of fan upto ±10 thou & then torquing of all mounting boards like engine & alternator

iii. **Inspection of piston torque-** at BDC & free rotation of the engine

iv. **All connections-** water, fuel & lube
   - connection all sensors (i.e. temp & pressure)
   - all electrical connections- electric cable connection
   - air inlet connection port is checked
   - fitment of all hand hole covers which are total 32 in nos

## *3. BRAKE IN & FULL LOAD TEST*

i. Start Soakback pump & check turbo lube oil circuit, min. pressure must be 5 psi for 5 min

ii. Command the engine for 2-3sec for 3-4 revolutions to clear out all dust particles for all 16 cylinders by loosing its cylinder test valve & then test valve is closed.

iii. Now the engine is ready for initial cranking, run it for 10 min without load.

| NOTCH | RPM | ENGINE BHP | TIME (in min) |
|---|---|---|---|
| 1 | 270±4 | 300 | 25 |

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| | | | |
|---|---|---|---|
| 2 | 354±15 | 530 | 35 |
| 3 | 486±15 | 1110 | 5 |
| 4 | 572±4 | 1440 | 5 |
| 5 | 675±15 | 1840 | 25 |
| 6 | 764±4 | 2290 | 25 |
| 7 | 863±15 | 3550 | 25 |

- 1-7$^{th}$ notch is called Brake in run i.e. engine is without load.
- Cut-off the load & run the engine at 8$^{th}$ notch & check that OST (Over Speed Trip) range should be 1035- 1050rpm
- Check & set Rack setting
- Set or check fuel timing is done by Firing order
- Visual inspection
- Engine is ready for full load test
- Start the engine & go upto 8$^{th}$ notch for full load test

**OST-** It is a safety device. If load is reduced then rpm increases from the desired rpm so there can be any failure. So a safety device OST is introduced. It cut-off the lube oil from camshaft.

**Rack-** According to notch wise, it is cut in mm in GM engine & in inches in ALCO engine

**Firing order-** According to the sequence in which power stroke is obtained from the cylinder

**Firing order for ALCO engine-** 1R 1L 4R 4L 7R 7L 6R 6L 8R 8L 5R 5L 2R 2L 3R 3L

**Firing order for GM engine-** 1 8 9 16 3 6 11 14 4 5 12 13 2 3 7 10 15

| NOTCH | RPM | ENGINE BHP | TIME (in min) |
|---|---|---|---|
| 8 (First Rated load) | 954±4 | 4500 | 80 |
| 8 (Second or Overload run) | 954±4 | 4600-4700 | 10 |
| 8(Third or Rated load) | 954±4 | 4500 | 60 |

- If all data are within specified range, then cut-off the load & bring it to First Notch

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- Check LWS (Low Water Switch) function. LWS is a safety device
- Again at full load check Turbo rundown (TRD) & test for 50sec
- If rotor assembly stops before 50sec then bearing tends to failure. Check Turbo bearing pressure at $8^{th}$ notch & at First notch.

Engine Testing is completed. Now visually inspect for all bolts & connections are safe & disconnect all connections.

# *III. LOCO DIVISION*

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After being tested from ET (Engine Testing), the engine is now ready to move to the Loco Division. Fabrication of underfame is a highly skilled process. Steel plates, I-Beam, channel

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and angles are cut by using plasma and laser cutting techniques. Fabrication is done taking on tubes to ensure strength and another parameters required. This is achieved by qualified team of welders, supervisors and officers. Wheels, Axles, Traction motors & Truck frame are assembled together as Bogie Assembly on which the locomotives run on track. Two of such Bogies hold around more than a 100 tonnes load of loco assembly to take a diesel engine on to the rail track.

Loco division the engine into locomotive by assemblies of various subassemblies like engine and turbosupercharger, driver cabin, contractive compartment engine cover i.e. long hood and short hood are placed on the underframe.

Really now, and important event in manufacturing process of the locomotive is the lowering of 100 tone loco on to bogies is performed by highly skilled workers under close supervision with utmost care and without any error.

***INSPECTION OF UNDERFRAME***

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***THE BOGIE ASSEMBLY***

***DRIVER CABIN***

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***LOWERING OF 100 TONNE LOCO ON 2 BOGIES***

## *LTS (LOCO TEST SHOP)*

The locomotive after assembly is ready to be tested & goes through-

1. Shower Test
2. Performance test on Load Box
3. Road run trail

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